Modelling the Multi in Multi-Party Multimedia Communication

Emma F France

Thesis submitted for the degree of Doctor of Philosophy in the Department of Psychology, Faculty of Social Science, University of Glasgow, January 2000.

Abstract

This thesis investigates the effects of multimedia communications technology on the interaction of mixed- and same-role groups. The first study explores the effect of video and audio conferencing on small, role-differentiated problem-solving groups in the laboratory. The second laboratory study examines the impact of shared video technology on the communication of role-undifferentiated groups. A multi-faceted analytical approach is employed, including indices of task performance, process and content of communication, patterns of interaction and subjective user evaluations. Lastly, a field study looks at how the communication process of business meetings is affected by status constraints and audio conferencing technology.

The findings show that both multimedia video and audio communications technology have similar impacts on the patterns of speaker contributions in different types and sizes of groups, and that the extent of their effect is influenced by the presence or absence of role differences between group members - whether experimentally manipulated in the laboratory or organisationally assigned roles in a naturalistic setting. Technology-mediation appears to exaggerate the impact of status and role such that group members say more disparate amounts and interact less freely than in face-to-face groups; in particular it exaggerates the dominance of one individual. Surprisingly, multimedia conferencing technology can support free and equal participation in groups whose speakers have similar roles but evidence of its effect on speakers of similar status is equivocal. The implications for communication outcome and design of communications technology are discussed.

Executive summary

Main issues and aims

This thesis investigates the effects of multimedia communications technology[1], specifically audio and video conferencing technology, on the interaction and collaboration of small groups of adults. It aims to address some of the gaps in the literature, for instance, there are few studies investigating the impact of multimedia communications technology on group rather than dyadic communication. In particular little is known about how sharing conference sites and equipment affects group interaction. The impact of multimedia technology on role and status constraints between members of a group has also received scant attention. These areas are explored in three studies combining different methodological and analytical approaches.

Description and main findings of three studies

Two laboratory studies of small face-to-face and technology-mediated[2] groups employ a multi-faceted analytical approach including indices of task performance, process and content of communication, patterns of interaction and subjective user evaluations.

Laboratory experiment 1

Study 1 investigates the impact of unequally distributed[3], high quality video and audio conferencing technology on the interaction of three-person groups in a service encounter simulation. Two 'clients' share one conference site in the technology conditions in order to communicate with a remote 'travel agent'. Groups perform equally well across the media, say similar amounts and speaker exchanges are equally co-ordinated. However, a detailed analysis of the patterns of participant interaction reveals that co-present, same-role participants interact significantly more (in turns and words exchanged) in the video context and have a

---

[1] See glossary in Appendix V for definition of this term.
[2] " " " " "
[3] See glossary in Appendix V for definition of this term.

tendency to converse more in audio conferences compared to face-to-face communication. Surprisingly, remote conversations are remarkably stable across communicative conditions. There is an impact of communication medium on how equally speakers contribute to discussions with one of the individuals (playing the role of a client) saying more than the other participants in the technology conditions but not when face-to-face. These patterns are confirmed when the conversational content and structure of VMC and face-to-face conversations is analysed using Conversational Games Analysis.

Laboratory experiment 2

Study 2 explores the effect of video communications technology on groups whose members have homogenous roles. Four-person groups participate in a persuasion and decision-making task in a video (with two participants at each of two sites) and a face-to-face context. Despite the remarkable similarity of the face-to-face and video contexts and of the cross- and same-site communication in the amount said, the co-ordination of speaker turn-taking, the formality of conversations, the speakers' persuasive behaviour and how equally speakers contribute to the discussion, groups perform more poorly in the video condition. There is an impact on the extent of group members involvement in cross-site, video-mediated conversations - one individual at each shared site is verbally dominant in these interactions, however analyses show that this does not appear to explain the poorer VMC performance; only some participants are adversely affected in the technology condition and they are not the same the individuals who are less involved in cross-site[4] talk. Rather, users' perceptions of communicative difficulties seem to affect their behaviour and performance: they appear to talk more and concentrate less on the discussion with negative consequences for their performance.

Field study

A different methodological approach is adopted in study 3 which looks at how the communication process of established work groups in business meetings is affected by organisational status constraints and multimedia audio conferencing. The

[4] See glossary in Appendix V for definition of this term.

research reveals that technology-mediation appears to exaggerate the impact of status, in particular, the dominance of the highest status member increases in terms of how much they say in words, turns and pairwise (two-person) conversations and how much they influence the flow of the conversation through initiation of and participation in pairwise conversations. Participants interact most freely and equally in same-status groups during audio conferences but the consistently smaller group size in these meetings compared to mixed-status groups could explain these findings.

Conclusions

This research shows that both multimedia video and audio communications technology have similar impacts on the patterns of speaker contributions: multimedia communications technology can exaggerate the constraints of role and status such that group members say more disparate amounts and interact less freely than in face-to-face groups, in particular it exaggerates the dominance of one individual. Furthermore, sharing conference sites[5] can create inequality of speaker participation in conversation with remote group members, yet overall, sharing technology does not have a major impact on group communication. Another finding is that persuasion can be as effective via video-mediation as during face-to-face communication. In addition, the value of combining different methodological approaches and analytical methods is highlighted.

Examining the ways in which groups are affected by status and multimedia communications technologies provides some interesting insights into the subtle effects of technology and status on the equality of speaker contributions which may impact the success of communication. This has possible implications for the design of multimedia communications technology to support groups.

[5] See glossary in Appendix V for definition of this term.

Contents

List of Tables

List of Figures

Acknowledgements

Firstly, I would like to thank my academic supervisor, Professor Anne Anderson, for her help, advice and support throughout my research and the writing-up of this thesis.

My thanks also go to my industrial supervisors, Dr. Michael Gardner and Mary Jones, for their help and support, especially in carrying out the field research component of this thesis. I am grateful to Jim Mullin and Anne-Marie Fleming for their technological expertise and assistance which made the research in this thesis possible. Finally, thanks to my family, friends and colleagues for their encouragement.

Declaration

I declare that this thesis is my own work carried out under normal terms of supervision.

1 Chapter 1. Group communication and collaboration

This thesis concentrates on a particular type of communication, interactive communication between groups of adults engaged in collaborative tasks. The research examines the impact of multimedia communication technologies upon the process of such interaction in the laboratory and the field.

Multiparty or group communication has become of interest recently after years of researchers concentrating on communication between two people. This may be due to the realisation that dyads do not necessarily interact in the same way as groups of three or more persons. Since group communication and its effectiveness are so important to many areas of life it is essential that we understand its characteristics.

Before reviewing the literature in this area, it is first necessary to define 'group' and 'communication'. Communication, according to the Collins dictionary is : *'the act or an instance of communicating; the imparting or exchange of information, ideas or feelings'*. Furthermore, communication has a goal or purpose, either social or task-oriented. A group can be defined according to its characteristics which differentiate it from a collection of individuals: members of a group interact and they have an investment in the group which has importance and relevance to them (Hare, 1962; Carletta, Garrod and Fraser-Krauss, 1998).

Multiparty communication is thought to have certain distinctive characteristics. Tajfel and Fraser (1978) propose that the smallest real social group consists of three people, while Steiner (1972) believes that three is a special or 'critical' group size since it is the smallest size in which certain phenomena can occur:

> *'a coalition can form, one individual may provoke or mediate disagreements between others, and the continuance of the group no longer depends upon the*

willingness of every member to participate. More important perhaps is the fact that any member can be outvoted by his associates.' (p100).

This represents a sharp break with the dyad in which none of these things can occur. He argues that pairs feel mutual responsibility, favour co-operation rather than conflict and participate more or less equally, even when this is counterproductive or inappropriate. In three-party situations equality has little influence on the way the group is organised. Furthermore, the addition of a third person to a group introduces uncertainty over who will speak next. Larger groups have characteristics similar to the triad.

This review of the literature focuses on research which has studied the process of group communication in detail. The large body of studies exploring the social psychology of groups (e.g. the phenomena of conformity, the bystander effect, groupthink, social loafing and so forth) have not carried out such analyses, and for this reason they are not included here. Communication, of course, includes written messages, however this chapter concentrates on multiparty face-to-face communication in which communicators are co-present, visible to each other and communicate by talking.

Communication can be split into two component parts:

- **linguistic information** - the structure of dialogue and the semantic content of the words and phrases. This includes **paralinguistic information** - the physical aspects of language such as intonation patterns and pauses.
- **non-linguistic communication**- refers to visual cues in the behaviour of people and in the physical environment.

The literature has been organised according to this dichotomy.

1.1 ***The Linguistic Channel of Communication***

There are two main types of research on verbal communication: 'content-free' or 'structural' dialogue analysis which examines patterns of group interaction over time; and analysis of dialogue content which takes into account the meaning of utterances. Most group communication research has been of the content-free sort, mainly concentrating on turn-taking, amount of talk and patterns of speaker participation.

Content-free dialogue analysis

Speaker participation patterns

Studies of the structure of interaction have focused on two main levels of analysis: the contribution rates of individual group members to discussions and the overall pattern of group interaction. Analyses of the patterns of interaction are based on the fact that conversations appear to proceed turn by turn with one person talking at a time. However, 'turn' has not been defined consistently in the literature. There are two main definitions, one technical, the other less so; why one is chosen over the other appears to be largely arbitrary. Feldstein and Welkowitz (1978) maintain that a 'turn'

> '*begins the instant one participant in a conversation starts talking alone and ends immediately prior to the instant another participant starts talking*' (p335).

Such a technical approach considers all utterances, even very short ones, to be turns. In contrast, other authors (e.g. Burke, 1974) question whether short interruptions, such as back channels[1], should be called turns as these are not really attempts to take the floor. In everyday conversations, new turns most often begin after only thirteen words have been spoken and two thirds of all turns are less than twenty words long (Orestrom, 1983).

Studies of communication patterns

Stasser and Taylor (1991) maintain that studying patterns of speaker interaction can aid understanding of the '*flow of information and influence*' during group discussion (p675). Various different units of analysis have been adopted in order to examine these patterns. The first researchers to examine the structure of interaction were Bales and colleagues (Bales, 1950; Bales, Strodtbeck, Nills and Roseborough, 1951; Bales and Borgatta, 1955). They based their analyses on the patterns of participant contributions or 'acts', an act being defined as the smallest overt segment of behaviour that has 'meaning' to others in the group. They noted on paper the originator and the recipient of each act (at the time, facilities for audio recording discussions were not available). This Interactional Process Analysis, as it is called, is described in more detail in the section on dialogue content. In contrast, Stephan and Mishler (1952) used the 'participation' as their unit of analysis which is defined as one individual's uninterrupted contribution, although when there was a clear change in content this was recorded as a new unit. Burke (1974), on the other hand, used three units: the turn, Bales' acts (per turn), and the back channel response. More recently, investigators such as Parker (1988), Stasser and Taylor (1991) and Carletta, Garrod and Fraser-Krauss (1998) have based their analyses on the speaking turn.

Individual differences in contribution rates

In analyses of participation patterns that have been carried out at the level of the individual group member, that is, analyses which have examined the amount of talk by individuals in a group, inequality has been found in the number of contributions made to conversations by group members. Volubility of an individual is influenced by many factors: seating position; position in the group's communication network outside of the meeting; motivation to complete the task; the value of the person to the group (McGrath, 1984); the current disposition of group members (Stasser and Taylor, 1991); and gender may also have an effect (Dabbs and Ruback, 1984). There are other influences: a happy or angry emotional state leads to more talk (Festinger, 1950); the relatively constant rate of volubility for a particular individual suggests that personality may play a part in talkativeness (Borgatta and Bales, 1953b); and if a person has spoken recently they are more likely to speak again soon afterwards (Dabbs and Ruback 1987; Parker 1988).

An interesting pattern of participation has been observed by several researchers: those who speak infrequently tend to address their comments to frequent participators who direct most of their comments to the group as a whole. These talkative people also have the most comments directed back to them (Bales, 1950; Stephan and Mishler, 1952). Along similar lines, Bales, Strodtbeck, Nills and Roseborough (1951) examined a variety of different types of groups from newly-formed groups of students, to committees or work groups in the field, to therapy groups. They found regularities between groups ranging in size from three to ten persons: the person who initiated the most 'acts' also had the most comments directed back to him or her, the second most talkative had the second largest amount of comments directed back to her or him, and so on. These findings seem to suggest that the distribution of contributions (whether 'acts' or 'participations') between speakers in a group arises out of propensities to talk.

Consequences for the group of individual amounts of talk

What effect do individual differences in talkativeness have upon a group? In meetings of four to twelve participants in the field, Stephan and Mishler (1952) found that removing highly talkative persons from a group increased the communication rate of the remaining group members. Borgatta and Bales (1953a) in a study of three-man groups in the lab revealed that in a group composed of 'high participators' (in terms of number of 'acts' contributed), the individuals depressed each other's activity. In groups of 'low participators', the group members did not depress each other's activity. Nonetheless, groups with more talkative members converse more, in fact it is the highest participator who determines the length and pace of discussion (Hoffman and Clark, 1976). Several investigators maintain that participants with relatively higher status say more, for example leaders talk more than other individuals (Bales *et al.*, 1951; Dabbs and Ruback, 1987; Carletta, Garrod and Fraser-Krauss, 1998). What is more, a leader who encourages equal participation is effective in increasing the individual rate of communication (Bovard, 1951). Hence, individual differences in talkativeness do affect the overall amount of communication in groups.

Leadership and participation rates

Participation rates can reveal the 'influence structure' within a group: there is evidence of a relationship between amount of talk and influence and leadership. Borgatta and Bales (1953a) also discovered that qualitative differences of performance were associated with differences in interaction rates for both groups and individuals. For individuals with a high interaction rate they tended to display leadership behaviours, whereas those with lower rates tended to adopt supportive roles, while group members with the lowest interaction rates were more likely to be excluded or withdrawn. In addition, Hoffman and Clark (1976) found that in ad hoc problem-solving groups, the person who was the 'highest participator' also had the most influence in almost 75% of three-person groups but in only 50% of five-person groups. The influence of individuals was measured by the amount they contributed to the 'valence' or attractiveness and importance of the adopted solution. However, results from a previous study by Hoffman and Maier (1967) show that it is not just the amount of discussion about a solution that is important but how favourably the solution is talked about: an investigation of the group problem-solving process found a strong correlation between number of positive comments and the likelihood that a solution was adopted by the group. To be influential, a person must also reflect the beliefs of the others in the group in what they say.

Dabbs and Ruback (1987) report similar results from three of their lab studies exploring the communication of five-person groups performing brain-storming, problem-solving and social tasks. They discovered that individuals who talked more of the time were rated higher on leadership, and groups were liked more by their members when there was more communication.

Dabbs and Ruback (1987) have reviewed the research on speaker contribution rates in different types of groups to reveal other factors that influence the amount a group says. They identify many factors: the nature of the task - there is more talk in social interaction than in other types of groups; the type of communication network - there is more communication in decentralised than in centralised networks; the relevance of the issue; difficulty of the goal; the amount of time available to complete the task and the attractiveness of the group.

In the lab, Ishizaki and Kato (1998) found that although Japanese speakers in three-person face-to-face groups made equal contributions of Japanese characters and speaking turns to the conversations when engaged in three meeting scheduling tasks, a dominant individual emerged in terms of initiation of interactions (conversation initiation was based on classification of utterance types as assertions, commands, questions and prompts). Thus, there is some indication of a relationship between an individual's communication process and leadership.

Patterns of group participation

Research into group communication patterns has revealed that participation is not equally distributed among all group members as one might expect, most of the interactions are between two people. Bales (1950) in a lab study, and Stephan and Mishler (1952) in the field revealed that some pairs of participants in a group have more frequent exchanges than others, even in very small groups of three or four people. Later research using the 'turn' as the unit of analysis confirms these findings: in four-person conversation in the lab, Parker (1988) found that face-to-face communication was characterised by predominantly dyadic exchanges; these comprised 61% of turns. This coincides with Stasser and Taylor's (1991) finding that in six-person mock juries 49% of turns involve dyadic exchanges (less than found by Parker for smaller groups, but significantly more than expected by chance). Similarly, in the lab Ishizaki and Kato (1998) found that in equal status face-to-face three-person groups, the majority (over 70%) of 'act sequences' (i.e. from the start of a newly initiated until the next initiation), or interactions, were two-party. However, some groups tend more towards this pattern of a series of two-person exchanges than others: autonomous work groups (groups of employees who typically perform highly related jobs and who have significant responsibility and authority for many aspects of their work) as compared to traditional work groups, spend less time in two-party conversations, have shorter two-party conversations, have more equal participation and show greater interaction (Carletta, Garrod and Fraser-Krauss, 1998). However, there was no measure of whether autonomous groups were actually performing any better than traditional groups. Hence, research in the lab and in naturalistic settings has highlighted the tendency of group communication to consist of two-person rather than truly group exchanges. The possible consequence is that the more time spent in dyadic conversation, and thus the less time spent interacting as a group, the lower the mutual understanding among all group members (Carletta, Garrod and Fraser-Krauss, 1998).

Predicting patterns of participation

Researchers have used this tendency to speak in pairs to attempt to predict patterns of participation in order to increase understanding of the speaker selection process. Burke (1974), for example, found that how active someone was in the conversation was positively related to the probability of being selected as next speaker. Subsequently, Parker (1988) and Stasser and Taylor (1991) tried to identify and predict patterns of turn-taking in four- and six-person student lab groups respectively. Parker found speaker sequences followed an speaker A, speaker B, speaker A pattern, called a floor state. When this dyadic pattern was interrupted there was a very quick move back to two speakers conversing, either the same two or another two. Stasser and Taylor confirmed these findings with mock juries, and calculated that the number of floor states observed was greater than expected by chance. They maintain that groups will spend most of their time in two-party interactions, thus a good prediction of who will speak next can be obtained simply on the basis of who is currently speaking (Dabbs and Ruback, 1987; Parker, 1988; Stasser and Taylor, 1991). Parker (1988) did not draw any conclusions about group interaction from his research, but merely set out to give a description of the rules of speaking order; Stasser and Taylor (1991), on the other hand, propose that patterns of turn-taking are probably driven by individual and social processes, although they do not discuss these further. From an examination of turn content they conclude, however, that group participants who speak early and often in a discussion tend to be more influential in affecting the group's decision.

Effect of group size on patterns of participation

A characteristic of groups which is known to affect interaction patterns is group size. Group size can affect, for instance, the ability of participants to attend to all communicative 'channels' or speakers. It seems that in groups, some polarisation of discussion occurs before the burden of multiple channels becomes so great that sudden and dramatic polarisation occurs; rather this is a gradual process with the participants ignoring certain channels before they are obliged to do so (Bales, 1950; Stephan and Mishler, 1952). Similarly, Steiner (1972) maintains that eventually groups reach an unmanageable size; when there are too many channels, the effort of concentrating on a large number of information sources at one time is too great so group members become selective and concentrate on a few, that is to say, patterns of communication become more polarised.

However, there is conflicting evidence as to the existence of a critical group size. Problem-solving groups reach a size of six or eight persons before there is a reduction in the number of channels used (Bales 1950; Stephan and Mishler, 1952); James

(1951) observed that free-forming groups outside the lab rarely include more than seven people, whereas it appears that groups with leaders have a greater critical size of ten or twelve (Steiner 1972). There is evidence that no more than eight or ten persons can be directly responsive to one another (e.g. Steiner, 1972). Even in small groups of three or four individuals, some pairs of participators speak to one another more than others, although this becomes more marked at size six or eight (Dabbs and Ruback, 1987). Yet, the development over time of a hierarchical organisation of communication channels can aid group members to communicate effectively (Blau and Scott, 1962). Thus, the structure of the group appears to be an important factor in whether groups can successfully interact. It is possible that if the communication is somehow directed or mediated, e.g. by a leader or facilitator, then larger numbers of participants could successfully co-ordinate their contributions. In addition, critical group size may be dependent on the task and the extent and nature of the interaction, for instance, the critical size may be smaller when the task requires rapid, continuous and complex communication.

Communication networks

In the management literature, communication analysis takes the form of investigating communication networks, i.e., the pattern of the distribution of communication channels in a group. This refers to who can communicate with whom and whether the communication is direct or via another group member. These lab simulations (e.g. Leavitt, 1951) usually have involved small face-to-face groups of four or five people intended to represent hierarchies of communication in larger organisations where a number of people are in touch with one another only indirectly. For discussion aimed at solving simple tasks, centralised networks, i.e., those in which all communication is directed through a limited number of individuals, are usually more efficient: the problem is solved more quickly, there are fewer mistakes and fewer messages are required than in decentralised networks. For complex tasks, less centralised networks are usually more efficient, at least in the short term. Nevertheless, satisfaction is highest in less centralised networks, particularly when everyone is involved in decision-making (Leavitt, 1951). It is possible that these results reflect what may happen in groups which are structured in different ways, for example those which have an appointed leader versus those in which all members are equal at the outset. The literature on the impact of status on communication is reviewed in detail in the introduction to chapter 5.

Interruptive speech

Another aspect of co-ordination of speaker exchange (turn-taking) is speaker interruptions. Interruptions and overlapping speech are not defined uniformly in the literature. Generally, an overlap is when speaker B's speech overlaps that of speaker A; an interruption is when one person starts speaking while another is still talking, thus most studies have treated overlaps and interruptions as synonymous. A more fine-grained distinction, however, can be made: although an interruption is always contained within an overlap, occasionally overlaps occur independently of an interruption, i.e., when the speakers start talking simultaneously (Boyle, Anderson and Newlands, 1994).

The role of interruptions in group interaction was examined by Mishler and Waxler (1968) in the milieu of the family. In 'normal' families without a schizophrenic child, family members interrupted one another significantly more often than in families with a schizophrenic child. More interruptions were taken as a sign of a natural, relaxed and spontaneous conversation, hence, interruptions can be used as an indicator of conversational style.

More recent research has explored the relationship between influence in groups and interruptive behaviour. Dabbs and Ruback (1987), for instance, related various communicative behaviours, including interruptions, to subjective evaluations of leadership and group satisfaction, and peer ratings. They differentiated between interruptive and non-interruptive simultaneous speech; the former leads to a change of speaker, the latter does not. They discovered that both types of interruptive behaviour added to the positive evaluation of the group by its members but only interruptions which were successful in taking over the turn led to more positive evaluations of an individual. They explain this with reference to involvement and interest in the group: both kinds of simultaneous speech show involvement with the discussion, thus the more simultaneous speech, the higher the favourable ratings of the group. Non-interruptive simultaneous speech by an individual shows interest in the conversation of another person, whereas the interruptive kind shows interest in her/his own ideas; so for individuals, interruptive simultaneous speech is seen to contribute to their rank as a leader.

Smith-Lovin and Brody (1989) were also interested in successful and unsuccessful interruptions, but they explored how they were affected by gender and group composition (the ratio of males to females). In addition, they explored the affective character of interruptions (supportive, negative and neutral). In six-person student experimental groups, men interrupted women more than they interrupted men, while women interrupted men and women equally often. In other words, there was considerable gender inequality in interruptions due to men discriminating in their interruption attempts. The sex composition of the group had a complex effect on in interruption patterns: men interrupted men with supportive comments in all male groups, but these supportive interruptions decreased the more women there were in the group; supportive interruptions also succeeded in gaining the speaking turn more often in single sex groups. The reasons for this unusual gender effect are unclear, although the researchers discuss the possible roles of status and conflict dynamics.

In the lab, Ng, Brooke and Dunne (1995) also made a distinction between successful and unsuccessful interruptions in their analysis of the relationship between interruptions and perceived social influence in six newly-formed four-person discussion groups. They classified interruptions according to their function; they were either proactive (dissent, offer, request) or reactive (consent, reaction, modification). They found that group members who gained more turns by successfully interrupting others were seen as more influential. One possible reason given by the authors for this effect is that the louder and faster speech usually associated with successful interruptions may have made the interruptions more salient to group members. However, turns obtained through non-interruptive means were also significantly related to influence rankings. There was also a positive relationship between yielding to interruptions and being seen as influential, perhaps because highly influential members who interrupted others often also received many interruptions. The content of the interruption was also associated with interruption success, with dissent, offer and reply being more strongly associated with interruption success than other types.

Thus, the above studies have focused on the relationships between interruptions and gender and influence. However, interruption data can also be used to indicate other aspects of conversation. They can reveal the interactivity and formality of a conversation: generally, the lower the rate of interruptions the more formal and less interactive the dialogue. Anderson, O'Malley, Doherty-Sneddon, Langton, Newlands, Mullin, Fleming and Van der Velden (1997) suggest that social interactions are more relaxed than problem-solving discussions as shown by the relatively large amount of overlapping speech in the former. Other researchers investigating groups, such as Bales and colleagues (1951), Parker (1988) and Stasser and Taylor (1991) have not included interruptions in their analyses of group interaction.

Summary of studies using content-free dialogue analysis

The structural analyses of communication in the studies cited here have used three different units of analysis, the act (e.g. Bales *et al.,* 1951) and the 'participation', as employed by Stephen and Mishler (1952), or the speaking turn used by Parker (1988) among others. Obviously, the use of diverse methods for assessing patterns of communication could cause difficulties in comparison among results, however, the results presented here tend to converge in their findings: speaker order is quite predictable with the majority of conversation taking place between pairs of participators (e.g. Parker, 1988); some pairs participate more frequently than others (e.g. Stephan and Mishler, 1952); and there is also inequality in the amount individuals contribute (e.g. Bales *et al.*, 1951). In addition, several studies have discovered a relationship between the amount an individual contributes to group discussion and the amount of influence they have (Hoffman and Clark, 1976), or are perceived to have (Dabbs and Ruback, 1987). Dabbs and Ruback (1987), Parker (1988) and Stasser and Taylor (1991) show that attempts to try and predict patterns of turn-taking have been successful only in discovering that the next speaker can be predicted from the current one, but not in identifying why this should be so.

There are some criticisms of the research in the area of participation patterns. There has been little systematic research into how interaction patterns are affected by group size. One exception is a study by Stasser and Taylor (1991) who found that their six-person groups spent less time in two-person exchanges than Parker's (1988) four-person groups. While Dabbs' and Ruback's (1987) study is one of the few that explores the effect different types of task have on turn-taking and patterns of participation. In addition, many of the above studies of group communication have analysed only the interaction patterns, ignoring other indices of the communication process such as what was said (e.g. Stephan and Mishler, 1952; Parker, 1988; Carletta, Garrod and Fraser-Krauss, 1998). A further shortcoming is that most studies of face-to-face multiparty interaction have not used a measure of communication success along with detailed analyses of the surface structure of the dialogue. Such analyses are useful because they give an idea of how efficient communication is in achieving its goal - shorter dialogues which achieve the same outcome as longer ones are more efficient. Such a method could highlight differences in communication process and outcome due to group task, size or composition.

A model of turn-taking

Many of the studies reviewed thus far have based their analyses of group communication on the conversational unit the 'turn'. The question of how speaker turns proceed has generated debate; there have been various attempts to account for all the phenomena of turn-taking. The most influential model is that of Sacks, Schegloff, and Jefferson (1974), a 'simplest systematic' model, which was formulated to account for the structural organisation of naturally occurring conversations analysed from audio-recordings. Commonly referred to as conversational analysis (CA), this model assumes that interaction is structurally organised and that contributions to interaction are contextually oriented.

One structure discovered is the 'adjacency pair', this refers to the fact that the content of the next turn is partly constrained by expectancy about the appropriate response to the semantic content of the preceding turn (Schegloff and Sacks, 1973). This is what Schegloff and Sacks call 'adjacency pair structure'. In this way, CA also brings function into the means of analysis, however this structure only serves a function due to its sequential arrangement with other parts of talk.

The following observations led Sacks *et al.* to develop rules which determine allocation and construction of turns: in conversation there is

- continual speaker change
- a tendency for one person to talk at a time
- infrequent gaps and overlaps
- variability of turn size, turn order, turn distribution, turn content and number of participants

The rules of the model are stated in full below:

(1) For any turn, at the initial transition-relevance place of an initial turn-constructional unit:

(a) If the turn-so-far is so constructed as to involve the use of a 'current speaker selects next' technique, then the party so selected has the right and is obliged to take next turn to speak; no others have such rights or obligations, and transfer occurs at that place.

(b) If the turn-so-far is so constructed as not to involve the use of a 'current speaker selects next' technique, then self-selection for next speakership may, but need not, be instituted; first starter acquires rights to a turn, and transfer occurs at that place.

(c) If the turn-so-far is so constructed as not to involve the use of a 'current speaker selects next technique', then current speaker may, but need not continue, unless another self-selects.

(2) If, at the initial transition-relevance place of an initial turn-constructional unit, neither 1a nor 1b has operated, and following the provision of 1c, current speaker has continued, then the rule-set a-c re-applies at the next transition-relevance place, and recursively at each next transition-relevance place, until transfer is effected.

(from Sacks *et al.*, 1974, p704).

Some explanation is required: the model has two basic components: one is 'turn-constructional' units and the other is 'turn-allocational' units. The first units refer to techniques for the construction of utterances and the second to allocation of speaking turns. Turns in English may be built of different unit types - sentences clauses, phrases, and lexical constructions. The main feature of a suitable unit-type is that as a hearer, one is able to predict what type of unit has been undertaken and how and when it might be expected to end. Reflecting the existence of these unit types is the 'transition-relevance place', the first possible point at which speaker change could occur. To be allocated a turn is to be given the right to produce a turn-constructional unit (TCU). The above-described rules operate recursively upon completion of successive unit types and are said to constrain behaviour. In contrast, Clark *et al.* (Clark and Wilkes-Gibbs, 1986; Clark and Schaefer, 1987, 1989; Clark and Brennan, 1991; Wilkes-Gibbs and Clark, 1992) take the view that it is the need to establish mutual understanding, not rules of turn allocation, which shapes turn-taking, i.e., participants in a conversation will take turns when and if they have to, in order to achieve their goal of mutual understanding, known as 'grounding'. This approach will be discussed shortly.

Most of the many criticisms of CA are of Sacks *et al.*'s failure to specify how a speaker selects the next speaker, and how one recognises TCU's and transition-relevance places (Edmondson, 1981). These problems may arise as a result of having ignored the visual aspect of communication, hence the role of the listener in regulating conversation. Research by Duncan (1972), for example, showed that a variety of cues affected the hand-over of turns at transition-relevance places; linguistic, paralinguistic and visual cues all play a part in indicating when one person wants to talk and when another is willing to pass over floor control. One obvious linguistic way of selecting a person is to address them by name, e.g. 'What do you think John?' (Sacks, 1992, vol. 1). Verbal expressions such as 'so', 'you know' and 'anyway', the completion of a grammatical clause (McLaughlin, 1984), or asking a question (Sacks, 1992) are indications that the speaker is ready to hand over floor control. Paralinguistic signals, such as falling or rising intonation at the end of phrase, can perform the same function (McLaughlin, 1984). Hand gesturing, changing posture and patterns of gaze are among the visual behaviours that can indicate that someone wishes to take a turn or continue speaking (Beattie, 1980; McLaughlin, 1984). In groups with many members, attendance to such signals can be difficult as participants cannot monitor everyone effectively. Indeed, this is borne out by Steinzor's observation (1955) that in a discussion group of ten people sitting in a circle, interaction was greater between people seated in one another's line of vision, and that the next speaker was more likely to be someone opposite the current speaker than someone sitting next to her/him. Thus, speaker exchange in groups appears to be more complex than that of dyads.

There are conflicting views over the relative importance of language, paralanguage and visual behaviours in turn management (e.g. Beattie *et al.* 1979, 1980; Rosenfeld, 1987). This may reflect the effects of different discourse genres, for example.

Despite being influential, Sacks, Schegloff and Jefferson's model (1974) has many other flaws, for instance, it is culture specific; it does not distinguish turns from non-turns, such as, back channels (McLaughlin, 1984; Clark, 1994); and it does not distinguish between different kinds of conversational silence which occur, such as hesitation pauses - which occur within a turn - and switching pauses that occur between the turns of speakers (McLaughlin, 1984). The model is further criticised for its view that gaps and overlaps/interruptions disrupt 'smooth' turn-taking thus preventing 'successful conversation'. In contrast, Clark (1994) believes that although overlapping speech, interruptions and gaps are disruptive of turn-taking, they are not necessarily an obstacle to achieving mutual understanding. Since understanding one another, not smooth turn-taking, is said to be the goal of communication these disfluencies do not indicate that communication has deteriorated nor do they prevent successful communication. Indeed, overlapping speech and interruptions are considered indicative of spontaneity, not necessarily of breakdown, in a conversation (Jefferson, 1973).

Communication as a collaborative process

Clark and colleagues (Clark and Wilkes-Gibbs, 1986; Clark and Schaefer, 1987, 1989; Clark and Brennan, 1991; Wilkes-Gibbs and Clark, 1992) propose an influential model of communication. Although the model has tended to focus on dyadic interaction, it may also be applicable to multiparty communication. The basic premise is that communication is a collaborative activity and requires that information is shared by participants. Common ground is a type of shared information and has been described by Clark (1992) as '*the sum of their* [the conversational partners] *mutual knowledge, mutual beliefs and mutual suppositions*' (p3). Common ground is updated by a process called 'grounding', that is, speakers collaborate to ensure that they understand one another's utterances. The communicative partners' goal is to reach a 'grounding criterion' that they mutually believe that they have understood one another well enough for current purposes. Clark and Schaefer (1989) state that this generally involves two phases in conversation, a presentation and an acceptance phase.

> Presentation phase - A presents utterance *u* for B to consider. He does so on the assumption that, if B gives evidence *e* or stronger, he can believe that she understands what he means by *u*.
>
> Acceptance phase - B accepts utterance *u* by giving evidence *e* that she believes she understands what A means by *u*. She does so on the assumption that once A registers that evidence, he will also believe that she understands.

(Clark and Schaefer, 1989, p. 265).

In other words, a speaker presents an utterance and addressees give evidence that they have, or have not, understood. Grounding is said to be essential to communication. How grounding is affected by the constraints of different communicative contexts is discussed in chapter 2.

How does grounding proceed in group conversation? It is known from studies of two-person discourse when there was an overhearer, that addressees understand better what was said than overhearers because addressees have the opportunity for active collaboration with the speaker in order to achieve grounding (Schober and Clark 1989). The results suggest that in group conversation, grounding could be very difficult if one considers that most of the talk in groups consists of dyadic conversation which other members overhear. Although there is the opportunity to ask for clarification in a group situation, the constraints of turn-taking may prevent this from happening at the relevant moment. Furthermore, while reaching consensus or mutual understanding is relatively easy for dyads, in groups it is thought to be difficult to establish the general level of acceptance of information, agreement with a point, or understanding of all participants because it is more difficult to see and hear everyone's contributions (Carletta, Garrod and Fraser-Krauss, 1998).

Summary of research into dialogue structure

So far, a range of research has been reviewed which has tended to focus on the structure of group interaction. However, this type of 'content-free' analysis by its very nature ignores the semantics and various social and psychological aspects of conversation. Hoffman and colleagues' (Hoffman and Maier, 1967; Hoffman and Clark, 1976) studies are good examples of the importance of combining analyses of structure and content as these revealed a link that would not have been apparent from the results of content-free analysis alone, specifically that *what* was said was more influential on affecting decision-making than *how much* was said, at least for lab groups engaged in problem-solving tasks. The next section in this chapter examines research that has investigated the content of group interaction.

Analysis of dialogue content in groups

There has been little work on the meaning and function of what is said in multiparty dialogue. Empirical research into multiparty face-to-face communication which has performed some form of content analysis is scarce. Some of the few studies of this type include three studies by Bales and colleagues (Bales, 1950; Bales *et al.*, 1955; Bales and Borgatta, 1955) on unstructured groups; Kelly and McGrath's (1985) examination of factors affecting group performance; a field study of design meetings by Olson, Olson, Carter, and Storrosten (1992); and a qualitative analysis of workplace meetings by West, Garrod and Carletta (1998).

Bales (1950) developed a method of a dialogue analysis called Interaction Process Analysis (IPA) based on work with problem-solving groups. Every act of verbal and non-verbal communication between members of a group is classed into one of twelve categories which combine into four major types:

- questions- asking for orientation, opinion and suggestion
- problem-solving - giving orientation, opinion and suggestion

- positive reactions - showing agreement, tension release and solidarity
- negative reactions - showing disagreement, tension and antagonism

Discourse is divided into 'acts' or units
'*the unit to be scored is the smallest discriminable segment of verbal or non-verbal behaviour to which the observer [...] can assign a classification*' (Bales, 1950, p37), that is to say, a meaningful expression, a simple sentence, a laugh or a nod. Who performs the act and to whom it is directed are recorded.

Empirical studies of dialogue content

IPA has been used subsequently to examine group problem-solving discussions, mainly by Bales and his colleagues (Bales, 1955; Bales and Borgatta, 1955). Bales (1955), using his IPA method, observed unstructured newly-formed groups of two to seven people over four sessions in the laboratory. Social interaction was classified according to the afore-mentioned categories. More than half of the acts in a group session were problem-solving attempts and 46% of acts were questions and reactions. Thus it can be seen that action tended to oscillate between the problem-solving attempts of one person and the reactions of someone else.

Bales relates the distribution through time of the categories to the decision-making process: giving information happens most often at the outset of the meeting, most opinions are given during the middle section of the meeting, in the later stages of a meeting giving information decreases while suggestions and positive and negative reactions increase. Once a decision has been reached negative reactions usually reduce and positive ones rise. These are seen as steps in a chain leading to consensus over a solution. The ratio of negative to positive reactions tends to be higher in response to suggestions than in response to factual statements. These objective content analyses were related to participants' subjective evaluations. Individuals who had higher than average rates of giving suggestions and opinions and who talked the most were rated by the group as having the best ideas, while the best-liked individual was usually the second or third most talkative member.

Bales and Borgatta (1955), using the same IPA method, analysed the effect of group size on the dialogue content of unstructured experimental groups over four sessions. For groups from sizes three to seven, groups with even numbers of members showed high disagreement and antagonism and were low in asking for suggestions. The authors postulate that even numbers can split into two equal parts therefore there will be times when there is no majority so arriving at a decision takes longer. When the group increases from size three to size seven, showing tension release and giving suggestions showed large increases, showing solidarity showed a smaller increment. Showing tension decreased a lot and agreements decreased somewhat with increase in group size. Most of the trends found are attributed by the researchers to two main factors: 1) each person has less talking time as group size increases; 2) as size increases there are more people with whom to interact and relatively less time to do so (Bales and Borgatta, 1955).

Trends over the four sessions showed that with increasing group size there was a modest increase in solidarity and a large increase in tension release. The latter is probably an artefact of the method of attributing group laughter to every group member separately. It must be borne in mind that the results are based on only four groups of each size, therefore caution must be exercised when generalising from these findings. Furthermore, Borgatta and Bales (1953b) in their paper discussing the reliability of the IPA test admit that 'few data have been produced in this area' and those which exist are on very small samples sizes thus casting reasonable doubt on the reliability and validity of this method. It appears that the way in which discussions were divided into units or acts was purely subjective and not necessarily meaningful. Nonetheless, Bales' work has been very influential in subsequent investigations of communication content.

Kelly and McGrath (1985) performed a type of content analysis adapted from Bales (1950) IPA and related this to objective measures of group performance. A time sampling method was used to record interaction content of ad hoc four-person student groups during production, problem-solving and planning tasks. This involved observers recording a code for each comment that was made on the tenth second of each 10 second interval. Each observed comment was coded into one of eight categories adapted from Bales (1950): answer, question, agree, disagree, positive interpersonal, negative interpersonal, neutral, and silence. Hence, a sample of the groups' comments formed the basis of the analysis.

The main aim of the study was to examine the effects of task type and time limits on group performance and interaction. Groups took part in two tasks both of the same task type within two time limits, either 10 minutes then 20 minutes, or 20 minutes then 10 minutes. Kelly and McGrath found that these time and task manipulations affected the content of interactions. When the first trial was longer (20 minutes) a greater proportion of time was taken on agreement, disagreement and positive and negative interpersonal behaviours than groups who participated in the shorter 10 minute trial first (between groups comparison). Greater proportions of time spent on these categories of interaction was related to better performance, as judged by creativity and originality. The authors suggest that better performance is related to more interpersonal activity between group members. Those working within a tighter time limit also experienced more stress, were less satisfied with the solution and found the task more difficult which Kelly and McGrath believe also may have been related to lack of interpersonal activity. Between group analysis revealed that the content of interaction becomes set - aspects of the first trial 'entrained' people to interact in a certain way in the second trial even when this was counterproductive. The authors accept that the concept of 'entrainment' is more descriptive than explanatory.

Olson *et al.* (1992) observed ten design meetings of between three and ten people in two organisations. They recorded what proportion of discussion time was spent on various activities and identified eleven different categories of talk which they analysed in various ways. They also looked at what kinds of activities followed one another. In general, the meetings were very similar in allotment of time. The one dimension along which they did vary was in the amount of time spent on project management. This took around 13% of each meeting and this varied with meeting size, due mainly to the preponderance of project management in one group of seven. Problem-solving was split into three categories: Issue - the major problems of the designed object to be addressed; Alternative - solutions or proposals about aspects of the designed object; and Criterion - the reasons, arguments or opinions that evaluate an alternative solution or proposal. Only 40% of the time was spent on direct discussions of design, and hence on problem-solving. Clarification of ideas (a cross-cutting category) took up one third of the time and half of clarification time was taken up by issue, alternative and criterion. 30% of talk was taking stock of progress, and 20% on pure co-ordination activities, defined as meeting-management and its clarification. Examination of the transitions between topics shows that alternative and criteria, or problem-solving, were responsible for two thirds of transitions in only a little more than a third of the time. Interestingly, they found that groups through sizes three to ten participants allocated their time in very similar ways according to the content categories investigated.

The purpose of the Olson *et al* study was to aid development of IT tools to support group work by providing detailed information about how groups work, therefore non-verbal signals were not examined and there was no detailed analysis of the functions of individuals' utterances. Neither was there a measure of the success of interactions, either subjective or objective, therefore it is not possible to say how the meeting content related to its effectiveness.

West *et al.* (1998) have distinguished between good and bad work place decision-making teams on the basis of the amount of time they spend upon management of problem-solving, referred to as 'group task reflexivity'. Non-reflexive groups fail to discuss objectives and strategies and do not forward plan, whereas reflexive groups do all of these things and anticipate errors. They illustrate their arguments with a qualitative analysis of the content of facilitated workplace meetings, maintaining that facilitation can help to overcome communication constraints that discourage reflexive action. The two constraints on decision-making, which are related to the interaction content, are relevance of contributions and group consensus. They maintain that due to the difficulties of co-ordination of turns in groups, people are not always able to make a relevant response at an apposite moment simply because someone else takes the next turn. Whether this was an appropriate shift or not, the following contributions are expected to be relevant to this one making it difficult to return to an earlier point without it losing its salience. A professional facilitator should ensure that those with potentially relevant contributions are given the opportunity to make a timely contribution. Consensus can constrain decision-making since the ways in which people indicate their agreement, such as nodding, eye contact and back channel responses, is somewhat limited; these behaviours can be difficult to observe in all group members.

Summary of studies of dialogue content

As these researchers investigated group processes for the specific purposes of their studies, different tasks, different types of group and different coding schemes for content analysis were used which renders comparison between results somewhat difficult. Nonetheless, there were some common findings: rates of problem solving were found to be similar in two of the studies even though Bales' (1955) groups were non-established discussion groups whereas Olson *et al.*'s (1992) groups were established design teams. It can be seen that rates of problem-solving attempts did not account for the majority of the discussion time in both studies which is surprising considering that was the main purpose of the tasks.

Analysis of dialogue content is necessary because words have meanings and are said for a reason - conversation is not merely an exercise in turn-taking. It appears that few very detailed content analyses have been undertaken on group discourse as they have been for two-party discourse (e.g. Carletta, Isard, Isard, Kowtko, Doherty-Sneddon and Anderson, 1995; Anderson *et al.*, 1996; Doherty-Sneddon, Anderson, O'Malley, Langton, Garrod and Bruce, 1997). Furthermore, the categories used for group interaction do not code all of the dialogue or do not code every utterance by function because they do not have sufficient categories to cover every utterance, thereby losing some of their data. Olson *et al.* (1992) provide for such an eventuality by using an 'other' category but cannot analyse these data meaningfully. Kelly and McGrath (1985) coded by time interval so lost approximately a tenth of the dialogue, and inter-rater reliability was low for two of their categories, disagreements and negative interpersonal comments. Coding of every utterance, although time-consuming and labour intensive even for two-person dialogues, is a superior method in that no information is lost, and dialogues from different types of meetings, and various sizes and sorts of groups may be reliably compared to see if they are structured differently. Perhaps these methods were not necessary or suitable for the purpose of the study, e.g. in Olson *et al.*'s (1992) study, nonetheless, if no data are discarded then the possibility remains of performing different analyses on them in the future. Kelly and McGrath's (1985) research shows the usefulness of having a measure of performance: aspects of communication content can then be related to communication success.

Paralanguage

Another potentially relevant feature of communication is paralanguage. Unfortunately, few studies on group interaction have explored this phenomenon. Paralanguage, or 'non-verbal, vocal messages' (Adler, Rosenfeld and Towne, 1995, p204), is the term used to describe the expressive qualities of language at a physical level. This includes rate, pitch, tone, volume, and disfluencies, e.g. stammering, which can give the same words many meanings. A rising pitch at the end of a phrase can indicate a question is being asked; pauses and other aspects of timing show syntax; loudness can give emphasis. Paralanguage also conveys emotional information (Fussell and Benimoff, 1995) and plays a role in turn-taking (McLaughlin, 1984).

There does not appear to have been much interest in paralanguage in group conversation. It is nevertheless potentially an important aspect of communication as paralinguistic cues have been shown to indicate the emotion of a speaker and the strength of that emotion (e.g. Knapp and Hall, 1992); their attitude; and can override conflicting information in the verbal message, such as when a sarcastic tone of voice is used to convey the opposite meaning of the words. Some analysis of paralanguage has been performed by Dabbs and Ruback (1987) who report that the people who the group members say led the group, pause less in the middle of their turns than other people. Why this should have an affect on leadership ratings is not explored.

Summary of linguistic communication research

It is often difficult to compare studies due to their differing methodologies; some studies of verbal communication investigate ad hoc groups and others established groups, different tasks have been used, and some studies have looked at structured and others unstructured groups. Few studies have combined content and structural analyses to give a holistic picture of multiparty communication, while only studies employing Interactional Process Analysis have included non-verbal communication in their analyses (Bales, 1950; Bales *et al.*, 1951). Furthermore, there have been few studies that employ measures of the outcome of multiparty communication, one exception is Kelly and McGrath (1985). These are important as they allow us to assess the success of the interaction. In defence of some of the investigators (e.g. Olson *et al.*, 1992), it is not always easy to establish a mutual goal to use as an objective measure of communicative success in real life group tasks, subjective impressions could however be useful.

1.2 Non-linguistic Communication

The above section has reviewed the literature in the area of linguistic communication. The other major area which has been explored is that of non-linguistic communication. This refers to visible cues both in the environment and in human behaviour which communicate information to those present. There are various non-verbal behaviours that play a role in communication:

posture[2] refers to the inclination and orientation of the body.

gaze is the behaviour of looking at someone or something.

mutual gaze is when two people make eye contact with one another.

facial expression is the complex set of patterns and configurations made up by the eyes, eyebrows, nose and mouth.

gesture[2] includes the movements and shapes formed by the hands and arms during interaction.

(as defined by Acker and Levitt, 1987).

touch refers to physical human contact e.g. a handshake

Non-linguistic cues which exist in the environment include:

seating/spatial arrangement of participants - the arrangement of people around a table or in a room.

people- the presence of other people can be inferred from their visibility, and information from their physical appearance is available (Whittaker and O'Conaill, 1997).

objects and events - information about objects and events in the participants' shared environment and their spatial configuration is used in communication (Whittaker and O'Conaill, 1997).

Non-verbal behaviour

Visual cues are considered to be important to communication, more so in 'social' tasks, such as negotiation or bargaining, than in problem-solving tasks (Short, Williams and

Christie, 1976). They perform a wide variety of functions and herein lies their importance. Eye contact, for instance, plays a part in turn-taking: gaze helps to regulate speaker exchanges by helping the listener to judge if the speaker is ready to yield the floor, and indicates to the speaker that the listener is willing to take a turn (Acker and Levitt, 1987). A speaker wishing to hold the floor at a pause point looks away from the interlocutor, who may gesture (Short *et al.*, 1976), shift posture (Argyle, 1988) or gaze at the speaker when he or she wishes to talk. In addition, it has been observed that people look away as they start to speak and give a sustained gaze upon finishing, although are unaware of doing this (Short *et al.*, 1976); Beattie (1981) interpreted this as a reflection of the speaker's cognitive effort and concentration in forming their message. This pattern of gaze can act as a cue to the timing of floor hand-over.

Gaze also reflects status differentiation: when talking to a lower status person, a high status individual looks just as much when speaking and listening (Exline, Ellyson and Long, 1975), yet between female dyads who are peers, 60% of looking occurs while listening but only 40% takes place while speaking (Ellyson, Dovidio, Corson and Vinicur, 1980), therefore, looking may also be being used to establish dominance of one party over another. Indeed, one of the very few studies on patterns of gaze in groups discovered that people who 'out glance' peers in the first meeting become 'influential high participators' when they work with those partners in a three-person Bales-type discussion group (Rosa and Mazur, 1979). The authors suggest that gaze plays a role in the formation of status differences. While in a study of gazing in triads, Kalma (1992) found evidence that appointed and emergent leaders were more likely than other participants to show a 'prolonged gaze' (an uninterrupted gaze of one second or more) at the end of an utterance and that the receiver of the gaze took over the floor 70% of the time.

In conversation, gaze is a general indicator of mutual attention and responsiveness: it can be used to monitor the addressee to see when clarification is needed, or to check if the listener dissents or approves of a proposal (Whittaker and O'Conaill, 1997). Thus it also has a regulatory function in communication, as does posture: agreement in an interlocutor is accompanied by leaning to the side, whereas folded arms, legs crossed tightly above knee and the head supported in one hand reflect disagreement (Argyle, 1988). Carletta, Garrod and Fraser-Krauss (1998) maintain that difficulties in speaker co-ordination in groups arise due to the more limited ability of participants to monitor effectively the non-verbal behaviour of all group members in comparison to dyadic interactions.

Not only is gaze used to monitor other people but it is also used to make evaluative judgements about them: based on a person's pattern of eye gaze they are labelled friendly, sincere, or trustworthy. However, frequent eye contact alone may not be sufficient to lead to positive evaluations of individuals, it may need to be combined with positive verbal content (Ellsworth and Carlsmith, 1968). Furthermore, extended gaze has been found to occur when a speaker is being more persuasive or deceptive (Kleck and Nuessle, 1968).

In addition, eye contact is involved in relationship formation, for example, a person will look more if she or he wants to establish a closer relationship (Short *et al.*, 1976) and eye contact (mutual gaze) can increase intimacy (Whittaker and O'Conaill, 1997). Short, Williams and Christie (1976) define 'social presence' as 'the degree of salience of the other person in the interaction and the consequent salience of interpersonal relationships' (p65). This concept is discussed further in the next chapter.

Posture too can convey interpersonal attitudes, such as dominance and status, liking, attraction, and rapport. Symmetry of posture between interactors is thought to be a sign of good rapport or an attempt to improve poor rapport (Argyle, 1988). One study of body movements in a six-person group by McDowall (1978) found no evidence of synchrony of movement among participants but did not look at possible time-lag effects. Such judgements of group participants' personalities and attitudes will obviously affect the way people interact in a positive or negative way.

Visible behaviours can also convey a person's emotions and mood, of which the best indicator is facial expression. Posture is useful too, if less dynamic: interest is signalled by a forward lean and by drawing back the legs; boredom is communicated by a lowered head, the head supported on one hand, leaning back, outstretched legs, or by turning the head away. Body stance also shows relaxation and tension, can be an extension of gesture, and may convey personality to some extent (Argyle, 1988). There is great cross-cultural agreement over the meaning of different facial expressions, but not over the meaning of postures (although there is a limited repertoire of postures in every culture), so in multicultural groups interpretation of facial expression must be carried out cautiously (Argyle, 1988).

In addition to eye contact, touch and proximity are regulators of intimacy. There is an optimal distance between people at which they consider one another friendly and sensitive, this is at approximately 4 ½ feet apart. Closer than this is reserved for family and partners, otherwise it is seen as threatening. 'Social distance' (i.e. for formal business interactions) is thought to be between 4 to 12 feet and 'public distance' (i.e. the distance kept from important public people) is from 12 to 25 feet (in Western societies) (Argyle, 1988). The most basic meaning of touch is the offer or establishment of an interpersonal bond. There are two main dimensions of meaning: warmth and dominance. In group encounters, the most obvious use of touch is when people greet with a handshake, at least in Western society. Touch is not a very clear channel of communication even within cultures, but there are also big cultural differences (Argyle, 1988).

It is important to note that non-linguistic cues interact with verbal communication: for example they can clarify a speaker's message such as when facial expression reveals when someone is being ironic, and hand and arm movements can be used for illustration or emphasis (Acker and Levitt, 1987). Behaviours known as emblems can substitute for utterances, for instance, head nods can replace 'yes'.

Non-verbal cues in the environment

People communicate unconsciously through other kinds of non-verbal cues such as their physical appearance. Initial judgements of people are made entirely on this basis. Individuals who stand out from the group are more memorable and often judged as more influential or important in a group of people of equal status (Short *et al.*, 1976).

Clothing is one obvious aspect of physical appearance. Research performed several decades ago (Gibbins, 1969; Sissons, 1971) identifies a whole range of messages that clothing communicates, from educational background to moral character. However, it is probable that a current day replication of these studies would not repeat their findings since we dress more homogeneously today, regardless of social class and background. Yet, it is maintained that clothing is still a clue to a person's status (Argyle, 1988; Adler, Rosenfeld and Towne, 1995). It is nevertheless known that judgements based upon first appearances are short-lived and change with further acquaintance (Short *et al.*, 1976).

The shared physical location in which communication takes place including the setting, objects and people therein, is considered to be part of the communicators' common ground (Fussell and Benimoff, 1995). Objects, e.g. a document, can be manipulated or modified and people can gesture at or orient towards aspects of the environment. One such visual cue in the environment is seating position. The physical arrangement of group members determines to a significant degree the flow of communication and interaction in the group, the status assigned to group members and emergence of leaders. It has been observed that a circular seating arrangement encourages more participation in students (McKenna 1987), while people who are in your direct line of view are judged as playing a more central role in discussion, to contribute more often and make better points than others who speak equally often and make equally valid contributions (Shaw, 1971). Generally, a high status person occupies the best position and the person who occupies a better position is seen as high in status. At a rectangular table, the high status position is the head of table; when the table is square, status differences are communicated by greater distance between higher and lower status individuals, with people tending to place distance between themselves and those of both higher and lower status (Lott and Sommer, 1967). The importance of seating patterns is reflected in seating preferences at a rectangular table: for casual conversation corner to corner and face-to-face arrangements are preferred; co-operative tasks are carried out side-by-side; while two people in competition sit face-to-face or at opposite ends of the table (Shaw, 1971). Moreover, communicators use this information about where people are located when speaking and listening: speakers frequently direct their eye-gaze to particular individuals, often as an indication of whom they are addressing and who they expect to respond to an utterance (e.g. Argyle and Cook, 1976). Gestures are also used to designate a certain person (Fussell and Benimoff, 1995). In these ways, cues in the environment are interacting with behaviours to aid grounding (Short *et al.* 1976).

Summary of non-linguistic communication research

Thus it is apparent that the non-linguistic channel is a very rich source of information about those with whom we interact. Non-verbal cues in people's behaviour and in the environment add to the information available in the verbal channel. Nonetheless, some of the information in the visual channel is also available in the audio channel from cues such as tone of voice, choice of words, pausing behaviour and so on (Short, Williams, and Christie, 1976). Research is needed that integrates non-verbal communication analysis with the linguistic processes of communication since the two cannot necessarily be usefully separated (Boyle *et al.*, 1994); one affects the meaning of the other. Non-verbal signals can interact with signals in both verbal and non-verbal channels to alter or expand upon the whole message (Birdwhistell, 1952).

1.3 Summary of review

This chapter has reviewed the research into various aspects of face-to-face group communication, concentrating on studies that have examined verbal and non-verbal interaction. Most of these appear to have focused on the structure of multiparty communication in terms of turn-taking behaviour and patterns of speaker participation, while fewer have investigated the use of non-verbal cues in groups and the content of dialogue. Much of the research about groups which does exist concentrates on only one aspect of communication such as the patterns of interaction. A more holistic approach is desirable in order to give a more realistic picture of the complexity of multiparty communication, perhaps working towards a common way of coding the different aspects of human multiparty communication.

One of the major issues being investigated in this thesis is how group collaboration is achieved when speakers no longer communicate face-to-face but do so by technological-mediation; specifically, the multimedia communication contexts of video-mediated communication (VMC) and audio conferencing will be explored. These modes of communication and what is known of their impact on human interaction will be discussed in detail in the next chapter.

---

[1] Back channels are short feedback utterances from the addressee, such as *mhm, uhuh, OK.*

[2] Gesture, posture and other forms of body movements are grouped under the general heading of kinesic cues.

2 Chapter 2. The Effects Of Multimedia Technology On Human Communication.

2.1 Introduction

In chapter 1, the literature on group communication was reviewed revealing that face-to-face communication between three or more individuals poses challenges compared to dyadic communication for achieving mutual understanding between speakers. There are a variety of different media for communication other than being co-present, perhaps the most widespread being the telephone. Other types of communications technology are being used now, such as multimedia video and audio conferencing technology, which provide a richer medium than the telephone. This chapter will review research investigating the impact of multimedia technology on the communication of both dyads and groups.

Advances in multimedia telecommunications technologies have progressed at an incredible pace determined largely by what has been technically feasible rather than by their suitability for supporting human communication. More recently researchers have tried to redress the balance by investigating the impact of these technologies on human interaction and collaboration. This critique pulls together evidence from around fifty such studies and research reviews.

'Multimedia' in this context refers to communication systems that incorporate more than one medium for communication - this may include any combination of audio, video and data. No mention will be made in this review of studies focusing solely on text-based communication technologies such as electronic mail. The use of multimedia for presentation purposes, such as found on CD-ROM's and the Internet, is also excluded despite the huge literature in this area.

2.2 *Types of communication systems*

Video-mediated communication (VMC) systems

In face-to-face interaction participants are co-present (in the same room or space) with no technological mediation of communication. In contrast, video communication is achieved via a video and audio link between two or more sometimes remote sites. There are a number of different types of systems including video telephones, desktop video conferencing, group systems and media spaces and special purpose systems.

Video telephones

The video telephone simply adds a video image to the audio connection provided by the telephone.

Group systems

These can be specialised rooms equipped with several cameras and monitors for business meetings between remote sites or a new type of mobile system with integrated camera and monitor on a trolley. These systems usually provide a much better quality image than videophones and are much more expensive than an ordinary phone call (Angiolillo, Blanchard, Israelski and Mane, 1997).

Desktop video conferencing (DVC) facility

Such systems use a single computer, such as a PC, with a video card, a camera and telephone/ microphone; the video image usually occupies a small 'window' on the computer terminal. There is the possibility of simultaneously sharing data either by transferring files or images or by sharing an application and working on it jointly. Such facilities can be two- or multi-party connections. The audio and video links can be of variable quality depending on bandwidth[1] restrictions.

[1] Bandwidth is the measure of the amount of information that can be transmitted across a communications system at once.

Media spaces and special purpose systems

These are VMC systems some of which create a virtual meeting room for distant locations that gives a sense of co-presence with people at the other location (e.g. Fish, Kraut, Root and Rice, 1993), while others link remote locations, such as offices, by means of an open video connection to allow colleagues to interact (e.g. Heath and Luff, 1992). Most are designed for specific business needs (Angiolillo *et al.*, 1997).

VMC systems and eye contact

Some VMC systems enable eye contact, others do not. To truly preserve eye contact participants must look directly into the camera but eye contact is compromised when you must also look at the video image of the other person or at the computer screen. The most typical placement of the camera is above the screen, this is better than below the screen which gives an unflattering shot, or to the side which can make someone appear untrustworthy (Angiolillo *et al.*, 1997).

Two systems that support eye contact for two-party interaction only are 'Gazecam' (Acker and Levitt, 1987) and the 'videotunnel' (see O'Malley, Langton, Anderson, Doherty-Sneddon and Bruce,1996; Smith, O'Shea, O'Malley, Scanlon and Taylor, 1996; Doherty-Sneddon *et al.*, 1997). The 'videotunnel' consists of two rooms linked by audio and video, each contains a small colour television monitor mounted behind a half-silvered mirror; a second fully-silvered mirror is fixed below the half-silvered one so that light reflected from the first mirror hits off the second one and passes to a video camcorder beneath the monitor. The camera is placed so that subjects appear to have eye contact with each other when looking at the image of their partner on the monitor. The 'Gazecam' (Acker and Levitt, 1987) system uses a similar arrangement, except that there are three cameras in each room thus giving a variety of views of each participant. The choice of image from the different cameras is handled in an external switching booth.

Video-mediated group communication

Multiparty communication presents unique problems to the design of a video system which in turn can have an effect upon communication. Some systems are explicitly designed for meetings in which there are more than two people communicating; some are still restricted to only two locations but can have several people at each one.

The presentation of the video images for multiparty communication presents a challenge. Angiolillo *et al.* (1997) identify two basic solutions - split-screen multiple 'windows' or image switching; the former presents visual images from up to four other locations on one screen split into quadrants, hence such a system can support communication between up to five locations. PIP (picture-in-a-picture) (Sellen, 1995) is one such system. The second solution, image switching, involves a single image being selected and transmitted to each participant at any moment; this can be achieved in various ways. Manual switching between images, called 'chair control', is one option: the chairman chooses and displays the active speaking site on a full monitor, other sites are shown using a picture-in-a-picture format. LIVE-NET operates like this when there are more than four sites participating (O'Conaill, Whittaker and Wilbur, 1993). Problems with this chair control type of switching is that one person must concentrate on doing this rather than on the meeting and that the others may not like the choice of image. If switching is automatic this is often 'voice-activated switching': all endpoints receive the image of the person currently speaking (or speaking loudest) and the speaker sees the last person to speak (LiveWire operates in this way - Sellen, 1995). The problem with voice-switching is that it occurs even when inappropriate, for instance, when someone coughs or merely confirms understanding; furthermore, the person talking loudest does not necessarily have the most relevant contribution. The alternative is the broadcasting of a single source in a lecture-style presentation: all locations see the main speaker and the speaker can view points that have comments.

Hydra (Sellen, 1992; Sellen, 1995) provides a different solution: it simulates a four-way round table meeting, using multiple cameras, monitors and speakers. All participants are simultaneously visually available on separate Hydra units each consisting of a video monitor, a camera and a loudspeaker. These are set out on a table in front of each remote participant.

Forms of audio transmission

There are also different methods of audio transmission between sites. Transmission can be full- or half-duplex and there can be one or several audio channels. Full-duplex audio allows the complete and simultaneous transmission of all audio communications from all locations; this is the most natural way to talk over video systems. Systems providing this are PIP, Hydra and LiveWire (Sellen, 1995). In contrast, half-duplex audio allows only one side of the audio conversation to be heard at one time leading to stilted audio transmission; only one person can talk at a time and they must stick to strict turn-taking rules. An example is video running over ISDN (integrated services digital network) lines (O'Conaill *et al.,* 1993).

With multi-channel audio, voices appear to emanate from specific locations (e.g. Hydra, Sellen, 1995); this is advantageous in group communication as it enables selective listening and side and parallel conversations. When there is a single shared audio channel, sound is not directional therefore these conversational behaviours are not possible. A single channel is nonetheless sufficient for two-person conversation since behaviours such as selective listening cannot occur when there are less than four people communicating.

Audio conferencing

Audio conferencing can be similar to desktop video conferencing without the video capability: two or more participants can communicate through a computer either via a hand held audio system (phone) or a hands-free microphone and speaker.

Again data can be shared and audio quality varies depending on the system. However, multiparty telephone calls are also referred to as audio conferences.

2.3 Methodologies used in empirical studies comparing communication media

Video-mediated communication was presumed to be an improvement on audio-only interaction, such as telephone conversations, due to the importance of the visual channel to face-to-face communication. Visual cues can indicate the emotions, social status (Kiesler, Zubrow, Moses and Geller, 1984), attention and comprehension of others; can help to regulate speaker exchange (turn-taking); substitute for verbal information; resolve ambiguities in the speaker's message (Acker & Levitt, 1987); as well as providing information about the environment (Whittaker and O'Conaill, 1997). However, much of the information in the visual channel is also available in the audio channel from cues such intonation, choice of vocabulary, pauses and so on (Short, Williams, & Christie, 1976). All of these uses of the visual channel are discussed in more detail in the preceding chapter.

Many studies have tried to capture why it is that face-to-face communication is generally so successful, whether VMC can replicate this and how both face-to-face and VMC interaction differ from audio-only communication. Is VMC better than audio-only? Is it equivalent to co-presence? The variety of research is huge. Studies differ on many aspects: communicative task; number of participants; video system employed; type of group (ad hoc versus existing groups); evaluation data used, such as objective and subjective measures of communication; and whether studies are laboratory- or field-based. With such heterogeneity of research it can be confusing trying to make sense of the sometimes contradictory findings.

Laboratory-based research, although artificial, allows for the manipulation of a wide range of parameters and for tight control of extraneous factors in order to establish causal relationships between type of media and aspects of communication. Field studies, on the other hand, have the advantage of a real-world setting and studying actual communication tasks, usually between people who form part of an existing work group. The disadvantage is that it can be hard to infer causal relationships due to the many other factors which can affect communication. Field studies have tended to focus on group communication, unlike laboratory studies which have tended to concentrate on dyadic interaction.

For the most part, studies using a variety of different methodologies have relied on comparisons between face-to-face conversation and that which is technologically mediated. In this way differences and similarities are revealed which allow us to draw certain conclusions about the effects of telecommunications on human interaction. For instance, objective measures of dialogue structure have been used to compare the communication processes in different communicative media. Such measures include number of words spoken and turns taken by participants (i.e. the length of the conversation) which can indicate the amount of verbal effort expended; the length of speaker turns with longer speaker turns indicating a less interactive discussion; and the number and rate of interruptions and the amount of simultaneous talk which are thought to show the formality and spontaneity of an interaction. Although they have been interpreted otherwise by different researchers, a popular view is that a relatively large amount of overlapping speech indicates a more relaxed, spontaneous interaction (O'Conaill *et al*, 1993; Boyle *et al.*, 1994; Sellen, 1995; Anderson *et al.*, 1997). However, interpretation of speaker interruptions is problematic; many interruptions are variously said to reflect disrupted turn-taking or informality of communication style within the same communicative task (Anderson *et al.* 1997; Boyle, Anderson and Newlands, 1994), and between tasks (O'Conaill, Whittaker and Wilbur, 1993). Anderson *et al.* (1997) suggest that interruptions may reflect different aspects of communication in different tasks, for instance, it may be more important to avoid interruptions that could obscure important information in problem-solving tasks. They warn that indices of interruptions and overlapping speech are vulnerable to the type of transcription and coding tools employed and that this may cause difficulties in making comparisons across studies. Instead, they recommend that such data be related to more robust measures of process and outcome of communication when drawing conclusions. Information about conversational structure in combination with objective indices of communication outcome or success, such as user performance measures, can give an indication of communicative efficiency: for a certain level of performance a shorter conversation said to be more efficient (Boyle *et al.*, 1994).

Furthermore, the actual meaning and function of what is said - the content of the dialogue - can also be analysed and there are various ways of doing this. Utterances can be classified or coded according to their function, e.g., was it a question, an opinion, a response; or the percentage of talk concentrating on different purposes, such as problem-solving, clarification and so on, can be calculated (refer to chapter 1 for examples of analyses of the content of face-to-face group communication). Analysing the content can give an idea of the differences between mediated and co-present conversations in terms of the relevance of the contributions and how people reach decisions, mutual understanding and consensus.

In addition, questionnaires and interviews asking users for their opinions and perceptions of the communication process, the task outcome and the technology can reveal subtle differences between media that are not always exposed by objective behavioural measures, or that give further support to objective analyses.

The most informative method of investigating the impact of communication technologies on human interaction 'triangulates' or employs a range of objective and subjective measures of communication process and outcome, as recommended by various researchers including Monk, McCarthy, Watts and Daly-Jones (1996). For instance, in order to make judgements about the relative efficacy and efficiency of communication media, the success of the communication outcome must be combined with an index of the communication process, such as amount of verbal effort or length of interaction. Some research has tried to form such a holistic picture of technology-mediated communication by combining various methods of communication analysis, other research has a narrower, less well-balanced approach, focusing solely on, for example, subjective indices of communication.

2.4 *Laboratory studies of face-to-face and technology-mediated two-party communication*

The Map Task

A series of laboratory studies on video-mediated communication, which employed many of the different forms of analyses above, has been based upon and compared to an original study by Boyle, Anderson and Newlands (1994) which compared communication in dialogues taken from the HCRC Map Task corpus when visual information was and was not available. This study established operational definitions of many speech characteristics which have been used as a basis for analysis in subsequent studies in the series.

Boyle *et al.* compared face-to-face and audio-only (co-present) communication during a collaborative problem-solving task, the 'Map Task'. This task was designed to elicit relatively unconstrained and spontaneous dialogue from a pair of subjects. It involves one member of a pair, the information giver (IG), conveying information about a route on a map to his/her partner, the instruction follower (IF), who then has to draw the route onto his /her map as accurately as possible. To introduce some difficulties the landmarks on the two maps differ. This task allows an objective measure of task success: the area of deviation between the two routes is measured in square centimetres to give the accuracy of the route.

Boyle *et al.* analysed measures of speaker co-ordination and dialogue efficiency. Dialogue efficiency was ascertained by combining the results of task performance and the length of the dialogue (in numbers of turns and words). For a given level of performance on a task, a short dialogue is more efficient at transferring information than a longer dialogue. Co-ordination, or the management of turn-taking, was established by calculating the number and rate of interruptions and back channel responses, and the amount of overlapping speech. The more incidences of these characteristics of conversation, the less smooth the turn-taking is said to be. Overlapping speech was said to occur when one or more words of different speakers overlapped. Interruptions, which are always contained within overlapping speech, are when one person begins to speak while another is already talking. Overlaps can occur independently of interruptions although they rarely do. The number and rate of interruptions (percentage of turns containing an interruption) and episodes of overlapping speech and number and rate of back channels were counted. Back channels signal agreement, attention or understanding (while an interruption is usually used to indicate misunderstanding or lack of agreement). These were operationalised as a turn which consisted of 'uhuh' or 'mhm' standing alone or repeated. The number of turns and number of words per turn were also calculated with all utterances, even very small ones, being defined as turns.

The results of Boyle *et al*'s experiment demonstrate that visual access to ones conversational partner improves information transfer and the management of turn-taking in this task. That is to say, face-to-face communication led to shorter dialogues for the same level of performance as audio-only communication, with a lower rate of interruptions, less overlapping speech and fewer back channels.

Subsequently, O'Malley and Langton (1994a) wanted to make a direct comparison with Boyle *et al.*'s study but where face-to-face communication was mediated by video technology. They first verified that their computer-based version of the Map Task was equivalent to the paper-and-pencil version employed by Boyle *et al.* In the paper-and-pencil version, the maps were presented on and hand-drawn onto A3 paper; in the technology-based experiments, the map was seen on-screen and the route was drawn onto the computer screen by clicks on a mouse button. The authors claim that the results of the computer-mediated Map Task overall were consistent with the paper-and-pencil version of Boyle *et al.* (1994) and show the same benefits of face-to-face interaction. There are some inconsistencies[2] and a lack of detailed reporting of results, however, the evidence provided by O'Malley

[2] In Boyle *et al.*'s (1994) experiment the visibility condition had a significantly lower number and rate of interruptions than the no visibility condition, whereas O'Malley and Langton (1994a) found the same two conditions to have equal amounts of interruptions. Hence, the interruption data should be interpreted with caution when comparing the face-to-face and video conditions of the subsequent study by Doherty-Sneddon *et al.* (1997).

and Langton (1994a) appears to be generally supportive of their claim; the face-to-face advantage appears to be replicated by video-mediation in the computer version of the Map Task.

The second part of O'Malley and Langton's study (also reported in Doherty-Sneddon *et al.*, 1997) was intended to address whether the benefits of face-to-face over audio communication found in Boyle *et al.*'s (1994) experiment hold for VMC, and also to discover whether eye contact is important for communication. Each pair of subjects performed three tasks one in each of three conditions: high quality video with eye contact; high quality video without eye contact; and audio-only (video conditions used 'video tunnels' and full-duplex audio). Video communication without eye contact was more efficient than VMC with eye contact but was not as efficient as face-to-face communication; it was more similar to audio-only communication on this measure. Surprisingly, communication via video that allowed eye contact was less efficient (it had longer dialogues for equivalent performance), less interactive (it had longer speaker turns) and speakers interrupted each other more often relative to communication in audio-only and video without eye contact conditions. In contrast, Boyle and colleagues (1994) had found that face-to-face communication was more efficient than audio-only communication. Therefore O'Malley and Langton concluded that subjects communicated less efficiently via video when they could make eye contact than in face-to-face communication compared to audio-only interactions. It also appears that VMC led to less efficient management of turn-taking than did face-to-face interaction; this is shown by the higher frequency of interruptions in VMC which allowed eye contact versus the lower number of interruptions in the face-to-face conditions compared to the no visibility conditions.

From these results we know that VMC affects conversational patterns in Map Task dialogues, but how does it alter the content of video-mediated and face-to-face dialogues? Doherty-Sneddon *et al.* (1997) report further analyses of the dialogues analysed by O'Malley and Langton (1994a). Using Conversational Games Analysis (CGA) (Kowtko, Isard and Doherty-Sneddon, 1991), they carried out a content analysis of the face-to-face and audio-only dialogues from Boyle *et al.*'s

(1994) study, and also analysed dialogues from the video and computer-mediated audio conferencing conditions reported in O'Malley and Langton's (1994a) paper. CGA involves coding the functional use of utterances in task-oriented dialogues. A Game is a sequence of Moves which are used to accomplish some goal. A Move is an utterance or sequence of utterances from one speaker which embody the same function. There are six types of Games. An ALIGN Game is when the speaker checks that the listener has understood the message, a CHECK Game is when the listener checks her/his understanding of the message, EXPLAIN Games are freely offered information, an INSTRUCT Game is a direct or indirect request for action or instruction, a QUERY-YN is a yes-no question and a QUERY-W is an open-answer 'wh' question. A fuller description of CGA is to be found in chapter 3.

Upon coding the dialogues from Boyle *et al.*'s experiment, Doherty-Sneddon *et al.* found that all types of Games increased in number in the audio-only context compared to the face-to-face one. The only statistically significant differences between the two communication modes involved ALIGN and CHECK Games: audio-only dialogues contained more ALIGN Games than face-to-face ones, and the vast majority of these were started by information givers. They also contained more CHECK Games, for which information followers were primarily responsible. This means that when speakers could not see one another their dialogues were structured differently: speakers attempted to confirm their listeners understanding or agreement more often, while listeners were less sure that they had understood the speakers' message.

The only difference between video-mediated and audio-only dialogues was that VMC dialogues contained significantly less ALIGN Games. This reveals that in the audio condition, speakers were less confident that the listener had understood the message than in VMC. Video and face-to-face communication were similar in this respect. Hence, the visual signals in face-to-face and video contexts appeared to be operating in the same way: they were providing visual feedback information which reduced the need for eliciting verbal feedback. However, VMC discussions did not contain any fewer Games than remote audio discussions; this appears to be because the decrease in CHECK and EXPLAIN Game in face-to-face communication was not replicated in VMC, in fact there were slightly more CHECK and EXPLAIN Games in video-mediated compared to audio-only dialogues. The equivalent or increased numbers of all Game types in VMC overrode the benefit of a reduced number of ALIGN Games.

Overall, compared to face-to-face communication, more Games, or units of conversation, were required in VMC interactions; face-to-face situations elicited less verbal feedback than audio-only conversations, whereas in VMC there was more verbal feedback than in audio-only communication. The authors interpreted this as indicating that communication ran more smoothly in face-to-face than in VMC situations. It is assumed that the increased verbal feedback in VMC is there to compensate for impoverished visual cues in VMC, cues which normally serve a feedback function in face-to-face communication. Consequently, the researchers argue that even high bandwidth VMC with eye contact does not give the same benefits as face-to-face communication.

In summary, for this collaborative problem-solving task, the Map Task, dyadic communication via high quality VMC was not equivalent to communicating face-to-face, with video communication that permits eye contact being less efficient than face-to-face communication.

A possible criticism of the studies reported in O'Malley and Langton (1994a) and Doherty-Sneddon *et al.* (1997) is that the audio condition used for comparison with VMC were remote, while in Boyle *et al.*'s (1994) study the audio condition compared to face-to-face communication was co-present. Yet, evidence from Rutter, Stephenson and Dewey (1981) suggests that being physically together does not affect behavioural measures of depersonalisation, spontaneity or task orientation differently from being physically separate.

Dyadic communication in other lab tasks

All of the above studies investigated the effect of technology-mediation on communication during the same task, the Map Task. Will the findings of this research hold for other types of task? An early study by Ochsman and Chapanis (1974) compared the effect of ten communication modes on the problem-solving of sixty dyads for three different tasks involving class scheduling, fault finding or part identification problems with one correct solution. The modes included audio-only communication, video and audio communication and a 'communication rich mode' in which subjects sat in separate rooms, viewed each other through a sound insulated glass panel, and talked through a microphone and speaker. Time to solution, behavioural measures of activity, and linguistic measures were analysed. They concluded that the most important channel of communication in a telecommunications link was the voice (audio link) not the visual channel. They found no evidence that the addition of video had any effect on communication times and behaviour.

In a similar study by Weeks and Chapanis (1976), pairs of subjects solved co-operative and conflictive problems via video, face-to-face and telephone communication. They discovered that the addition of a visual channel to voice mode did not appreciably decrease solution times, nor did it matter whether the visual channel was face-to-face or over closed-circuit television (CCTV). When participants had visual access to each other, they spent more time concentrating solely on the verbal message being sent or received rather than 'multi-tasking'. In video mode, subjects were even less likely than in face-to-face mode to carry out tasks concurrently, suggesting video communication may be more task-focused than face-to-face and audio communication. The authors warn that this advantage may be a short-lived consequence of participants' self-consciousness at being caught on camera.

These studies by Ochsman and Chapanis (1974) and Weeks and Chapanis (1976) did not include a true co-present face-to-face condition as a comparison, but involved participants being physically separated from one another. This could be the reason for the apparent similarity of VMC and the 'face-to-face' condition. They did find, however, that the effect of VMC and audio communication on solution times was similar, although the process of video-mediated communication differed.

A study by Anderson *et al.* (1996) which did include a co-present face-to-face condition used a simulated travel agency encounter, the Travel Game, (a collaborative problem-solving task) to investigate the nature of dyadic computer-mediated video and audio communication, and face-to-face and audio-only paper-and-pencil conditions in the laboratory. Full details of this study are given in the introduction to chapter 3. The video technology did not permit eye contact and the frame rate was very low at 4 to 5 frames per second[3]. In the paper-and-pencil conditions, face-to-face communication was more efficient (dialogues were shorter for the same level of performance) than in the audio-only condition and speaker co-ordination was similar as shown by rate of interruptions. In contrast, the addition of a video channel in the computer conditions did not improve upon communication through the audio channel alone; the dialogues were of similar lengths, equally co-ordinated and performance scores did not differ significantly between the two, thus communication in both contexts was said to be equally efficient and formal. Subjective data also showed advantages of face-to-face communication over VMC. Overall, low quality VMC was very similar to audio communication in terms of the impact on the communication process and outcome, whereas face-to-face communication was more efficient than audio-only communication.

However, one methodological problem is that in the paper-and-pencil face-to-face and audio conditions of Anderson *et al*'s study, the task may have been made easier by allowing a longer time for completion (20 minutes were allowed versus 15 minutes for computer conditions); and performing the task on the computer may not be equivalent to the paper-and-pencil version of the task. The computer task may have been more demanding and hence affected the interaction adversely.

These are alternative explanations to explain why VMC does not show the same advantages as face-to-face communication in this study.

Summary of the effect of VMC on two-party communication

The above research comparing dyadic VMC, face-to-face and audio communication, demonstrates that when two people carried out information exchange tasks, low quality video communication was less efficient (conversations were longer but performance was equivalent) than face-to-face communication (Anderson *et al.*, 1996). Even high quality video communication which permitted eye contact was less efficient and had less co-ordinated turn-taking than audio communication, whereas face-to-face communication was more efficient and co-ordinated than audio-only interaction. Video-mediated communication which did not allow eye contact was remarkably similar to communication when no visual information at all was available; and, surprisingly, was actually more efficient than when eye contact was possible via video (Boyle *et al.*, 1994; O'Malley and Langton, 1994; Doherty-Sneddon *et al.*, 1997). Overall, even high quality VMC does not appear to replicate all the advantages of face-to-face communication and seems to be more similar to audio communication, at least for dyads performing information exchange and problem-solving tasks in the laboratory. What is the effect of VMC on group communication?

2.5 Group technology-mediated communication research

All of the Map Task studies already reviewed above have focused on dyadic mediated communication. A recent study of VMC comparing dyadic and small group communication is that of Anderson, Mullin, Katsavras, Brundell, McEwan, Grattan and O'Malley (1999). Students participated in the Map Task in one of three communication conditions: two-party high quality VMC, three-party high quality VMC or three-party face-to-face communication. Communication process and outcome were analysed. The investigators found no significant differences between the three conditions in performance, but the amount of verbal effort

---

[3] Frame rate or frames per second (fps) refers to the number of times per second that a video image is updated. Frame rate is also referred to as Hertz (Hz).

differed between conditions: participants in two-party VMC said significantly less words to complete the task than participants in three-party groups who said similar amounts in the face-to-face and video contexts. Two-person VMC also had significantly fewer speaking turns than three-party VMC, and almost significantly fewer turns than in three-party face-to-face communication. Hence, it appears that it is the more complex nature of multiparty interaction and not technology-mediation that results in longer discussions. Participants appear to have had more difficulty in managing their turn-taking in three-party VMC since speakers interrupted one another significantly more than in the three-person face-to-face and two-person VMC groups which did not differ. In three-party face-to-face groups, there were significantly more back channel responses than in the VMC conditions which did not differ, suggesting that VMC leads to a more formal communication style than face-to-face communication. Turn length (in words) was significantly longer in the face-to-face condition than in the video conditions which did not differ.

Overall, differences between the media reflect the difficulties of multiparty communication whether mediated or not for this problem-solving task, although greater difficulties in co-ordinating the conversation appear to be due to the combined effect of communicating in a group and doing so via video technology. Two- and three-party VMC and three-party face-to-face communication have similar communication outcomes but different communication processes: multiparty communication was more problematic for speaker co-ordination than was dyadic interaction. VMC, whether two- or three-party, had a more formal communication style than face-to-face communication. Does other research using different communicative tasks, for instance, social tasks involving more persuasion or negotiation, support the findings of the information transfer tasks?

Social tasks

Studies of social types of task have tended to investigate group mediated communication, although there are relatively few such studies. Those which exist will be described in detail in the next chapter, however, the main findings are outlined below.

A lab experiment by Gale (1990 & 1991) compared four-person groups interacting in three communicative contexts: data sharing, audio with data sharing, and audio and video plus data sharing (there was no face-to-face condition). There were no significant differences in time taken to complete information dissemination and co-operative tasks, but the fastest completion time for a negotiation task was in the audio condition. The measure of quality of output did not successfully differentiate between discussion sessions and no measures of communication process were analysed. See chapter 3 for more detail about this experiment.

Sellen (1995) observed four-person groups in the lab carrying out a debate task via three VMC systems, audio-only and face-to-face communication. She discovered that VMC (without eye contact) was no different from audio-only conversations on measures of turn-taking and formality. VMC also had similar turn-taking behaviour to face-to-face communication but more formal speaker transitions. She concluded that all types of mediated conversations show depersonalisation, psychological distance and formality. There was no measure of performance success due to the nature of the task (a debating task). Therefore, although the media Sellen investigated led to different styles of communication we cannot comment on their relative efficacy. This study is described in greater detail in chapter 3.

A study which does allow judgements of efficiency to be made is that of Olson, Olson and Meader (1994; 1997) which is fully reported in the next chapter. Existing three-person work groups took part in a design task in the lab in one of four conditions: conventional face-to-face communication; face-to-face with a shared editor (a simple text editor that allows all participants to type simultaneously); remote audio with the shared editor; and remote high quality video and audio with the editor. The authors analysed the communication process and outcome and subjective user perceptions. They discovered that quality of work with video was as good as in both face-to-face conditions. In addition, subjective perceptions of the video technology revealed various benefits of VMC. However, groups working remotely without video produced lower quality work than face-to-face groups using an editor, but of similar quality to conventional face-to-face groups. Although communication outcome (work quality) was similar in VMC and face-to-face contexts, the process of the work (as with all remote groups) differed: it took extra effort to manage the group and clarify messages in VMC.

The success of video for supporting communication in Olson *et al*'s experiment may be due to the fact that the task involves a degree of persuasion and negotiation, as opposed to simple transfer of information required in the Map Task and Travel Game. It is possible that a video image is more distracting than helpful if being able to see ones partner's face is less important to task success; this may be the case for information exchange tasks. When having access to the face is positive and beneficial, for instance, when the communication involves some persuasion and negotiation, e.g. in a design task, you would expect video to be more beneficial than in the less 'social' tasks. However, these studies also differ on a number of other factors: in Olson *et al*'s study high quality, life-size video images and directional sound and vision were used, groups not dyads took part, and these were established not newly-formed groups. Hence, perhaps these seemingly contradictory results are in fact a product of methodological differences.

Summary of group mediated communication studies

For groups performing information exchange and a social task, Gale found no differences between VMC and face-to-face discussions in time to complete the task. Olson *et al* (1994; 1997) found VMC and face-to-face to result in equally successful communication outcomes, albeit through a different communication process. Sellen (1995) also found that the process of communication differed in technology-mediated and face-to-face conversations in terms of how dialogues were structured and co-ordinated but there was no measure of communicative success.

With the exception of the research by Olson and colleagues, all of the above studies of technology-mediated communication have explored the communication of newly-formed groups or dyads. Existing groups are quite different from ad hoc groups: members have a shared history which is likely to affect their communication patterns. It is known that people who are familiar with one another communicate in a different way from unfamiliar dyads (Boyle *et al.*, 1994). This is one reason why field studies investigating established work groups can make an important contribution in this area.

Furthermore, while lab research allows conclusions about cause-and-effect relationships to be drawn, a disadvantage is that as the users are generally inexperienced in the use of video conferencing technology, any differences in the impact of technology on communication compared to a face-to-face context could be transient and change with increased exposure to the technology. On the other hand, field studies looking at users over a longer period of time can present a more realistic picture of the effect of technology-mediation on the communication process.

2.6 Field studies of communication

Perhaps evidence from naturalistic studies can clarify how video-mediation affects communication. The field studies by Tang and colleagues (Isaacs and Tang, 1993; Tang and Isaacs, 1993; Tang, Isaacs and Rua, 1994) of workplace groups using video prototypes to communicate highlight several positive aspects of VMC: compared to phone communication it led to greater mutual understanding between participants; compared to face-to-face conversations, those over the video were more task-focused with less small talk. Finally, the feeling of distance in video interaction meant that people could easily work separately as well as together. However, another consequence of this distance is that users were also more likely to deal with distractions in video conferences than in face-to-face meetings. These studies are discussed more fully in the next chapter.

O'Conaill, Whittaker and Wilbur (1993) compared 'real life' group meetings of four to nine participants via two quite different VMC systems and face-to-face communication. They found that high quality video mirrored many of the characteristics of face-to-face conversation but interaction was still more formal than face-to-face communication. This was thought to be due to the absence of directional sound and vision which support cues that co-ordinate speaker transitions. This research is described in more detail in chapter 3.

In the above field research, assessment of the relative efficiency of the different media was not possible since actual communication tasks do not lend themselves to measures of performance success, they do, however, support some of the findings of lab studies about the impact of technology on communication process. For example, high quality VMC was also found to be more formal than face-to-face communication in the lab (e.g. Sellen, 1995; Anderson *et al.*, 1996).

In sum, the research reviewed does provide evidence that technology-mediated communication differs from face-to-face communication, and some evidence that video does not seem to provide all of the benefits of co-present communication. However, the ways in which the communicative media differ appear to vary from study to study which sometimes provide contradictory results. One contributory factor is the variety of communication technologies investigated. Another is the variety of methodologies utilised: different tasks, group sizes, communication analyses, and types of studies (lab and field studies) have been employed making comparisons between studies difficult.

For instance, Sellen's (1995) results differ in some ways from those of the Map Task studies. O'Malley and Langton (1994a), for example, found that VMC had longer speaker turns than audio-only conversations, while Sellen found that the contexts did not differ on this measure. However, these experiments differed on a number of aspects: the task, the group size, the video technology, and the operational definitions of aspects of communication. For example, Sellen investigated four-party groups performing a social task, whereas O'Malley and Langton looked at dyads carrying out an information exchange task. Perhaps most importantly, Sellen's operational definition of a 'turn' was not the same as that used by O'Malley and Langton, or subsequent related Map Task studies (O'Malley *et al.*, 1996; Doherty-Sneddon *et al.*, 1997), which all used the definition of Boyle *et al.* (1994). Sellen proposed that a speaker's turn starts when she/he alone is talking; for the utterance to be considered a turn the speaker must not be interrupted for at least 1.5 seconds and periods of mutual silence at the end of talk were also included in the turn. On the other hand, Boyle *et al.* considered all utterances, even the shortest ones as turns and they measured the length of turns in number of words, not in seconds as Sellen did. Moreover, Boyle *et al.*'s definition ensured that all back channels were counted as turns while Sellen's excluded back channels from the measurements. Due to these differences, we cannot be sure that the comparisons of VMC, audio and face-to-face communication conditions made by Sellen's are comparable to those in the studies of O'Malley *et al.* (1994a & 1996), Anderson *et al.* (1996) and Doherty-Sneddon *et al.* (1997).

However, not all of the differences in communication process and outcome found to exist between media can be explained by methodological differences between studies. Some of the differences, such as the poorer co-ordination of turn-taking in VMC, that have been discovered between video and face-to-face interaction may be due to the way in which non-verbal cues, particularly gaze and gesture, are used and perceived over the video.

2.7 The role of eye contact or gaze in video-mediated and face-to-face communication

Some VMC systems allow speakers to make eye contact, other do not (as described in section 2.20, this chapter). Eye contact means eye to eye contact, while gaze awareness is being aware of where others are looking. Eye contact or 'mutual gaze' and gaze awareness are known to perform a variety of important functions in face-to-face communication (see chapter 1 for a full discussion of the use of gaze in face-to-face communication). In short, eye contact serves at least five functions, it

1. regulates the flow of conversation

2. provides feedback on how the communication is perceived by the listener
3. communicates emotions
4. communicates the nature of interpersonal relationships and
5. avoids excess information output (Sellen, 1992).

Empirical studies have examined the effect of the ability to make eye contact on subjective and objective measures of the communication process in VMC. As there is a lack of studies which combine detailed communication analysis with how gaze is used in video-mediated groups, studies of gaze between video-mediated dyads will also be reported here.

In the Map Task experiments investigating dyadic communication (Boyle *et al.*, 1994; O'Malley *et al.*, 1996; Doherty-Sneddon *et al.*, 1997), the researchers investigated the possibility that the way in which the non-verbal cue of gaze was used in the VMC and face-to-face contexts differed, and that this may have been a cause of the structure and process differences between face-to-face and video conversations. As already mentioned, for equivalent performance, face-to-face conversations were significantly shorter than audio-only conversations, whereas high quality video-mediated conversations were similar in length to remote audio-only discussions. Boyle *et al.* (1994) defined gaze as whenever a person looked up in the direction of their partner - this could be either a movement of the whole head or of just the eyes. They investigated the use of gaze in face-to-face communication between dyads. They found that interlocutors tried to establish eye contact significantly more often at times of communicative difficulty, whether dyads were familiar or unfamiliar with each other. They proposed that this may have been to provide or seek feedback to help grounding of knowledge.

Subsequently, O'Malley *et al.* (1996) examined the relation of dyadic gaze to conversational structure, as revealed by Conversational Games Analysis, in the same face-to-face dialogues analysed by Boyle *et al*, and in a high quality VMC condition in which eye contact was possible. They discovered that 53% of gaze in face-to-face conversations occurred in the same dialogue locations where information givers tried to elicit feedback from listeners in the audio-only context, suggesting that gaze does indeed serve a feedback function in this task, and was being used for monitoring the non-verbal signals of the other participant. However, in VMC the patterns of gaze were different: there was 56% more gaze than in face-to-face communication. In the face-to-face context, information givers gazed far more when speaking than when listening, whereas in VMC, information givers gazed similar amounts when speaking and listening. This appears to indicate that the visual channel was 'over-used' in VMC. The authors propose that this may lead to increased cognitive load and difficulties processing verbal information with the result that subjects may need to say more to reach mutual understanding.

A further set of analyses are reported in Doherty-Sneddon *et al* (1997). The use of gaze between two people in VMC contexts in which eye contact was and was not possible was explored. When eye contact was possible via video, there was, on average, 66% more gaze than between dyads in a VMC condition without eye contact. If gaze does indeed interfere with cognitive processing, this could explain why more words and turns were needed to complete the task in the VMC condition allowing eye contact in which gaze was very frequent. This 'over-gazing' is thought to be a transient effect of the novelty of video-mediated technology for inexperienced users.

In addition, although gaze can provide feedback on how the communication is perceived by the listener, Doherty-Sneddon and colleagues found that despite excessive gazing in VMC (when eye contact was possible) there was also more verbal feedback in VMC than audio communication, (as opposed to less verbal feedback in face-to-face compared to audio-only communication).

However, it is not clear how novelty could lead to over-gazing. In what way is the technology causing this non-verbal cue to be used differently? It may be related to the way people react to a two-dimensional video image as opposed to a real three-D person; perhaps social constraints, such as the taboo on staring, are lessened. In fact, it has been shown that it is possible to stare at remote participants without them being aware of the intensity of the observer's gaze; Storck and Sproull (1995) claim that users take advantage of this 'opportunity' to have a good look!

This is, however, in contrast to claims by O'Conaill *et al.* (1994) that staring is perceived as confrontational.

All participants in the Map Task studies were inexperienced in use of VMC systems, and exposure to the technology was brief. Only a longitudinal study can establish whether over-gazing is indeed a short-term side effect of the novelty of the technology that is replaced by more natural patterns of gaze over time. It seems probable that the whole nature of video communication will change with extended use of such systems.

Surprisingly, the presence of eye contact in a video system can make communication less efficient than audio-only conversations, contrary to the expectation that it would be more efficient since it is more like face-to-face communication in which non-verbal signals play an important role in co-ordinating the communication process. What is the role played by gaze in technology-mediated interactions during different communicative tasks?

Eye contact and video-mediated groups

Acker and Levitt (1987) carried out an experiment in which students participated in groups of four with two group members seated at each of two conference sites, only one of which was equipped with technology allowing eye contact. The ability to make eye contact via video was found to be positively related to user satisfaction with the technology as a medium for negotiation; it allowed a more confident evaluation of counterparts' feelings which is critical to managing a negotiation, and participants also felt more comfortable exchanging information. Thus, the social aspect of interaction appears to have been enhanced when eye contact was possible. Acker and Levitt did not assess how the communication process and outcome were affected by eye contact in this negotiation exercise.

In contrast, for a similar experimental set-up involving four-person groups with two group members at each of two sites, Mühlbach, Böcker and Prussog (1995) found that lack of eye contact had no significant effect on satisfaction with, or acceptance of, video communication and no effect on another subjective measure - telepresence, that is, the degree to which participants had the impression of sharing space with remote participants. A possible reason for this contrasting result is that subjects in this study took part in a negotiation and a problem-solving task but did not give their subjective impressions of the technology for each of these tasks separately; this could have obscured any benefits of eye contact for user satisfaction in the negotiation task.

Qualitative analyses of the way in which gaze is used in VMC in the field have been carried out by some investigators who maintain that the effectiveness of peripheral monitoring is reduced over the video thus diminishing participants' gaze awareness, i.e., their awareness of where the other person is looking, both for dyads (Heath and Luff, 1992) and for groups of physically distributed colleagues (Isaacs and Tang, 1993). While O'Conaill *et al.* (1993) found that in group video conferences allowing eye contact, even experienced users stared fixedly at their partners; this felt confrontational and resulted in the recipient giving little feedback.

Tang and Isaacs (1993) in their field study of a four-person distributed work group found evidence to suggest that inability to make direct eye contact may not be that damaging to communication in the long term. In fact, it could be more beneficial than the ability to make eye contact if this leads to staring even after extended periods of use. They discovered that gaze awareness was possible even when no direct eye contact was possible; after two weeks of using video technology most users could tell when others were looking at them and after fourteen weeks everyone could tell. It is revealed that even without eye contact (but when the technological configuration provided near eye contact), users adapted and learnt to tell when others were attempting to make or avoid eye contact.

In support of the Map Task finding that gaze is used differently between two people in video contexts, Sellen's (1995) lab study of group communication during debates found that the ability to direct ones gaze and attention in the Hydra video system did not replicate all the advantages this gives in face-to-face interaction:

although VMC was equivalent to face-to-face in terms of frequency, duration and distribution of speaking turns, Hydra had more formal hand-overs of the floor[4] than the co-present condition. Sellen muses that the non-verbal cues of selective gaze cannot have carried the same impact as in face-to-face communication, thus leading participants to compensate verbally (by using tagging and naming the next speaker). However, we do not know how gaze differs between Hydra and face-to-face conversations since Sellen did not look at instances of gaze. Nevertheless, participants rated Hydra significantly better than a VMC system in which eye contact was not possible (PIP) at allowing monitoring of the attention of others, allowing selective attention, (which enables side or parallel conversations), and avoiding ambiguity over who was being addressed. Thus, Hydra had an impact on the perceived ease of speaker co-ordination but not on actual co-ordination. Eye contact had more of an effect on subjective experiences of conversation co-ordination than on actual communication. It is not known how these differences affected communicative success since efficiency of communication could not be measured due to the type of task employed.

Evidence contradictory to the finding that gaze is used differently in VMC and face-to-face interaction comes from Smith *et al.* (1996). They maintain that pairs of interactors used eye contact (and gestured and talked) in *normal* ways via the videotunnel even though physically separated. Yet O'Malley and Langton (1994a) point out that a different type of task was used, (a collaborative learning task), with more negotiation and discussion than the Map Task. It also involved a shared workspace where participants could see what the other was doing in respect to the task. It is hard to say which aspect of this study led to such natural patterns of gaze since the two studies differ in many ways.

---

[4] A formal handover of the floor is when the speaker indicates verbally that she/he has finished speaking. This can be done by asking a question, known as a verbal tag, or by naming the next speaker (Sacks, 1992).

Summary of studies of gaze

To sum up, there is evidence to indicate that when eye contact is possible in video mode, gaze is used in a different way from face-to-face gaze, at least by novice users in two-party interaction (O'Malley and Langton, 1994a & b; Sellen, 1995; Doherty-Sneddon *et al.*, 1997). It is proposed that characteristics of the technology interfere with the way in which this cue is used making VMC with eye contact less efficient than audio-only and face-to-face communication. Anderson *et al.* (1997) suggest that this may be an effect of users being distracted by the video capability of the new medium. Field studies suggest that over time, users can adapt to the video medium in order to use eye contact more effectively (O'Conaill *et al.*, 1993; Tang and Isaacs, 1993). Subjective user data on the perceived benefits of the ability to make eye contact in group interaction are equivocal (Acker and Levitt, 1987; Mühlbach *et al.,* 1995).

2.8 Gesture and VMC

Research indicates that another non-verbal cue, gesture, may also be affected by video mediation. Gesture can be used to indicate when we wish to take a turn in the conversation (Short *et al.*, 1976), can substitute for verbal information, can help to regulate turn-taking and people can gesture at aspects of the environment (Acker & Levitt, 1987). Chapter 1 outlines the use of gesture in face-to-face interactions in greater detail.

It is argued that in face-to-face interaction, participants can judge how their gestures are being perceived and tailor their behaviour to be most effective at that moment. However, naturalistic observation of individuals using a VMC system to collaborate in their work environment (Heath and Luff, 1992) shows that certain gestures which are used to organise face-to-face interactions are ignored in VMC; participants are quite insensitive to a lot of each others' visual behaviours. The researchers refer to this as the 'asymmetry' of the communicative environment. The consequence of this is that people are unaware of how others perceive their gesture. Ineffective use of gesture poses possible problems for speaker co-ordination and achieving mutual understanding. Yet this asymmetry in VMC is not wholly negative in its influence on communication; the feeling of distance the technology affords was observed to allow participants to concentrate on individual tasks and activities and to simultaneously carry out more or less related tasks while still interacting with each other. In addition, the recognition of the speaker and the co-ordination of speaker change were still observed to be aided by the visual channel and these behaviours were more flexible than in audio-only situations, but the visual information in VMC was still not as good as in face-to-face communication.

Why is gesture not received in the same way as in face-to-face communication? There are various possible explanations. Heath and Luff (1992) hypothesise that television, where interaction is not necessary, has made people insensitive to screen-based images with the result that users do not pay attention to the video image of the face as much as they need to for communication purposes, or as much as they would in face-to-face contexts. It could also be that the physical aspects of the technology, such as the position of the camera and the size and flat nature of the screen, distort and limit the view of gesture, e.g., gesture may be off-camera (Heath and Luff, 1992; Tang, Isaacs and Rua, 1994). Indeed, observations of workers using VMC in the field show that the technology makes peripheral vision less effective (Isaacs and Tang, 1993). The video image is only a small part of the visual field and if the user is not near or looking at the screen then she/he is less likely to notice even large movements in the image. Hence, gesture is either seen directly or just as part of the whole screen in a person's peripheral vision. In this way, subtle movements and cues are lost to the conversational partner.

Fussell and Benimoff (1995) maintain that another technological characteristic of some video systems - lack of synchrony between the audio and video signals (due to a transmission delay) - can lead to confusion when participants speak and gesture simultaneously as these are not perceived to be in synchronisation; consequently, the images displayed may be inappropriate to the context of the conversation. This can cause ambiguity and be a distraction to speakers.

In spite of the evidence of problems in perception of gesture over video, Isaacs and Tang (1993) say that VMC does still show advantages of being able to convey gesture for work place groups. It allows subtle problems, for example, of miscomprehension, to be transmitted without having to disrupt the speaker; this provides 'effortless and on-going' feedback. The authors say that for this reason video should be very helpful when a rich set of interaction skills are needed, for instance, in conflict resolution, negotiation and creating rapport.

Subjective reports from users of VMC in the lab support these naturalistic observations, Sellen (1995) found that in conversations over high quality video with directional sound and vision (the Hydra system), speakers reported difficulties in knowing how their gestures were received, while the addition of a 'confidence monitor' in another VMC system (PIP) meant that people could see their own image as others saw it. This may have helped people to modify their visual behaviour to suit the medium.

There is observational evidence that in the long term users may be able to adapt their non-verbal behaviour during video conferences to be more effective. Rudman and Dykstra-Erickson (1994) and Dykstra-Erickson, Rudman, Hertz, Mithal, Schmidt and Marshall (1995) noted that over time users gradually became more sensitive to other participants' non-verbal cues (including gesture and facial expressions) and learnt how to emphasise their own non-verbal behaviour by manipulating the video camera. However, this adaptation of behaviour was dependent on several factors, for instance, there was less adaptation in two-person teams than in larger ones and when group members had less interest in task outcome.

Summary of use of gesture in multimedia communication

Thus, observational studies and subjective reports indicate that gesture in VMC seems to be used in a different and less effective way than in face-to-face communication (Heath and Luff, 1992), although some ability to use gesture effectively remains (Isaacs and Tang, 1993). The physical characteristics of the video systems are thought to be responsible for these difficulties (Heath and Luff, 1992). Nevertheless, there is anecdotal evidence to suggest that over time, users do adapt and learn to use their body movements to greater effect to ensure that their gestures are effective in VMC (Rudman and Dykstra-Erickson, 1994), although this evidence appears mainly observational or anecdotal. No experimental studies on the use of gesture in VMC seem to have been published. Such research could reveal whether users compensate verbally for their unsuccessful attempts to gesture, and what impact this has on the communication process and outcome. For instance, does the inability to use gesture naturally affect the efficacy of the interaction?

2.9 Theories of differences between communication media

So far the empirical research reviewed has revealed that, in general, video-mediated communication does differ from face-to-face communication and has been found by some investigators to be more similar to audio conferencing communication in terms of the communication process. Nonetheless, technology-mediated and co-present face-to-face communication have often been found to be equally effective for achieving communicative goals.

There are various theories which try to account for differences and similarities between media: Williams (1977) placed them into three categories -

1. efficiency of information transmission
2. function of non-verbal cues
3. immediacy or 'social presence'.

Various models can be classified under these headings. Examples of theories based on the efficiency of the communication media's information transmission are the grounding theory of Clark and Brennan (1990) and the Media Richness Theory of Hollingshead, McGrath and O'Connor (1993). The cuelessness model of Rutter (1981; 1987) and the lack of social context cues model of Kiesler *et al* (1984) base their approaches on the function of non-verbal cues (non-verbal cues are aspects of the environment and visual behavioural cues such as gesture, posture and facial expression), and the social presence theory of Short, Williams and Christie (1976) utilises the concept of immediacy. All of these approaches are discussed below.

Social presence theory

Social presence theory is interpreted as just another non-verbal cue theory by some authors but others, e.g. Williams (1977), see it as a more holistic approach in which the absence of some channels is seen to affect the whole nature of communication. The presence of non-verbal cues in face-to-face interaction is believed to be involved in relationship formation between participants (affective interaction). This is related to the concept of 'social presence', i.e., the degree of salience of the other person/people in an interaction and the consequent salience of the interpersonal relationships. It is a hypothetical construct which is a subjective quality of medium (Short *et al.*, 1976).

It is thought that face-to-face conversation offers greater social presence than audio-only conversation which is more impersonal, contentious and tightly-focused. VMC may fall somewhere in-between in terms of social presence (Williams, 1977). Williams (1977) summarised findings of early studies and concluded that people are seen as less 'real' or human in mediated communication but that this low social presence only has a consequence when the task involves social relationships, e.g., negotiation, rather than simply information exchange or problem-solving. Indeed, Olson, Olson and Meader (1994 & 1997) discovered that lack of co-presence altered the communication process such that more verbal feedback was required in remote conditions to clarify and manage the conversation. Nevertheless, this did not disadvantage the outcome of video compared to face-to-face communication.

Contradictory evidence comes from a study by Rutter *et al.* (1981) in which neither physical presence nor visual communication was the critical variable in differences in content and style of communication between media. What was important was the number of sources of social cues available to interactors, or the 'cuelessness' of the medium. Face-to-face communication appeared to provide the most cues, leading to a less task-oriented, less impersonal and more spontaneous interaction, while audio-only communication, the medium with the least cues that was investigated, led to a more depersonalised, more task-focused and less spontaneous interaction.

In addition, findings from attitude change research cannot be explained by this theory - it seems reasonable to assume that face-to-face interaction would lead to greater attitude change than other media but the opposite appears to be true. However, Short *et al.*(1976) suggest that this is because non-verbal cues distract people from the formulation of their own arguments and from understanding others' arguments.

Theories based on function of non-verbal cues

Cuelessness Theory

Rutter *et al.* (1981; Rutter, 1987) refer to situations with reduced social cues, such as VMC and audio-only interaction, as increasingly 'cueless' compared to face-to-face communication. In face-to-face communication, cues are available from both visual communication and physical presence, in video communication there are cues from the visual channel, while in audio-only communication there are no social cues from either of these two sources. Their argument is that the smaller the aggregate number of available social cues, the more task-focused and impersonal the communication content and the more stilted the style of interaction. The primary effect of 'cuelessness' is said to be on content which in turn affects the style and outcome of the communication. A more recent version of this theory claims that the effect of cuelessness is indirect, mediated by 'psychological distance', and dependent on the number of *usable* cues.

Lack of social context cues model

A similar approach is the lack of social context cues hypothesis of Kiesler and colleagues (Kiesler *et al.*, 1984; Kiesler, 1986; McGuire *et al.*, 1987; Siegel *et al.*, 1986; Sproull and Kiesler, 1986) based on empirical studies of a low bandwidth medium - computer text conferencing - using established experimental paradigms. Their central argument is that absence of social and contextual cues leads to a reduced impact of social norms and constraints, for instance, they maintain that the consequences of reduced bandwidth are: greater self-absorption; more equal rates of participation; communication which becomes more excited and uninhibited; and more polarised, extreme and risky group decisions than in a rich medium such as face-to-face communication. Although this theory was actually formulated to account for the characteristics of text-based conferencing, it has possible relevance to other forms of technology-mediated communication.

These two theories try to explain the effects on communication of different media with reference to the presence or lack of non-verbal cues. However, Short *et al.* (1976) had pointed out previously that such approaches treat verbal and non-verbal channels as discrete when they are not: non-verbal cues are always combined with other non-verbal cues and usually with a verbal message. Moreover, in a low bandwidth situation (such as a medium with impoverished visual information) people are likely to compensate by adjusting their behaviour to suit the medium, e.g., replace head nods by verbal phrases when speaking on the telephone. The point that Short *et al.* are making is that the absence of non-verbal cues in mediated interactions is not necessarily equivalent to their absence in face-to-face conversation and, as Walther (1995) suggests, does not necessarily lead to predictable changes in communication. As Short *et al.* (1976) state:

> '*there is no compelling reason why removal of cues at the level of the mechanics of the interaction should always lead to a reduction in the overall efficiency*' (page 62.)

Indeed, Sellen (1995) found that the number and type of cues available in a medium did not have a significant effect on the communication process; what did have an effect was technological mediation of communication. A further criticism is that such a theory does not allow for development or change in conversational variables across time, nor for the influence of other external factors such as relationships or context (Walther, 1995).

Efficiency of information transmission

Efficiency of information transmission is a 'bandwidth explanation'. Face-to-face communication is seen as having high bandwidth, that is to say, a lot of information is transmitted and received by all the senses so that the uncertainty of the message's meaning is reduced. It is said that audio and video communication have lower bandwidth; this can lead either to frustration due to uncertainty of meaning, or to communicative efficiency if the signals are sufficient for understanding (Williams 1977). Such theories have been criticised for being unable to explain the qualitative effects of communication medium, i.e., its effect on the quality of the outcome of communication. One such theory is Grounding Theory (Clark and Brennan, 1990), another is Media Richness Theory (Hollingshead, McGrath and O'Connor, 1993).

Grounding Theory

Clark and colleagues (e.g. Clark & Wilkes-Gibbs, 1986; Clark & Schaefer, 1987, 1989; Clark and Brennan, 1990; 1991;) move away from the notion of visual cues; their explanation centres around the concept of constraints on grounding. This approach to understanding communication is described more fully in chapter 1. In brief, 'grounding' is the process by which participants try to establish that what has been said has been understood, that is, they try to 'ground' what has been said, or make it part of their 'common ground'. Clark and Brennan claim that we try to say as little as possible to achieve grounding. Different communication media are characterised by different 'constraints' on the grounding process of which there are eight. These are outlined below.

1. co-presence - A and B share the same physical environment
2. visibility - A and B are visible to each other

3. audibility - A and B communicate by speaking
4. contemporality - B receives at roughly the same time as A produces
5. simultaneity - A and B can send and receive at once and simultaneously
6. sequentiality - A's and B's turns cannot get out of sequence
7. reviewability - B can review A's messages
8. revisability - A can revise messages for B (Clark and Brennan, 1991).

In face-to-face communication the constraints are co-presence, visibility, audibility, contemporality, simultaneity, and sequentiality; VMC has all of these constraints apart from co-presence; while telephone communication has all of the constraints except for co-presence and visibility. When a medium lacks a characteristic it generally forces people to use alternative grounding techniques; it does so because the costs of the various techniques of grounding change. There are many different types of cost: costs in time and effort to formulate, produce, receive and understand messages; the cost of starting a new conversation; costs of delaying an utterance in order to plan it; costs of speaker change; and the costs of gesturing or using other behavioural cues to aid communication.

In face-to-face discourse, the costs of starting a conversation are minimal, one person need only get the attention of the other and speak; whereas getting attention of the other person has been found to be more difficult or costly in video-mediated interactions (Heath and Luff, 1992). In face-to-face communication, the participants find it easy to regulate turn-taking; it is easy to point, nod at, present an object and use gaze to order conversation. In media without co-presence, gestures cost a lot, are severely limited or are out of the question. In video, a limited range of gesture can be used and it is not always possible to make eye contact with, or gaze at, someone as a way of picking them out as addressee. In brief, the more channels available, the easier it is to achieve the grounding process. When participants can see each other they have access to an extra channel which can be used to provide and seek information which can facilitate the grounding process.

Media Richness Theory

Another example of such a theory is Media Richness Theory (MRT) (Hollingshead, McGrath and O'Connor, 1993) which predicts a relationship between the potential richness of information transmitted by a communication medium and the potential richness required for task success. For example, an idea generation task may only require transmission of specific facts and ideas but no emotional and social cues about the source or message are necessary, whereas in tasks requiring negotiation of conflicts of interest, the speakers also need to convey attitudes, emotions, values, and so on. In summary, information richness becomes increasingly important for effective task performance as the group's task makes reaching consensus more difficult, hence requiring that richer information be communicated. Figure 2-1 shows the theoretical suitability of different communication media for various task types.

Summary of theories of mediated communication

One difficulty in creating a comprehensive model of differences between the effectiveness of various communication media is that the results from many studies are contradictory. All of these theories have their strengths and their weaknesses, for example, social presence theory is difficult to verify objectively (Olson *et al.*, 1997). Perhaps a combination of the ideas and concepts put forward will be more successful in accounting for differences between communication media.

Figure 2-1 The relationship between suitability of communication medium for task type

Increasing potential richness required for task success ↓	**Task type**	**Computer systems**	**Audio systems**	**Video systems**	**Face-to-face communica -tions**
	Generating plans and ideas	Good fit	Marginal fit Medium too **rich**	Poor fit Medium too **rich**	Poor fit Medium too **rich**
	Choosing correct answer: intellective tasks	Marginal fit Medium too constrained	Good fit	Good fit	Poor fit Medium too **rich**
	Choosing preferred answer: judgement tasks	Poor fit Medium too constrained	Good fit	Good fit	Marginal fit Medium too **rich**
	Negotiating conflicts of interests	Poor fit Medium too constrained	Poor fit Medium too constrained	Marginal fit Medium too constrained	Good fit

Increasing potential richness of information transmitted →

Taken from Hollingshead *et al.* (1993, p. 312)

2.10 Summary of review

A large body of research has been reviewed in this chapter, covering a wide variety of studies. Some studies have focused on dyadic and others on group communication, some have been carried out in the lab and others in the field. Furthermore, research has varied in the type and quality of conferencing system assessed, the tasks performed, the operational definitions of communication behaviour adopted, the interpretation of the same types of data and the methods of analysis. Nonetheless, there are some common findings and a brief summary follows.

In the laboratory, problem-solving situations between dyads, audio and video communication (both high and low quality video) appear to be very similar in their effect on communication outcome, regardless of whether eye contact can be made or not (Ochsman and Chapanis, 1974; Weeks and Chapanis, 1976; O'Malley and Langton, 1994; Doherty-Sneddon *et al.*, 1997). However, audio-only and video-mediated communication seem to have different communication processes: in high quality VMC there is more verbal feedback than in face-to-face interaction compared to audio conferences (Doherty-Sneddon *et al.*, 1997); video-mediated conversations tend to be more task-focused (Weeks and Chapanis, 1976); and when eye contact is possible, conversations are less interactive and less co-ordinated than audio-only discussions (O'Malley and Langton, 1994; Doherty-Sneddon *et al.*, 1997). Yet, low and high quality video communication which do not allow eye contact between speakers show a similar level of speaker co-ordination and formality as audio-only communication (Anderson *et al.*, 1996).

For groups performing social tasks, the content of remote communication has been found to be more effortful than face-to-face communication, involving more clarification and management of the interaction (Olson *et al.*, 1994; 1997). Communication via video without the ability to make eye contact has a similar communication process to audio conferencing, while VMC which allows eye contact has similar turn-taking to face-to-face communication but is more formal

(Sellen, 1995). Three-person groups carrying out a complex problem-solving task expend similar verbal effort for equivalent performance in VMC and face-to-face context, but the process of their communication is more formal and has less co-ordinated speaker exchange in VMC than in face-to-face communication (Anderson *et al.*, 1999).

Similarly, work groups participating in video conferences in the field have less interactive and more formal discussions than in face-to-face meetings, even when users are experienced and familiar with each other and the technology (O'Conaill *et al.,* 1993), and conversations appear to be more task-focused and shorter in length than face-to-face conversations (Isaacs and Tang, 1993; Tang *et al.,* 1994).

A variety of theoretical approaches to explain the differing impacts of communication media have been reviewed in this chapter. Short *et al* (1976) believe that the salience of the other person/people in an interaction and the consequent salience of the interpersonal relationships, that is, the level of 'social presence', is the crucial variable that differs between media. On the other hand, Rutter *et al* (1981; Rutter, 1987) maintain that the number of cues available in the communication context affects the style of the interaction, with face-to-face communication being most personal and spontaneous. Whereas, Kiesler and colleagues (Kiesler *et al.*, 1984; Kiesler, 1986; McGuire *et al.*, 1987; Siegel *et al.*, 1986; Sproull and Kiesler, 1986) state that the absence of social and contextual cues leads to a reduced impact of social norms and constraints and it is this which influences the communication process and outcome.

Other theories centre on the communicative context's efficiency of information transmission. For example, grounding theory is based on the concept that communication modes have differing constraints on grounding or achieving mutual understanding (Clark and Brennan, 1990). A different explanation (Media Richness Theory) focuses on the relationship between the potential richness of information transmitted by a communication medium and the potential richness required for task success (Hollingshead, McGrath and O'Connor, 1993). It is still unclear which theory can best account for the characteristics of technology-mediated conversation.

In summary, at this stage in the research into mediated communication some tentative conclusions about the relative merits of the different communication media can be drawn. There is some suggestion that video communication has the potential to replace some face-to-face communication without compromising on efficiency, especially as people become more experienced in use of the technology.

As this review has shown, there has been little research in the laboratory or in the field which adopts a holistic approach to the analysis of how group interaction and collaboration is affected by multimedia technology; more such studies appear to have focused on dyadic communication. Study 1 will examine how small groups in the laboratory communicate in technology-mediated contexts during a problem-solving task. This research is extended in study 2 (chapter 4) which investigates the impact of video on the communication of larger groups performing a more social task, while chapter 5 goes on to explore mediated group interaction in the work place.

3 Chapter 3. Study 1. Impact of video- and audio-mediation on small group communication in the laboratory

3.1 Introduction

The literature reviewed in chapter 2 has shown that the impact of multimedia communication technologies on human communication in groups has been studied in-depth by few researchers. This chapter focuses on the impact of video-mediated group communication compared to face-to-face and audio communication. Study 1 explores the impact on the communication and collaboration of small problem-solving groups of multimedia video and audio conferencing technology which is unequally distributed between group members. This is achieved through an analysis of the process of communication, task performance and subjective perceptions of participants.

Why study multimedia communication technology?

Increasingly, organisations are adopting communications technology in order to facilitate the communication and collaboration of physically distributed individuals. Video technology, for instance, is currently being employed in business settings for informal communication, for distance learning, and for the provision of medical services to rural areas. The advantages of multimedia technology are that it provides multiple channels of communication allowing both spoken communication and sharing of data which, in the case of video communication, is intended to approximate face-to-face contact. Whilst there has been a moderate amount of research into dyadic mediated communication, group interaction has received little attention, despite the fact that much business and personal communication is carried out in groups of three or more individuals.

Lab studies of multiparty mediated communication

One exception is a laboratory study by Gale (1990 and 1991), mentioned in the preceding chapter, which investigated the impact of VMC for a negotiation task by comparing it to audio and data only conferences. Hence, there were three communication conditions: data only (shared whiteboard); data plus audio; and data, audio and video. Groups of four unfamiliar members carried out three tasks, an information dissemination task, a creative co-operative task and a meeting scheduling task. No objective analysis of the communication process was undertaken but subjective questionnaire data, observation of the uses of the audio and video channels, the quality of output and completion times were compared. Unfortunately, judges found it impossible to differentiate between sessions for the measure of outcome employed - the quality of slide produced. There were no completion time differences for the information dissemination and co-operative work tasks, however for a more social task requiring negotiation (the meeting scheduling task), the fastest completion time was found in audio conferences. This seems to suggest that the addition of a visual channel was disadvantageous for this social task, at least for a measure of temporal efficiency. However, subjectively VMC provided the best sense of 'presence', i.e., awareness of the presence of others.

Another laboratory-based study of video-mediated group communication by Olson, Olson and Meader (1994) (mentioned in chapter 2) explored the communication process, the quality of work, and the perceptions of existing three-person work groups when performing a design task. Four communication conditions were compared: face-to-face with whiteboard, paper, and pencil; face-to-face with a shared editor (a simple text editor that allowed all participants to type simultaneously); remote audio with the shared editor; and remote video and audio with the editor. The video system used did not give direct eye contact but the video image was life size, of high quality and directional sound was possible. The process of the work differed between communication media: remote groups, including video-mediated groups, spent more time managing the group and clarifying what they meant than face-to-face groups, hence, non-verbal feedback in

VMC did not lead to a need for less clarification and group management. It appears that the lack of physical presence in remote group work may have caused a change in the communication process.

Despite differences in the communication process, the quality of work in VMC was as good as in both face-to-face conditions. Remote work without video was inferior to face-to-face communication with an editor, although it was as good as traditional face-to-face communication, thus there was an advantage of video-mediated over other remote conditions for performance. The advantages of the video channel were also reflected in users' subjective reports: it made them feel more able to communicate with each other, to persuade and to resolve issues. Nevertheless, user satisfaction with their work was highest when communicating face-to-face with paper-and-pencil; although the shared editor led to more efficient work it was less popular with users than traditional tools due to its relative unfamiliarity to them. Olson *et al* concluded that objective measures show some benefits for the addition of a video channel but user perceptions show that video was clearly beneficial.

A lab study by Sellen (1995) (also summarised in chapter 2) investigated the impact of two VMC systems specifically designed to support multiparty interaction: Picture-in-a-picture (PIP) and Hydra. In PIP, participants share a single video screen divided into quads and there is a single audio source, thus PIP cannot support selective gaze and selective listening. Hydra on the other hand employs multiple cameras, monitors and loud speakers to provide directional sound and images to imitate a round-the-table meeting. The VMC systems were compared to face-to-face communication for groups of four adults having informal debates. The researcher predicted that conversations via Hydra rather than PIP would be more like face-to-face conversations. However, she found that the three communication contexts did not differ on the following measures of interactivity: frequency, duration and distribution of turns between speakers. Face-to-face interaction was less formal with more simultaneous speech and less formal handovers of speaking turns than either of the VMC discussions. Questionnaire data support these findings: participants perceived advantages of face-to-face over the two VMC conditions for taking control of the conversation, allowing them to attend selectively to group members, knowing when others were paying attention to them and they felt that it led to more interactive communication. Hence, the ability to use selective gaze in Hydra did give some but not all of the benefits of face-to-face interactions.

Sellen's second experiment tested whether the reduction of visual cues in VMC was responsible for its relatively greater formality. She compared PIP and LiveWire VMC systems with audio-only communication. LiveWire is a voice-switched video system in which only the current speaker can be seen on screen, while he or she sees the previous speaker. Turn-taking was unaffected by the presence or absence of a visual channel (for frequency, duration and distribution of turns) and audio-only conversations were not more formal or less interactive that video-mediated conversations (there were no differences between conditions in the proportion of simultaneous speech, number of interruptions, and formal handovers of the floor). Nonetheless, there were subjective benefits of PIP: participants perceived it as having fewer inappropriate interruptions, as being less unnatural, and as best for knowing when others were listening and attending to them. The author concludes that the crucial variable is not the number and type of cues present but whether conversation is mediated by technology; mediated conversations are depersonalised, formal and show psychological distance (Sellen, 1995).

Field studies of multiparty mediated communication

The above studies were carried out in the controlled conditions of the laboratory. Other investigators (whose work is outlined in the previous chapter) have looked at the impact of multimedia communication technology in real world settings. One example is a field study by O'Conaill, Whittaker and Wilbur (1993) which compared fourteen 'real life' meetings over two quite different VMC systems - ISDN and LIVE-NET - with face-to-face meetings. LIVE-NET (London Interactive Video Education Network) is a high quality video system (with negligible delays, full duplex audio and broadcast quality video) that connects up to eight sites but does not permit eye contact. On the other hand, ISDN suffers transmission lags (from 410 msecs to 780 msecs) for both audio and video, a half-duplex line and poor video quality. All meetings were mainly about co-operation and information exchange, the face-to-face and ISDN meetings had four to seven participants and LIVE-NET meetings had seven to nine participants. In video conferences some participants shared sites and communicated face-to-face.

The authors expected that LIVE-NET and face-to-face communication would be equivalent on all measures of communication process while ISDN would lead to a more formal style of communication. Indeed, compared to face-to-face communication, ISDN conversations had fewer and longer turns, fewer interruptions, overlaps and back channels and increased formality when switching speakers. Furthermore, users were less likely to anticipate turn endings and hence complete speaker utterances, and were less likely to hold the floor with redundant phrases. ISDN communication was equivalent to face-to-face communication on only one measure: the distribution of turns between speakers. Thus the authors summarise that ISDN video communication results in a formal 'lecture style' of interaction with long turns handed over by a very deliberate process. However, contrary to predictions even LIVE-NET with high quality video and audio led to fewer back channels and more formal handovers of turns, although it was equivalent to face-to-face interaction on measures of interruptions, simultaneous starts, turn size and turn frequency. User reports confirm that VMC took more effort and that it was difficult to take conversational control. The authors believe that the greater formality of even high quality video communication is due to the absence of directional sound and vision which support cues, such as eye gaze and head turning, that co-ordinate speaker transitions.

O'Conaill and colleagues also looked at participation rates of speakers sharing conference sites in the ISDN condition. They expected that participants would rely on two group members, one at either end of the link, to channel their cross-site interactions; however they did not find this pattern of results when they compared the amounts contributed by the two most frequent speakers across the three communication conditions.

Several studies by Tang and colleagues of the use of VMC in the workplace (Tang and Isaacs, 1993; Isaacs and Tang, 1993; Tang, Isaacs and Rua, 1994), some of which were not specifically intended to measure the effect of video but were designed to describe the use of various video conferencing prototypes, nevertheless uncovered impacts of video-mediation on group communication. Tang, Isaacs and Rua (1994) carried out a longitudinal field study of a distributed work group of ten people. They found that conversations over the video channel were shorter and more task-focused with less small talk than face-to-face conversations. Yet the reasons for this are not necessarily clear cut; it is possible that video was used for shorter but more frequent discussion than face-to-face conversations, or perhaps people did not trust the reliability of the system so had quick conversations. As a direct comparison was not made, the evidence is inconclusive regarding the relative efficiency of VMC and face-to-face communication.

Tang and Isaacs (1993) describe three studies, one of which looked at a four-person work group during eight video conferences (using dedicated conference rooms), five face-to-face meetings and one phone conference. They found difficulties in negotiating turn-taking and directing participants attention in video conferences compared to face-to-face meetings: there were less frequent changes of speakers, longer turns, and less back channel feedback responses, all of which indicate a more formal and less interactive style, most probably due to the one-way, half-a-second audio delay. This appeared to suppress use of video for complex, subtle or difficult-to-manage interactions, such as those involving conflict and disagreement.

The same authors report another study of desktop video conferencing which followed a four-person distributed work team over fourteen weeks. They were observed using their existing collaboration tools (phone, e-mail) and video-taped using a desktop VMC prototype first with and then without the video capability. The researchers found benefits of video communication, for example, users were willing to suffer poor audio quality in order to use the video for interaction. Qualitative analyses of video tapes of interactions revealed that the visual channel transmitted cues that conveyed disagreement and aided handling of sensitive issues; it also facilitated turn-taking, helped interpretation of reasons for pauses in speech, and conveyed participants' attitudes. In these ways the video led to greater mutual understanding between participants. Tang and Isaacs conclude from their study that the users' desire for video results from its impact on the *process* of communication, rather than from its perceived effect on any *product* of their interaction.

Summary of VMC group research

In the above studies, those which have examined communication outcome found performance to be equally successful in VMC and face-to-face communication but that audio communication was less successful than face-to-face communication (Olson *et al.*, 1994; Anderson *et al.*, 1996). Furthermore, high quality video communication technology was found to lead to communication that is similarly interactive to face-to-face communication but which tends to be more formal, while low quality VMC leads to difficulties in turn-taking (e.g. O'Conaill *et al.*, 1993; Sellen, 1995). The process of high quality video-mediated communication has been found to differ from that of face-to-face communication, being more effortful (Olson *et al.*, 1994) and more formal (Sellen 1995) but has been found to be similar to other types of remote communication such as audio conferencing (Olson *et al.*, 1994; Sellen 1995). Indeed, Sellen (1995) argues that all technology-mediated communication, not just VMC, is depersonalised compared to face-to-face interactions. There are, however, subjective advantages for VMC over audio communication such as higher perceived social presence (Anderson *et al.*, 1997), greater ease of monitoring the attention of group members, and fewer inappropriate interruptions (Sellen, 1995). In the field, VMC has been observed to be more task-focused (Tang *et al.*, 1994) and to promote mutual understanding, but to lead to difficulties in turn-taking (Tang and Isaacs, 1993).

Of the few studies in the domain of group mediated communication, even fewer take a holistic analytical approach which combines measures of communication process and outcome and subjective user data, one notable exception being the lab study by Olson *et al.* For instance, the other group research reviewed above did not have measures of communication outcome therefore judgements of the relative efficiency of video and face-to-face communication cannot be made. This is due to either the choice of methodology - the 'real world' nature of the data in field studies does not lend itself to objective outcome assessment (e.g. O'Conaill *et al*, 1993; Tang *et al* 1993) - or the nature of the task used (for instance Sellen's (1995) participants took part in debates) - or because the index of communication outcome was not sensitive enough to differences between groups, as was the case in the lab study by Gale (1990). There is therefore a need for more research into how group communication is affected by video communication technology, especially research which 'triangulates' or employs a variety of analytical methods to arrive at conclusions, as recommended by Monk, McCarthy, Watts and Daly-Jones (1996) among others. One way of doing this is to carry out studies in a controlled lab environment which is more conducive to measures of communication outcome than field research and allows systematic comparisons to be made which can help to identify causal relationships. This is the approach adopted in study 1 reported in this chapter.

All of the above studies, apart from that of O'Conaill *et al.* (1993), have looked at VMC systems specifically designed for groups where the technology is evenly distributed amongst all participants with each person occupying a separate conference site. However, there are situations, especially in the service industry, where it is more likely that some users will be sharing facilities. Indeed, Kristoffersen and Rodden (1996), in an ethnographic study of the use of VMC in a bank's customer service call centre, noted that a feature of the work was the frequent need of the customer service advisor to collaborate with colleagues to resolve customer complaints and queries. This could potentially involve a manager or a colleague sharing a video link with the advisor in order to address the client and resolve the query since the colleague does not have direct video access to the customer as the link is between the customer and the call centre agent only.

There is very little research into how sharing of conferencing technology could affect multiparty interaction. The effect of unequally distributed multimedia communication technology on group communication and collaboration is examined in this study for a task which simulates a service encounter. The task chosen is the 'Travel Game' which has been used to explore dyadic video-mediated communication (Anderson *et al.*, 1996).

Previous research using the Travel Game

Anderson *et al.* (1996) investigated the process and outcome of dyadic communication during video-mediated, face-to-face and audio-only interaction during the Travel Game, as outlined in the literature review in chapter 2. This is a collaborative problem-solving task in which a client (the subject) has to get flight information from a travel agent (a collaborator) in order to plan a trip across the USA. The aim is to visit as many cities as possible given certain restrictions on connecting flights. In the technology conditions the task was carried out on two computers with shared screen (whiteboard) facilities run over a local area network between adjacent rooms. The video link was a 3 ½ by 4 ½ inch window, no eye contact was possible and frame rate was low at four to five frames per second[1].

Direct comparisons were made between paper-and-pencil face-to-face and audio communication, and between multimedia audio and video communication for subjective and objective measures of communication process and outcome. In the paper-and-pencil conditions, face-to-face conversations were significantly shorter than audio-only conversations, yet the level of performance was equal. This indicates that more communicative effort was required when no visual cues were available. In contrast, the addition of a video channel in the computer conditions did not improve upon communication through the audio channel alone: the dialogues were of similar length and performance scores did not differ significantly. In terms of the formality of the communication style, face-to-face and audio-only interactions were equally informal as revealed by their similar rates of interruptions, as were VMC and audio conferencing conversations. However, in the computer-

[1] Frame rate or frames per second (fps) refers to the number of times per second that a video image is updated. This is also referred to as Hertz (Hz) e.g. 50 frames per second is the same as 50 Hz. A frame rate as low as four to five fps will result in a somewhat jerky image.

mediated conversations speakers interrupted each other less often than in the paper-and-pencil conditions.

An examination of the decision-making process in terms of the number of optional changes of plan made was expected to show a greater number of optional changes in media with a greater sense of social presence. Indeed, more optional changes of plan were made when face-to-face than when communicating via the audio channel. However, VMC and audio-only interaction did not differ on this index.

Participants' subjective perceptions of the communication process and outcome were ascertained by means of questionnaires which revealed that in face-to-face and audio conditions, users found it easier to communicate and felt that social presence was higher when face-to-face, whereas participants felt that communication was equally easy and that the degree of social presence was the same in audio and video conditions. Yet, in a further Travel Game study the same authors did find subjective benefits of VMC versus audio conferencing in establishing and maintaining social presence during remote collaboration over the Internet (Anderson *et al.*, 1996; Anderson, O'Malley, Doherty-Sneddon, Langton, Newlands, Mullin, Fleming and Van der Velden, 1997). Since face-to-face communication showed advantages over audio-only communication but VMC did not, Anderson and colleagues (1996) concluded that VMC does not necessarily give the same benefits as face-to-face interaction. However, the low frame rate of the video image (four to five frames per second) could have reduced its usefulness - it has been suggested that very brief gestures and facial expressions will be lost at frame rates as low as this, hence nuances of visual behaviour which can benefit communication go unnoticed (Bruce, 1996).

The above-described Travel Game lab studies explored the impact of multimedia communication technology on dyadic communication. However, in such service environments it is likely that more than one client will be involved in the interaction, after all, people do not generally plan holidays alone but often do so in concert with a friend or relative. Therefore, for this study of group communication the above version of the Travel Game has been adapted for three participants; two participants plan a trip together with the help of a collaborator 'travel agent'. Furthermore, the task was altered in order to take advantage of some more advanced multimedia applications, specifically, a higher quality video image (25 frames per second) was provided and video clips of destinations were used to help clients in their choices, in addition to the existing on-screen map of the States and the whiteboard. In the new version of the task the emphasis is now on selection of suitable destinations, not on maximising the number of destinations, hence the number of states to be visited is limited to four and the performance measure focuses on aptness of destinations chosen. In this study, the effect on the collaboration of three-person groups of shared VMC and audio conferencing technology compared to face-to-face communication is investigated for this collaborative problem-solving task. The key research questions being addressed are:

- how does multimedia communication technology impact small group collaboration?
- does it impact all group members in the same way?
- what is the effect of sharing technology?
- are groups able to carry out the task equally successfully in technology-mediated and face-to-face communication modes?

These questions will be answered through an examination of objective and subjective indices of the process and outcome of communication.

Measures of task outcome and process

The multidimensional approach to analysis employed in this study has been used by various researchers to assess the impact of communication technology on dyadic interaction in the lab (e.g. Boyle *et al*, 1994; O'Malley *et al.*, 1994; Anderson *et al*, 1997; Doherty-Sneddon *et al.*, 1997) and variations of this type of analysis using different slightly operational definitions or transcribing methods have been used by others to investigate group interaction in the field (O'Conaill *et al.*, 1993) and in the laboratory (Sellen, 1995) (as described in chapter 2). Aspects of conversation, such as the number and length of speaking turns and interruptions made by speakers, have been used to indicate the formality and interactivity of a discussion. Several studies have found that turn-taking behaviour in VMC is less interactive and less co-ordinated than face-to-face communication, having longer and fewer speaker turns (Cohen, 1982; O'Conaill *et al.*, 1993). Others have found VMC and face-to-face communication equivalent on such measures (Sellen, 1995). As this study employs a small but high quality video link in which eye-contact is not possible, and since eye-contact is known to be important in co-ordination of speaker exchange (Beattie, 1980), it is expected that the video and audio conferencing conversations will show difficulties in speaker exchange in the form of longer speaking turns. A turn is defined as when one person in a conversation talks to the exclusion of others (in this study all utterances even very small ones such as back channels were defined as turns).

The introduction of technology may lead to difficulties in communication, for instance, in earlier studies of technology with a delay in the audio signal (of approximately 500 msecs) this led to difficulties in the co-ordination of speaker exchange as revealed by a significant rise in the total number and rate of interruptions by speakers; the delay destroyed conversational synchrony between participants (O'Malley *et al.*, 1996). Therefore, the presence of an audio delay in the technology mediated conditions of this study is expected to lead to more speaker interruptions than during the face-to-face condition. The effect on number and rate of back channel verbal feedback responses was also explored. The number and rate of interruptions (percentage of turns containing an interruption) and number and rate of back channels responses were counted in this study using the definitions employed by Boyle *et al* (1994): interruptions are points where one person begins to speak while another is already speaking and back channel responses are brief responses by the listener signalling agreement, attention or understanding, specifically the utterances 'mhm' and 'uhuh' when standing alone or repeated. However, it is not clear how the sharing of multimedia communications technology will affect the interactivity and formality of the communication. These questions will be addressed:

- what is the effect of partial technology-mediation on the interactivity of communication in terms of turn length compared to face-to-face dialogues?

- what is the effect of the delay of the audio signal in shared video-mediated and audio communication on the co-ordination of speaker exchanges in terms of number and rate of interruptions and back channel responses compared to face-to-face communication?

In addition, the efficiency of the three modes of communication will be explored. One way of assessing the efficiency of communication is to combine a measure of communication outcome with a measure of the communicative effort required to complete the task; dialogue length (in numbers of turns and words) is one index that has been used to indicate verbal effort (e.g. Anderson *et al.*, 1996). For a given level of performance on a task, a short dialogue is seen to be more efficient at transferring information than a longer dialogue. What will be the effect of technology-mediation on communicative efficiency? Previous studies have found face-to-face to be more efficient than audio communication (Boyle *et al.*, 1994) and high quality VMC with eye contact to be less efficient than face-to-face communication and VMC without eye contact (Doherty-Sneddon *et al.*, 1997). In this study it is expected that face-to-face communication will result in the most efficient and audio conferencing technology the least efficient communication, with high quality VMC (without eye-contact) falling between the two other media. Therefore, the following experimental hypotheses were tested:

- face-to-face dialogues will be significantly shorter, in number of words and turns, than video-mediated and audio conferencing dialogues
- video-mediated dialogues will be significantly shorter in number of words and turns than dialogues in audio conferencing
- no difference is expected between the three conditions in terms of task performance, as measured by how well participants justify their choices of destination and follow the task rules.
- it is expected that face-to-face communication will be most efficient followed by VMC, and audio conferencing will lead to the least efficient communication.

Yet the methods of analyses employed here go beyond those described above which look at the microstructure or the superficial structure of dialogues. As the communication of groups is under investigation, a further level of dialogue structure is explored: the patterns of speaker interaction. What will be the effect of sharing multimedia communications technology on the communication of the different group members and on how they interact with one another? Will they be affected differently? An analysis of the patterns of participation involves examining how often the individuals in a group speak to each other, how much they say and to whom they say it, specifically, the numbers of words and turns exchanged and the numbers of sequences of three or more exchanges (pairwise conversations) between pairs of speakers are calculated and communicative contexts are compared. This type of analysis was developed by Carletta and colleagues (Carletta, Garrod and Fraser-Krauss, 1998; Carletta, McEwan and Anderson, 1998) based on the work of Parker (1988) and Stasser and Taylor (1991), to examine the patterns of participation and influence in face-to-face and video-mediated group business meetings. These analyses allow differentiation between communication which is mediated by technology and that which is co-present in the audio and video-mediated conditions. The hypotheses being tested are

- technology-mediated interactions will be less interactive than face-to-face interactions as shown by longer speaking turns.
- technology-mediated interactions will be less co-ordinated, as shown by more interruptions, than face-to-face interactions due to the audio lag.

Thirty-six three-person groups completed a problem-solving task in one of three communication conditions: face-to-face communication, shared high quality VMC or shared audio conferencing.

3.2 Method

Participants

Seventy-two students and two collaborators - a research assistant and a postgraduate student - of Glasgow University took part in this laboratory experiment for cash payment.

Design

Participants took part in the experimental sessions in groups of three consisting of a pair of students who knew one another[2], and a collaborator with whom they were not familiar. Each pair of participants took part in only one communication condition either face-to-face, VMC or audio communication. Each collaborator took part in half of the twelve face-to-face and half of the twelve VMC sessions. Only one of the collaborators was available to take part in the twelve audio conferencing sessions.

Task

As already outlined in the introduction to this chapter, the task is a simulated service encounter the 'Travel Game' (Anderson *et al.*, 1996), a collaborative task originally involving two people but adapted for three participants. Participants interact with a collaborator acting as a travel agent in order to plan a trip across the United States. They are permitted to make stops in only four states, travelling from east to west, and taking only direct flights between states. This task was designed to elicit natural and spontaneous dialogues within a content-controlled framework. Participants were given the following information about the task:

> Your task is to plan a holiday for yourselves and two friends travelling in the USA. Introduce yourselves to the travel agent and explain that you want to plan a 22 day trip for four people using your air travel pass.
> At the end of the session you will be asked to provide a short explanation of your chosen travel plan. Independent judges will assess these plans and the best holiday plan will win the first prize of 40 pounds.

In addition, participants were informed that their choices of destinations had to satisfy the preferences of not only themselves but two fictional travelling companions with specific interests. The instructions they were given are as follow:

[2] Subjects who were familiar with one another were recruited to participate together as it was considered to be more realistic to plan a holiday with a friend.

You are travelling with two friends who have different interests:

- Sue who likes the great outdoors, hiking, rock climbing etc. She has not travelled much before and is slightly nervous of big cities (but is willing to give it a go for a bit, if you're interested)
- Tom who is a history and culture enthusiast
- Both of you who like.... (Use your own preferences here but don't forget to include them in your justification)

They were also informed of the information available to them in order to complete the task and how to access this, for instance, they were told that the travel agent could send them video clips of destinations that were marked with a red icon on the on-screen map. They were told they had 30 minutes discussion time but this time limit was not strictly enforced. A full copy of instructions to participants is given in appendices A and B.

Procedure

In the technology-mediated conditions, the participants were located together in one room and sat side-by-side on swivel chairs in front of a shared computer terminal while the collaborator was in a separate room seated in front of another computer. In the face-to-face condition, all participants sat together on swivel chairs in front of one terminal.

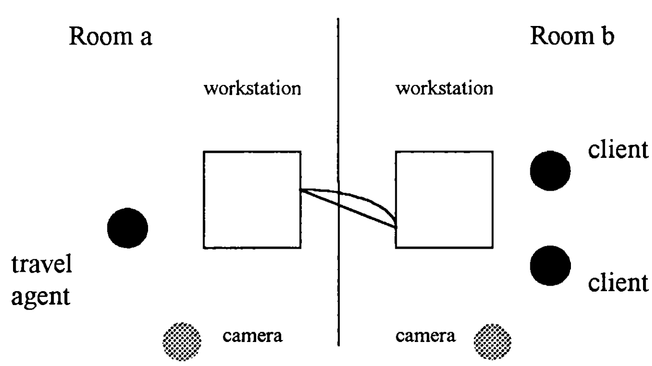
The participants were instructed that they had to choose destinations that met the interests of all those travelling in their party. Having chosen their four destinations, the participants then collaboratively justified their choice of destinations in roughly sixty words. The justifications were scored independently according to a set marking scheme in order to provide a measure of performance and the best justification received a £40 prize. Post-task user evaluation questionnaires were completed by all subjects.

The experimental hypotheses were not known to the travel agents. They were asked to be equally helpful to all clients and to allow clients to solve their own problems whenever possible. (See appendix C for a copy of the instructions to collaborators).

Apparatus and technological set up

In the video-mediated and audio conditions, the two participants were seated side-by-side sharing a SunSparc20 workstation while the collaborator was in a separate room in the same building seated in front of a second workstation (see Figure 3-1). The simulation was run over a dedicated local area network (LAN) between the two SunSparc20 workstations. In the VMC condition both agent and 'clients' saw a video image of the remote participant(s). In the audio condition the set up was identical apart from the absence of any video link. In the VMC condition, two JVC videomovie GR-AX60 compact VHS camcorders provided the video images. One was placed to the left hand side of client work station and the other to right of agent workstation therefore eye contact was not possible. Participants were informed that in order to appear to be making eye contact with the collaborator they must look into the camera lens. The colour video link was of high quality with a 25 frames per second refresh rate. The video image contained 384 by 288 pixels and was 5.3 inches wide by 3.9 inches high appearing in the top left-hand corner of the computer screen.

Figure 3-1 Technology-mediated communication set-up



'Hands free' audio communication was possible in the video and audio conditions, however, each party wore headphones to prevent the microphone picking up transmitted signals and generating feedback. There was an audio delay of approximately 500 msecs in both technology-mediated conditions; this meant that in the video condition the audio and video channels were not in synchronisation with each other with the audio signal arriving shortly after the video signal.[3] For methodological reasons a comparable audio delay was present in the audio condition.

The tools and data required to complete the task - including a map of the USA, a shared itinerary window and, in the video condition, a video image of the remote participants[4] - were presented on the computer terminal interfaces. The map, which could be scrolled around, showed the names of the states and red diamond-shaped icons indicated the availability of a video clip. The map was scrolled by using a mouse which either participant could reach easily.

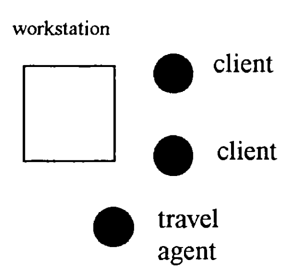
The travel agent held details of the direct flights available and could download multimedia files containing full motion video images (12 frames per second refresh rate) and text about various destinations. She/he was required to log the clients' itinerary on a shared whiteboard and was also provided with other general information on places to visit.

---

[3] This audio delay was due to a lag of approximately 2 to 5 seconds in the video card initialising. While this initialisation took place, the handling of data throughput was frozen; when processing of the audio input or output started during initialisation of the video card, a delay in the throughput and processing of the audio data occurred which lasted throughout the session.
[4] The video conference software was custom written for the Travel Game study by R. MacDonald while at the Multimedia Communications Group at the Department of Psychology, University of Glasgow.

In the face-to-face condition, all three participants were co-present seated side-by-side sharing one Sun workstation (see Figure 3-2). In the face-to-face condition, since the video clips and flight information were only accessible from one terminal while the videos could only be viewed from the other terminal, a mock-up of the process of accessing these data was required. This was achieved by having the agent pretend that she/he was accessing video and flight information by typing on the keyboard while at the appropriate moment the experimenter, who was listening in to the session from another room, would send a video or type flight information into the shared itinerary window and send it to the client machine. Instructions to the travel agent are given in appendix E. None of the clients was aware that it was not the agent who was controlling access to the data.

Figure 3-2 Face-to-face communication set-up



All sessions were video recorded on Konica super HG VHS tapes and in the remote conditions were audio recorded on Maxwell normal position cassettes on an AIWA stereo cassette deck XK-007 Excelia. In the face-to-face condition, sessions were recorded onto two channels, one for the participants and one for the collaborator, of a Sony Professional Walkman WM-D6C. Two lapel mikes picked up the signals - one worn by the collaborator and the second placed in front of the two subjects.

Analysis and results

All thirty-six three-person discussions were audio recorded and then orthographically transcribed including filled pauses, false starts, repetitions, back channel responses and interruptions.

Performance data

Subsequent to each experimental session, the pairs of participants collaboratively justified their choice of holiday destinations. Two independent judges scored all thirty-six participant justifications according to a set marking scheme, a summary of which is shown in

Figure 3-3, the full version is included in appendix D. Marks were awarded on the basis of the number of travellers pleased by each destination and the number of valid reasons given for visiting each state, while marks were deducted for choosing a large city and breaking the travel pass rules.

Inter-judge agreement was assessed by means of a Spearman rank order coefficient and the scores given by the two judges were found to be significantly positively correlated (r_s=.89, **p**=.001). A one-way ANOVA for independent groups revealed that there were no significant differences in performance quality between the three communication conditions, audio, video or face-to-face, as expected (**F**<1). (Mean performance ratings audio: 11.1, SD: 6.2; VMC: 14.1, SD: 5.5 face-to-face: 11.9, SD: 4.8). This was not due to a ceiling effect as there was a wide range of scores in each condition (from 2 to 25). Similar to the results of the dyadic Travel Game study by Anderson and colleagues (1996) (although for a different measure of performance), no significant differences in level of performance were found between the communication contexts in which participants were similarly successful in justifying their destination choices. An example of a justification and the marks it received can be seen in Figure 3-4.

Figure 3-3 Guidelines for awarding marks to justifications

Content of justification	**Points awarded**
For each valid reason for choosing a destination	One point
only two travellers stated as pleased by the choice of four destinations	One point
three travellers stated as pleased by the choice of four destinations	Two points
all four travellers stated as pleased by the choice of four destinations	Three points
a large city destination (Los Angeles, New York and Chicago only).	Minus one point (unless they have given a reason as to why Sue, who dislikes big cities, will be happy with going to a big city area).
each violation of flight rules	Minus one point
any other violation of rules (e.g. east to west only rule)	Minus one point

Figure 3-4 A moderately scoring justification from a face-to-face group

Justification	**Points awarded**
New York: everybody will enjoy big new cities,	1 point for valid reason
tom will have loads of cultural challenges,	1 point for valid reason
Joe and John will enjoy the city	1 point for valid reason
and partying	1 point for valid reason
new orleans: partying	1 point for valid reason
and culture again	1 point for valid reason
stay in the French quarter	1 point for valid reason
and we will drive to Florida to see the swamps and 'gators	1 point for valid reason
Arizona: mesa verde and grand canyon great outdoors	1 point for valid reason
and Indian culture	1 point for valid reason
camp out in Yellowstone	1 point for valid reason
San Francisco : chilling out	1 point for valid reason
No violations of flight rules	-
New York is big city destination (not specified why Sue would be happy to go).	minus 1 point
Three travellers specifically stated as being pleased by four destinations	2 points
TOTAL	**14 points**

3.3 Dialogue analyses

The first analyses of the communication process carried out are at the level of the dialogue, thus do not differentiate between communication in the two technology-mediated conditions which was truly mediated and that which was co-present. For the purposes of this results section, the technology conditions will be referred to as the audio conferencing and video-mediated communication contexts, with it being understood that these refer to interaction that was partially audio- and video-mediated[5].

Effect of communication medium on dialogue surface structure

For each measure of dialogue structure - dialogue length in words and turns, turn length, interruptions and back channel responses - a 3 by 3 analysis of variance (ANOVA) was carried out. Communication medium (three levels: face-to-face, video-mediated, and audio) is a between groups factor; and participant role (three levels: the travel agent, client 1 (the client who speaks first), and client 2 (the client who speaks second)) is a within dialogue repeated measure. As the focus of this investigation is on dialogue structure, the dialogue is the unit of analysis rather than each participant's separate contributions.

Since the focus of the analysis is on the impact of communicative context on the communication process, only the main effects of context and the interaction effects are stated below. The effects at the level of participant role, which were all statistically significant, are summarised here. Client 1 said significantly more words than the other two group members (**F** $(2,66)=8.7$, **p**$<.001$); the clients took significantly more turns than the travel agent, and client 1 took significantly more turns than client 2 (**F** $(2, 66)=37.4$, **p**$<.001$); the agent took significantly longer speaking turns than the clients, and client 1 took significantly longer turns than client 2 (**F** $(2, 66)=10.8$, **p**$<.001$); made significantly less interruptions (**F** $(2,66)=18.9$, **p**$<.001$) and interrupted at a significantly lower rate than the clients (**F**$(2,66)=17.3$, **p**$<.001$), made significantly more back channel responses

[5] See glossary in Appendix V for a definition of this term.

(**F**(2,66)=6.7, **p**<.01) and had a significantly higher rate of back channels than the clients (**F**(2,66)=6.9, **p**<.01). In sum, to complete the task one client (the one who spoke to the agent first) did significantly more talking and took significantly more turns in the conversation than the travel agent and other client, while the agent appears to have had a less interactive style of communication as revealed by longer speaking turns and fewer interruptions, but provided more verbal feedback than the clients in the form of back channels.

Dialogue length in words

There was no significant main effect of communicative context on the length of the dialogues (in number of words) contrary to the expectation that technology-mediated dialogues would be significantly longer than face-to-face dialogues (**F**<1.5). There was a significant interaction of role and medium on number of words uttered (**F** (4,66)=2.7, **p**<.05). Post-hoc analyses of the simple main effects revealed that this interaction effect was due to differences between speakers within the VMC (**F** (2,66)=5.3, **p**<.01) and audio (**F** (2,66)=7.1, **p**<.01) conditions, but not within the face-to-face condition (**F**<2). Planned comparison multiple t-tests showed that in VMC, client 1 said significantly more than both client 2 (**t**(11)=2.3, **p**<.05) and the travel agent (**t**(11)=3.1, **p**<.05) who did not differ from one another (**t**<1). In audio conferences client 1 said significantly more than the travel agent (**t**(11)=3.3, **p**<.01) but not more than client 2 (**t**<2), and client 2 and the travel agent did not differ significantly from one another in the amount of words they said (**t**<2). Table 3.1 below shows the mean number of words uttered.

Table 3.1 Mean number of words spoken by role and communication condition

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	1284.0 (414.6)	1154.2 (298.4)	948.3 (318.8)
client 1	1206.6 (334.4)	1708.5 (734.6)	1672.2 (669.5)
client 2	948.4 (564.3)	1173.7 (460.0)	1251.1 (436.4)
overall mean	3439.0 (769.8)	4036.4 (1127.2)	3871.6 (925.6)

Dialogue length in speaker turns

Further analyses investigated the impact of the communications technologies on how the words spoken were distributed in speaking turns throughout the dialogues. The dependent variable is the total number of speaking turns. A mixed design ANOVA revealed no effect of communication medium or interaction of medium with participant role on the number of speaking turns (**Fs**<2). Table 3.2 gives the mean number of turns by participant and communication context.

Table 3.2 Mean number of speaker turns per dialogue

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	116.0 (21.9)	107.0 (26.8)	96.3 (22.1)
client 1	150.7 (33.3)	172.2 (52.0)	166.8 (46.2)
client 2	125.3 (57.7)	149.9 (39.0)	141.3 (34.5)
overall mean	391.9 (92.1)	429.1 (108.5)	404.5 (81.8)

There are no significant differences between communication media in the amount of verbal effort required to complete the task to a similar level of performance. However, there is a tendency for VMC dialogues to be the longest and face-to-face dialogues the shortest. Groups in the video context contribute an average of almost 18% more words and take nearly 10% more turns to complete the task than face-to-face groups. Audio dialogues occupy an intermediate position in terms of numbers of words and turns taken to complete the task. The greater length of technology-mediated dialogues is largely due to one individual (client 1) contributing more to the discussion - around 40% more words in the VMC and audio conditions than in the face-to-face condition (although these differences are not statistically significant). Furthermore, there are significant differences between speakers in how much they contribute to discussions in the technology-mediated contexts but not in the face-to-face context. Again one individual (client 1) says more than the other group members when there is an element of technology-mediation.

Interactivity and formality of communication

What effect will partial technology-mediation have on the interactivity and formality of the communication? Perhaps differences between communication contexts in communication style will be apparent from an examination of the length of speaker turns, number of interruptions, and back channel responses.

Firstly, the length of speaker turns (in words) was calculated and compared between the three communication conditions. There was no significant effect of context (**F**<1) and no interaction of role and context on turn length (**F**<2). In VMC and audio communication, turns tend to be only half a word longer on average, as shown in Table 3.3, thus the communication in all contexts appears to be equally interactive.

Table 3.3 Mean number of words per turn (turn length)

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	11.3 (4.2)	10.8 (1.1)	9.9 (2.1)
client 1	8.1 (1.7)	9.7 (2.5)	9.8 (2.6)
client 2	7.3 (1.9)	7.8 (2.2)	8.8 (2.7)
overall mean	8.9 (1.7)	9.4 (1.2)	9.5 (1.2)

Another measure of speaker co-ordination is the number of times speakers interrupt one another. There is evidence that a delayed audio signal, which was present in the technology conditions of this study, will lead to difficulties in speaker co-ordination which is reflected in a greater amount of interruptive speech (O'Malley *et al.*, 1996). What effect will partial technology-mediation have on speaker co-ordination? The analyses of numbers of interruptions show that there were no significant differences between contexts (**F**<2) and no interaction of role and context (**F**<1.5). Despite the noticeable audio delay in mediated interactions, the overall number of interruptions did not differ significantly from face-to-face communication. The mean numbers of interruptions presented in Table 3.4 show that there is nonetheless a tendency for approximately 30% fewer interruptions in the face-to-face than in the technology-mediated dialogues.

Table 3.4 Mean number of interruptions

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	8.3 (5.4)	11.6 (4.4)	14.5 (9.3)
client 1	16.3 (7.8)	23.8 (11.8)	19.6 (10.3)
client 2	14.0 (8.3)	20.1 (10.2)	19.0 (11.7)
overall mean	38.7 (16.5)	55.5 (23.9)	53.1 (27.4)

The rate of interruptions was also calculated to control for the slightly different lengths of dialogues in the three conditions. This was calculated as the percentage of turns containing an interruption. An ANOVA showed no statistically significant differences between the three communication contexts in the rate of interruptions (**F**<2) and no interaction of role and context (**F**<1). The mean interruption rates shown in Table 3.5 below again show a tendency for less interruptive speech in the face-to-face condition.

Table 3.5 Mean rate of interruptions

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	2.2 (1.2)	2.7 (0.9)	3.7 (2.4)
client 1	4.3 (2.0)	5.4 (1.8)	4.8 (2.2)
client 2	3.5 (1.8)	4.7 (2.1)	4.5 (2.3)
overall mean	9.95 (3.7)	12.8 (3.8)	13 (5.8)

Number of back channel responses

Next the effect of communication medium on the verbal feedback behaviour of groups was investigated. A mixed design ANOVA showed a significant effect of communication context (**F**$(1,33)=6.6$, **p**$<.01$), but no interaction of role and context (**F**<2). Planned comparison t-tests showed that audio conferences had significantly fewer back channel responses than either face-to-face (**t**$(22)=3.3$, **p**$<.01$) or video-mediated communication (**t**$(22)=3.97$, **p**$<.01$), which did not differ significantly from one another (**t**<1). The mean numbers of back channels are given in Table 3.6.

Table 3.6 Number of back channel responses

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	11.4 (6.3)	16.2 (7.0)	5.6 (3.1)
client 1	8.2 (10.0)	3.9 (3.7)	3.1 (3.0)
client 2	9.5 (13.7)	5.8 (7.9)	3.3 (3.1)
overall mean	29.1 (17.6)	25.8 (11.1)	11.9 (5.0)

Rate of back channel responses

The back channel data were normalised to control for differences in dialogue length between conditions. The rate of back channel responses was calculated as the percent of turns which were back channels. An ANOVA revealed a significant effect of context on the rate of back channels (**F**(1,33)=6.4, **p**< .01) but no interaction of role and context (**F**<2). Post hoc planned comparison t-tests show that the audio condition had a significantly lower rate of back channel responses than either VMC (**t** (22)=3.3, **p**< .01) or face-to-face communication (**t** (22)=3.4, **p**< .01), less than half the rate as can be seen from Table 3.7. Face-to-face and VMC did not differ significantly in rate of back channel responses (**t**<1).

Table 3.7 Back channel rate

	Communication condition		
Participant role	**Face-to-face**	**VMC**	**Audio**
agent	3.2 (2.2)	4.0 (2.1)	1.4 (0.8)
client 1	2.2 (2.8)	1.0 (1.1)	0.8 (0.9)
client 2	2.1 (2.7)	1.5 (1.9)	0.9 (0.9)
overall mean	7.5 (4.2)	6.5 (3.0)	3.1 (1.7)

Summary

In the study, small groups collaborated equally successfully when interacting face-to-face or supported by video or audio conference links. Technology-mediation was not found to have significant impacts on the communication process in terms of efficiency, interactivity or formality. Similar communicative effort was found in all contexts in terms of the number of words and turns contributed, and the three communication modes appear to be equally successful for performing the task, hence the three media are interpreted as being equally efficient. The measures of interactivity and formality of the interactions - turn length and number and rate of interruptions by speakers - are similar across media. There were, however, differences in how equally group members participated in the discussions with significant differences between speakers in the amount of words and turns they contributed to discussions in the technology conditions. In the shared VMC context, one client (client 1) contributed significantly more words to the discussion than the agent and other client, while in the audio conference context one client (client 1) said significantly more than the agent to complete the task.

The only significant difference in communication process is in the number and rate of back channel feedback responses: both face-to-face and VMC have significantly more of these utterances than audio conferencing communication. As there was an audio delay in both of the technology conditions, this cannot be responsible for the results but audio conference participants may have had more difficulties in co-ordinating their conversation due to the lack of a visual channel; in video communication, the presence of the video image may have helped with co-ordination of turn-taking. These findings appear to indicate that the presence of a technology-mediated element does not affect the overall efficacy of the communication process and outcome in comparison to face-to-face communication, at least for this type of problem-solving task. However, as the above comparisons do not differentiate between communication which was technology-mediated and that which was co-present in the video and audio conditions further analyses were carried out.

Patterns of participation in face-to-face, video-mediated and audio-only dialogues

The above analyses of the overall dialogue surface structure showed that partial technology-mediation[6] had relatively little impact on the communication process compared to face-to-face communication. However, as already stated, in both technology-mediated conditions some of the interaction was co-present due to the unequal distribution of the technology. In order to assess the effect of the technology alone it is necessary to analyse the co-present and technology-mediated interactions in the video and audio contexts separately. One way of investigating the impact of the technology upon the interactions is to compare truly technology-mediated conversations with equivalent conversations (comparing speakers with the same roles) in face-to-face communication.

We know already from the analyses carried out thus far that in the technology-mediated contexts the dialogues have a tendency to be slightly longer than the face-to-face dialogues. Perhaps the increase in verbal effort is due to the interactions which were technology-mediated. If this is true, then there should be more interaction between the remotely located participants, that is, between the travel agent and each client, than in face-to-face dialogues. The amount the two clients interact with one another should not be affected since these participants were at the same site in each of the three communicative contexts. Therefore a different way of looking at the interaction is required. This is provided by an analysis of the 'patterns of participation' which focuses on patterns of turn-taking independent of the content of the turns. This involves looking at how much the different pairs of participants in the three-person groups interact. As the speakers in each group have different roles, the three combinations of conversational partners are as follow: the travel agent and client 1; the travel agent and client 2; client 1 and client 2. The first two pairs of speakers communicate via technology and the last pair is co-present, hence the following analyses separate the truly technology-mediated (cross-site) communication from that which was co-present (same-site) in the audio and video contexts.

---

[6] See glossary in Appendix V for a definition of this term.

The pattern of participation analyses exploit the fact that group discussion is typically made up of a series of conversations between pairs of individuals and that adjacent contributions in group discussions are typically related by their relevance to each other. It is possible, therefore, to identify who is addressing whom by examining the order of speaker turns (Parker 1988; Stasser and Taylor, 1991). A series of three or more exchanges between two individuals can be used to indicate the occurrence of a conversation between them (Carletta, Garrod and Fraser-Krauss, 1998). The amount of interaction between different pairs of participants can be indicated by the number of turns they exchange, the number of sequences of three or more turns, or 'pairwise conversations' (i.e. a speaker A - speaker B - speaker A pattern of exchanges) they engage in and the amount of words and turns they exchange within such conversations. These indices will be used to explore the interactive effort of pairs of speakers. The question being addressed is: will the technology-mediated conversations be more effortful than face-to-face conversations? It is predicted that

- technology-mediated conversations will take more interactive effort, that is, more words and turns will be exchanged, than in comparable face-to-face interactions.
- co-present conversations between pairs of speakers will not differ in the amount of interactive effort in pairwise conversations, words and turns between conditions

In addition, the communicative style of the face-to-face and technology-mediated exchanges in terms of their interactivity and co-ordination of speaker exchanges will be explored through an analysis of turn length in pairwise conversations and the rate of interruptions. It is predicted that technology-mediated conversations will be less co-ordinated and less interactive than face-to-face conversations, thus the hypotheses to be tested are

- technology-mediated conversations will be less interactive, that is, the turns will be longer than in comparable face-to-face interactions.

- co-present conversations between pairs of speakers will not differ in interactivity between conditions
- the audio delay in technology-mediated interactions will disrupt speaker co-ordination resulting in more interruptions than in equivalent face-to-face interactions

For each variable examined a 3 by 3 mixed design ANOVA was performed with communication context as a between groups variable (three levels: face-to-face, audio and VMC) and pair of conversational partners as a within dialogue repeated measure (three levels, one for each of the three combinations of participants: the two clients, the collaborator and the client who spoke first (client 1), and the collaborator and the client who spoke second (client 2)). The dependent variables are the number of turns exchanged, the number of pairwise conversations, the average length of these conversations in words and turns, the length of turns in pairwise conversations, and the rate of speaker interruptions. For completeness, the main effect of pair of conversational partners is reported but as this is not the focus of the investigation post hoc tests have not been performed.

Who speaks after whom

The number of times each pair of speakers addressed one another was calculated for each three-person group. This involved counting the number of times that each participant spoke after each other participant[7], then the total number of exchanges between each pair was calculated by adding together how often each member of the pair spoke after the other member of the pair.[8] An ANOVA, as described above, was performed to compare audio, VMC and face-to-face communication contexts for the interaction between the three possible pairs of conversational partners. The dependent variable is the number of times each group member spoke after each other group member, otherwise referred to as the

[7] This was done using a program written by J. Carletta of the Human Communication Research Centre, University of Edinburgh.

[8] For example, if the agent's turns preceded those of client 1 10 times and client 1's turns preceded those of the agent 6 times then the number of exchanges for this pair would equal 16. In this analysis, exchanges are not exactly equivalent to turns due to the fact that a turn interrupted by a back channel would be counted as two exchanges - one before and one after the back channel- rather than one. Thus exchanges are more numerous than turns.

number of conversational exchanges between pairs of speakers. There were no statistically significant differences between communication contexts (**F**=1), there was a significant effect of the pair of conversational partners (**F**(2,66)=46.1, **p**<.001), but no interaction effect (**F**<2). However, due to the expectation that context would have an influence on the amount of exchanges between different pairs of conversational partners, planned comparison t-tests were nonetheless carried out. These revealed that in the VMC condition there were significantly more exchanges, over 35% more, between the clients than in the face-to-face condition (**t**(22)=2.1, **p**<.05), that is, the clients exchanged more utterances between themselves when the travel agent was remote compared to when he/she was in the same room with them, despite these interactions being co-present. A similar pattern of results was found in the audio conferencing condition in which there was a tendency for the co-present clients to make an average of 22% more exchanges when the agent was remote than when he/she was co-present in the face-to-face context, although this comparison did not reach statistical significance (**t**<1.5). The number of exchanges between the clients in the two remote conditions did not differ significantly (**t**<1). The number of times the agent and each client made conversational exchanges was relatively unaffected by communication medium (**ts**<1.5). This is an unusual result since it was expected that the amount of technology-mediated talk would be greater than in comparable face-to-face interactions. The mean numbers of exchanges for each pair of conversational partners are shown in Table 3.8.

Table 3.8 Mean number of exchanges between participants in VMC, face-to-face and audio conditions.

	Pair of conversational partners		
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	192.0 (86.5)	163.5 (57.4)	96.3 (49.95)
VMC	264.2 (79.2)	151.6 (62.6)	93.0 (45.2)
audio	234.7 (80.1)	136.6 (36.4)	81.8 (36.4)

The shaded boxes indicate talk that was technology-mediated.

The analysis of the pattern of speaker exchanges has revealed a surprising pattern of results. The interaction between the agent and participants or 'clients' seems to stay relatively stable across all three conditions, despite being mediated by technology in the audio and video contexts. However, the clients' interactions were significantly affected by the technology: there were more conversational exchanges between co-present clients in technology-mediated interactions. Further analyses were carried out to verify this unexpected and unusual finding.

Conversations between pairs of technology-mediated and co-present participants

Another way of analysing the interaction is to identify sequences of three or more exchanges between pairs of speakers referred to as 'pairwise conversations'. The greater the number of pairwise conversations in a discussion, the less true group conversation. The number of such pairwise conversations was counted and the three communication contexts were compared. An ANOVA showed that there were no significant differences between the three communicative contexts for the number of conversations (**F**<1.5). There was a significance difference between pairs of speakers (**F**(2,66)=27.9, **p**<.001) but no significant interaction effect (**F**=1). However, since it was hypothesised that technology-mediation would affect the pairs of speakers differently, planned multiple comparison t-tests were carried out. These revealed that there were significantly more conversations between the co-located clients in the video than in the audio context ($t(22)=2.3$, $p<.05$), no differences in the numbers of conversations between clients in the remote conditions compared to the face-to-face condition ($ts<1.5$), but no differences in the amount of conversations between the agent and clients in the technology conditions than when they were co-present in the face-to-face condition ($ts<1.5$), as had been predicted at the outset. Table 3.9 gives the mean numbers of pairwise conversations. The pattern of results is slightly different to those of the other analyses of participation patterns in that the conditions which differ most are the remote ones, not the video and face-to-face contexts. It is hoped that a more detailed level of analysis will illuminate this.

Table 3.9 Number of conversations

Pair of conversational partners			
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	35.5 (14.3)	32.4 (7.0)	22.0 (13.2)
VMC	40.5 (12.5)	34.3 (14.0)	18.1 (11.7)
audio	30.4 (9.0)	29.9 (12.4)	17.9 (9.6)

The shaded boxes indicate talk that was technology-mediated.

Number of words exchanged in conversations

An analysis of the number of two-party conversations does not take into account how much was said during these interactions, therefore the number of words uttered during these conversations was compared between communicative modes. A mixed design 3 by 3 ANOVA showed that there was a statistically significant difference between the amount the different pairs of speakers interacted ($F(2,66)=29.7$, $p<.001$), there was no difference between the contexts ($F<1.5$)

and no interaction effect (**F**<2). In any case, planned multiple comparison t-tests were performed due to the expectation that technology-mediation would lead to more interaction between pairs of participants. Contrary to the hypothesis, these indicated that there were significantly more words, around 45% more, exchanged between the two clients when the agent was remote over the video link than in the face-to-face condition when he/she was in the same room (**t**(22)=2.1, **p**<.05) and the clients said an almost significantly higher amount to one another when the agent was across an audio link (**t**(22)=2.0, **p**=.053). The VMC and audio contexts did not differ significantly in how much the clients said to one another (**t**<1) and the number of words exchanged by the agent and each client did not differ between communicative contexts (**ts**<1), even though these conversations were technology-mediated in the remote conditions. These findings are similar to the results of the analysis of the order of speaker turn-taking. The mean numbers of words exchanged are shown below in Table 3.10.

Table 3.10 Numbers of words exchanged in same-site versus cross-site conversations

	Pair of speakers		
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	1338.1 (671.4)	1297.4 (627.2)	575.8 (442.6)
VMC	1944.7 (748.7)	1221.5 (632.6)	566.7 (451.3)
audio	1928 (740.8)	1077.2 (493.6)	587.6 (430.4)

The shaded boxes indicate talk that was technology-mediated.

Number of exchanges in conversations

The way in which words were distributed in exchanges during conversations was also examined. An ANOVA revealed that there were significant differences between different pairs of conversational partners (**F**(2,66)=39.8, **p**<.001), no significant differences between communication contexts (**F**<1) and no interaction effect (**F**<2). However, as more interaction was expected between pairs of conversational partners who communicated via conferencing technology, planned comparison t-tests were carried out. These indicated a nearly significant difference in the amount of exchanges which the two clients made when they were remote from the travel agent in the video condition compared to during the face-to-face condition (**t**(22)=1.9, **p**=.078). The number of exchanges between the clients in pairwise conversations did not differ significantly between the audio and face-to-face contexts (**t**<1.5) or between the video and audio contexts (**t**<1). The turns exchanged between the travel agent and each client were similar across communication conditions (**ts**<1). This finding follows the same pattern as the analyses of words and order of speaker contributions.

Table 3.11 Number of exchanges in two-party conversations between pairs of participants

	Pair of conversational partners		
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	182.4 (89.9)	155.0 (63.5)	76.3 (50.3)
VMC	248.5 (85.4)	140.2 (68.7)	68.5 (51.7)
audio	223.5 (85.5)	127.4 (50.5)	64.0 (38.1)

The shaded boxes indicate talk which was technology-mediated.

All of these analyses reveal the same general pattern of results: the two co-present clients interacted more with each other in terms of total exchanges, and number of words and exchanges made during pairwise conversations in the video condition, and to a lesser extent in the audio condition, than when the agent was face-to-face. Yet, the conversations of clients with the travel agent were relatively unaffected, contrary to expectations that the communication technology would make these interactions more effortful. Unusually, the communication technology only impacted the communication patterns of those group members who shared a conference site.

The interactivity of technology-mediated conversations

The interactivity and co-ordination of turn exchange of mediated and co-present talk were also investigated through an analysis of two types of data: the length of exchanges (in words) in pairwise conversations and the rate at which speakers interrupted each other. If technology-mediation leads to less interactive talk, remote talk between agent and clients should contain longer speaking exchanges than when they communicate face-to-face. If the audio delay is problematic for conversation co-ordination there should be a higher rate of interruptions in mediated than in face-to-face conversations.

Length of turns in mediated communication

A 3 by 3 ANOVA revealed no differences between contexts ($\mathbf{F}<1.5$) and no interaction of context and pair of conversational partners in the length of turns in pairwise conversations ($\mathbf{F}=1$). There was a significant main effect of pair of conversational partners ($\mathbf{F}(2,66)=27.9$, $\mathbf{p}<.001$). However, given the strong expectation of an interaction effect, planned multiple comparisons t-tests were nevertheless performed. Unexpectedly, the significant difference between contexts is not due to longer turns in mediated conversations between both clients and the travel agent than when face-to-face ($\mathbf{ts}<1.5$). Instead, turns were significantly longer between same-site clients in the audio conference condition when the agent was remote than in the face-to-face context when she/he was seated next to them ($\mathbf{t}(22)=2.9$, $\mathbf{p}<.01$). There was an almost significantly longer turn length between the same two individuals when the agent was communicating via video rather than audio conferencing ($\mathbf{t}(22)=2.0$, $\mathbf{p}=.057$), but no difference between the video and face-to-face condition ($\mathbf{t}<1$). Table 3.12 gives the mean turn lengths which show that the clients exchanged turns which were on average one-and-a-half words longer when the agent was remote. This is an unusual pattern of results and seems to suggest that there may be a reason other than lack of interactivity for the long turns exchanged between the co-located clients.

Table 3.12 Mean turn length in pairwise conversations cross- and same-site

Pair of conversational partners			
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	7.4 (1.0)	8.2 (2.0)	7.5 (2.2)
VMC	7.8 (1.1)	8.6 (1.3)	7.5 (2.6)
audio	8.7 (1.1)	8.4 (1.2)	8.8 (2.2)

The shaded boxes indicate talk that was technology-mediated.

Rate of interruptions

Co-ordination of turn-taking in mediated and co-present interactions was investigated through an analysis of the rate of interruptions. It was expected that same-site interruptions between the two clients would not differ between contexts as they never spoke to one another across the link, but that the interruptions over the conference link, i.e., between the collaborator and the clients, would be significantly higher in the video and audio contexts due to the presence of a delayed audio signal. For each pair of speakers, the proportion of exchanges in which they interrupted each other was calculated. A 3 by 3 ANOVA revealed a pattern of results very close to that which was predicted. There was a significant effect of communication context ($\mathbf{F}(2,33)=3.3$, $\mathbf{p}<.05$), a significant effect of pair of conversational partners ($\mathbf{F}(2,66)=6.8$, $\mathbf{p}<.01$) and a significant interaction effect upon the rate of speaker interruptions ($\mathbf{F}(4,66)=3.3$, $\mathbf{p}<.05$).

Planned comparison t-tests show that there was a significantly higher rate of interruptions between the travel agent and client 1 when they communicated via video ($\mathbf{t}(22)=5.4$, $\mathbf{p}<.001$) and audio conferencing technology ($\mathbf{t}(22)=2.6$, $\mathbf{p}<.05$) than when they communicated face-to-face. This is largely accounted for by client 1 interrupting the agent at a higher rate in VMC than in face-to-face conversations and in the audio context, by both agent and client 1 interrupting each other at a higher rate than in face-to-face communication. There was a nearly significant difference between contexts in the rate at which the agent and client 2 interrupted each other (**F**(2,33)=2.9, **p**=.071); they interrupted one another at a significantly higher rate when they communicated via audio conferencing compared to face-to-face (**t**(22)=2.4, **p**<.05) due to an increase in the rate at which both agent and client 2 interrupted each other in the technology condition. Their interruption rate in VMC was nearly significantly higher than in face-to-face communication (**t**(22)=2.4, **p**=.078) due to client 2 interrupting the agent at a higher rate in VMC. There were no differences between conditions in the rate at which the clients interrupted each other (**ts**<1.5). The mean interruption rates for each pair of conversational partners are shown in Table 3.13. This confirms that the technology-mediated talk contained more interruptions than face-to-face talk and shows that the audio lag did have the expected impact on co-ordination of the conversation: it led to difficulties in co-ordinating speaker exchange. This matches findings of previous research, (e.g. O'Conaill *et al.*, 1993; O'Malley *et al.*, 1996), which revealed that when an audio signal delay was present, speakers had difficulties co-ordinating their turn-taking such that turns were longer and there were more interruptions compared to VMC with no audio delay and face-to-face conditions.

Table 3.13 Rate of interruptions

Pair of conversational partners			
Communication condition	**client1 and client2 (SD)**	**agent and client1 (SD)**	**agent and client2 (SD)**
face-to-face	9.0% (4.4)	7.2% (3.2)	9.3% (3.1)
VMC	8.4% (4.5)	13.6% (2.5)	12.7% (5.7)
audio	9.6% (5.3)	11.7% (5.1)	14.3% (6.5)

The shaded boxes indicate talk that was technology-mediated

Summary and discussion of structure and patterns of participation results.

Two levels of dialogue analysis have been employed so far to investigate the effect of sharing multimedia communication technology on the process of three-party conversation. The first approach was to analyse as a whole the dialogues from discussions in the three communication contexts without differentiating between communication which was and was not mediated by technology in the video and audio contexts. These analyses revealed no significant differences between the communication modes in the amount of communicative effort the group made (in words and turns) and the co-ordination of turn-taking behaviour (shown by turn length, interruption and back channel response data). Nonetheless, dialogues tended to be the longest (in words and turns) in the video-mediated context and shortest in face-to-face interaction; this was mainly attributable to the contributions of the more dominant client. Audio conferences had a similar dialogue structure to VMC, but differed from the face-to-face context to a lesser extent. However, the groups taking part in the three communication conditions performed equally well as indicated by an objective measure of task performance. These results suggest that participants, particularly the clients in the technology contexts, seem to have needed to make the most interactive effort (most words and turns were needed to complete the task) to attain the same level of performance success as in the face-to-face context.

In order to clarify whether video- and audio-mediation were responsible for the slightly increased verbal effort in these conditions a second set of analyses was carried out which separated the mediated and co-present communication in the audio and video contexts. The analyses show a surprising pattern of results: the greater interactive effort in remote conditions, especially via video, is due to the tendency of the two clients to interact significantly more in terms of the number of exchanges and the numbers of words and exchanges made in pairwise conversations when the third group member, the travel agent, was remotely located. The mediated interactions between agent and the two remote participants, with the exception of interruption behaviour which tended to occur at a higher rate in technology-mediated interactions, were relatively unaffected by the video and audio conferencing technology. Furthermore, the majority of interaction in all conditions -93% of words uttered - took place during two-person rather than true group interaction. However, these analyses are based on the turn-taking behaviour of group participants and do not take into account the content and function of utterances in the communication. An investigation of the content of communication will seek to confirm the above findings and to illustrate how what is said is impacted by the communication contexts.

Conversational Games Analysis

A variety of ways of analysing the content of spoken dialogue exist which vary according to their focus and purpose, for example, Bales (1950) developed the method of Interaction Process Analysis based on work with problem-solving groups; Conversational Analysis (Sacks, Schegloff and Jefferson, 1974) focuses on the structure of conversation processes (both methods are described in chapter 1); Discourse Analysis (Sinclair and Coulthard, 1975) was intended to investigate classroom interactions; and Olson and colleagues (1992; 1994; 1997) used a content classification system to explore the communication process in design meetings (see chapters 1 and 2). However, the method of analysis adopted in this study, Conversational Games Analysis (CGA) (Kowtko, Isard and Doherty-Sneddon, 1991), was chosen for several reasons: it has a proven reliability between coders and across task domains (Carletta, Isard, Isard, Kowtko, Doherty-Sneddon and Anderson 1997), it is at a functional level of analysis, it maps hierarchical structure, several of the coding categories illustrate the processes of establishing mutual understanding, and it has been used successfully to study the differences between video-mediated, face-to-face and audio-only communication (Doherty-Sneddon, Anderson, O'Malley, Langton, Garrod, and Bruce, 1997). Furthermore, it proved flexible enough to be adapted to the analysis of multiparty discourse.

Conversational Games Analysis (also briefly described in chapter 2) is a comprehensive and exhaustive form of coding of speaker intent that focuses on the function and content of utterances in task-oriented dialogues. It models the pragmatic function of an utterance in the dialogue, not necessarily its semantic meaning. There are two functional levels of analysis within the coding system: Moves and Games. Moves are contributions or dialogue units which are functionally distinct, hence, one speaker's contribution may contain more than one Move. Moves are grouped into dialogue units called Conversational Games, however it is possible for a Game to consist of only one Move. When a participant initiates an interaction this is referred to as the start of a Conversational Game. Conversational Games are defined by the goal that a sequence of Moves serve within the interaction (and a Move is a step towards achieving the goal of the Game). Games can be embedded within each other in order to attain the linguistic or non-linguistic goal (Kowtko *et al.*, 1991). For example, an INSTRUCT Game is initiated by an *Instruct* Move and consists of the Moves required to carry out the instruction. For example, the listener may want to check she or he has understood the instruction so seeks clarification, this initiates a new Game (in this example a CHECK Game) embedded within the existing INSTRUCT Game, as shown in Figure 3-5.

As the greatest differences in dialogue structure between conditions were found between video-mediated and face-to-face contexts, these dialogues were selected for further investigation. It was decided not to code the content of all three communication conditions due to the very time-consuming nature of the selected coding scheme. The research questions being addressed are:

- is there more interactive effort in shared video-mediated communication than in face-to-face communication when the content of interactions is analysed?
- what types of interactions account for differences between contexts?
- do co-present participants (clients) also communicate more in terms of what they say when the collaborator is remote rather than face-to-face?
- how much pairwise as opposed to three-party interaction occurs in each context?

Figure 3-5 Example of the coding of an interaction with Conversational Games Analysis

Game 1:

client2

Game: INSTRUCT

I want to see Colorado please

Instruct Move

Game 2 (embedded):

travel agent

Game: CHECK

do you want to see the video? the video for Colorado?

Check Move

client1

mhm

Reply-y Move

End Game 2

travel agent

OK.

Acknowledge Move

End Game 1

Conversational Games Analysis was carried out on all twelve face-to-face and twelve video-mediated dialogues. Every individual utterance within the spoken dialogue was assigned the code appropriate to its function. The coding relies on three sources of information: the semantic content of the utterance, intonational information and its location within the dialogue. This is an extremely time-consuming and labour-intensive process requiring approximately three full days to code each dialogue (dialogues were approximately thirty to forty minutes long). There are six categories of Games or initiating Moves: INSTRUCT, EXPLAIN, CHECK, ALIGN, QUERY-W and QUERY-YN which are defined in Figure 3-6; and a further seven response Moves which are used to code replies to initiating Moves. The response Moves are not outlined here since *initiating* Moves are the focus of this analysis. This level of analysis was decided upon as response Moves are correlated with initiating Moves since the latter elicits the former, for example, a *reply-y* Move is an elicited affirmative response in reply to a previous question.

Figure 3-6 Definitions of the six types of initiating Moves or Games

INSTRUCT	communicates a direct or indirect request or instruction.
CHECK	checks self-understanding of a previous message or instruction by requesting confirmation.
QUERY-YN	yes-no question.
QUERY-W	open-ended question.
EXPLAIN	freely-offered, unelicited utterance describing status quo, provides new information.
ALIGN	checks the other participant's understanding or accomplishment of a goal.

Coding reliability

Inter-judge reliability between two coders (one expert and a relative novice) was assessed for one randomly selected dialogue. The coefficient of agreement for nominal scales, kappa, (Cohen, 1960) was used to measure the reliability of the agreement for coding of initiating Moves. Kappa is a co-efficient that ranges from -1 to 1 with a score of 0 indicating no agreement. There was 80% agreement regarding where initiating Moves began and on the type of initiating Move which is more than expected by chance at the 99% level of probability (κ=.64, p=.01, N=282, k=2).

3.4 Analysis and results

The focus of this investigation is on dialogue structure therefore the dialogue is the unit of analysis rather than each participant's separate contributions, hence, speaker role is a within dialogue variable while communication context is a between dialogue measure. A 3 by 2 analysis of variance (ANOVA) with two levels of communicative context (face-to-face and video-mediated communication) and three levels of speaker role (the travel agent, client 1 and client 2) was performed to compare the total number of initiating Moves in face-to-face and video-mediated dialogues. The frequency with which each type of initiating Move occurred in a dialogue (rather than number of Games which is slightly lower than number of initiating Moves[9]) was calculated. A greater number of initiating Moves was expected in communication which was partly video-mediated than in face-to-face communication. An ANOVA of the raw scores revealed that significantly more conversational Moves were required when some participants interacted via video (**F** (1, 22)= 4.5, **p**<.05). Since a Move initiates an interaction, more Moves suggest that more interactive work was carried out to complete the task in communication with a video-mediated element.

As shown in Table 3.14, on average it took 393 initiating Moves in VMC compared to 320 in face-to-face communication in order to complete the task, an increase of 23%. This was due to client 1 (**F** (1, 22)= 5.8, **p**<.05) and client 2 (**F** (1,22)=5.3, **p**<.05) making significantly more Moves in VMC than in face-to-face

[9] This is because not all initiating Moves begin new Games, they can also continue existing Games or serve to remind the partner of the purpose of the current Game (Carletta *et al.*, 1997, p 23).

communication (37% and 38% more initiating Moves respectively). The agent made a very similar number of Moves in both contexts (**F**<1).

Table 3.14 Initiating Moves of all types in face-to-face and shared VMC contexts

	Communication condition	
Participant role	**VMC mean**	**Face-to-face mean**
agent	102.8 (25.0)	108.3 (20.3)
client 1	161.3 (58.4)	117.8 (21.8)*
client 2	129.0 (39.0)	93.6 (36.6)*
overall mean	393.0 (106.6)	320.0 (55.2)*

*Significant at the 0.05 probability level.

Analysis of function of initiating Move types

In order to find out which types of utterances account for the greater number of Moves in video-mediated dialogues, the six different types of initiating Move were investigated. For instance, do participants in the video context check their mutual understanding more often than in the face-to-face context? Do they ask one another more questions? Six separate 2 by 3 ANOVAs were carried out, one for each type of initiating Move - *Instruct, Explain, Query-yn, Query-w, Align* and *Check* - with communicative context as a between groups variable (two levels: face-to-face and video-mediated communication) and participant role as a within dialogue repeated measure (three levels: the travel agent, client 1 and client 2).

Instruct Initiating Moves

There were significantly more *Instruct* Moves (58% more) in the shared VMC than in the face-to-face context (**F**(1,22)=9.7, **p**<.01); this is accounted for by client 1 giving significantly more instructions (more than twice the amount) in the video-mediated than in the face-to-face context (**F** (1, 22) = 14.77, **p**<.01). This greater number of *Instruct* Moves accounts for around 13% of the total increase in Moves in the VMC condition. See Table 3.15 for the mean number of *Instruct*

Moves by client 1. There were no significant differences in the number of instructions issued by the travel agent (**F**<2) or by client 2 (**F**<1) in the two communicative contexts.

Explain Initiating Moves

There were significantly more *Explain* Moves (32% more) in the video than in the face-to-face context (**F**(1,22)=4.6, **p**<.05). This was due to client 2 giving significantly more information (almost 50% more) in the video-mediated than in the face-to-face condition (**F**(1,22)=6.8, **p**<.05). This greater number of *Explain* Moves accounts for almost 71% of the total increase in Moves in VMC. The number of *Explain* Moves made by the travel agent did not differ significantly between contexts (**F**<1), while there was an almost significantly higher number of *Explain* Moves made by client 1 in the VMC condition (**F**(1,22)=3.5, **p**=.074). Table 3.16 gives the mean numbers of *Explain* Moves in each context and Table 3.15 gives the mean number of *Explain* Moves initiated by client 2.

Table 3.15 Significant interactions of role and communicative context on number of initiating Moves

Initiating Move	Participant role	VMC mean	Face-to-face mean	statistical probability
Instruct	client 1	12.9	5.9	**F** (1, 22) = 14.8, **p**<.01
Explain	client 2	77.8	51.5	**F** (1, 22) = 6.6, **p**<.05

Query-yes/no and Query-w Initiating Moves

Participants did not ask significantly different numbers of open-ended and closed questions (*Query-w*s and *Query-yn*s) in the two communicative contexts (**Fs**<1.5). Table 3.16 shows that the mean number of these types of Move were very similar in both contexts.

Check and Align Initiating Moves

Participants did not check their self-understanding (*Check* Moves) significantly more in the video context (F<1), in fact the mean number of *Check* Moves was lower in VMC, nor did they check the other participants' understanding or achievement of goals (*Align* Moves) significantly more in VMC than in face-to-face communication (F<2), as was found in two-person technology-mediated communication for a different task (Doherty-Sneddon *et al.*, 1997) described in chapter 2. See Table 3.16 for the mean numbers of Moves.

Table 3.16 Initiating Moves by Move type in shared VMC and face-to-face contexts

Initiating Move	VMC mean	face-to-face mean
Explain	204.3	152.8*
Query-w	73.5	69.1
Query-yn	54.2	46.9
Check	28.5	29.7
Instruct	25.3	16.0**
Align	7.2	5.2
Total	**393.0**	**320.0***

*Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

These analyses reveal that in the VMC context, significantly more interaction took place in terms of initiating Moves, in particular, there were significantly more interactions initiated that involved issuing instructions (*Instruct* Moves) and giving information (*Explain* Moves). There were no significant differences between the face-to-face and video condition in the numbers of all other Move types. Thus the increase in verbal interaction in the video condition does not appear to be due to difficulties in speakers reaching mutual understanding, as might have been expected in a less rich communicative environment such as VMC. The greatest increase in Move initiation in VMC was attributed to one of the clients volunteering more information (*Explain* Moves) in the video context. In addition, one of the clients issued significantly more instructions in the VMC context. These findings will be explored further in order to assess with whom the clients engaged in such conversations.

Ease of establishing mutual understanding

Embedded Games

It was found that VMC and face-to-face dialogues did not differ in the numbers of initiating moves which involve establishing mutual understanding- *Check* and *Align* Moves - however another indicator of ease of mutual understanding was analysed: the number of embedded Conversational Games or units of conversation in VMC versus face-to-face communication. Are VMC and face-to-face discussions also similar on this measure of ease of grounding?

When speakers have little difficulty in understanding one another, conversations proceed in a fairly straight-forward manner with the speaker presenting an utterance and the interlocutor indicating acceptance or understanding of the utterance. However, when there is some difficulty in resolving the interaction (for instance, when the listener disagrees with the speaker), initiation of a further conversation, which will be nested or embedded in the original conversation, may be required in order to resolve the communicative goal. Hence, more embedding of conversations can indicate more difficulties in resolving the Game or goal, thus more difficulties in reaching mutual understanding. If video is an impoverished visual medium this could make reaching mutual understanding more difficult than in the face-to-face condition (but none of the analyses so far suggest this is the case) and this may be reflected in a greater amount of embedded Games.

Once a Game has been initiated or opened, the participants work on the goal of the Game until they believe it has been achieved or that it should be abandoned. Embedded Games are ones which nest within the current top level Game and whose purpose is subordinate to, and furthers that of the top level goal (Carletta *et al.*, 1997). An example of an embedded Game can be seen in Figure 3-5 where the purpose of the CHECK Game initiated by the travel agent is subordinate to the top level goal, the instruction issued by client 2. The CHECK Game is used by the travel agent to verify his understanding of the instruction so that he can carry it out successfully, i.e., send a video clip of Colorado, and thus complete the conversational goal.

Independent t-tests show that there are no significant differences in the number of embedded Games in VMC versus face-to-face communication, either for raw scores (**t**<1) or for standardised data (i.e. the mean number of Games embedded per 100 words of dialogue) (**t**<1). The mean number of embedded Games in VMC is 154.2 (SD- 68.2) and in face-to-face communication 151.8 (SD-45.7). The mean number of embedded Games per 100 words in VMC is 3.99 (SD-1.5) and when face-to-face is 4.5 (SD-1.3). There is in fact a slightly higher rate of embedding in face-to-face than video-mediated communication. It appears equally easy to ground in face-to-face and VMC based on this measure, thus confirming the results of the analysis of *Check* and *Align* initiating Moves, which are the Moves concerning grounding of knowledge.

Discussion of Conversational Games Analysis so far

The Conversational Games Analysis so far shows that face-to-face communication and VMC do differ in the amount and types of interaction in terms of the function and content of what is said: it takes significantly more initiating Moves to complete the task via video when compared to face-to-face communication. Since an initiating Move is an utterance that introduces a new conversational goal into the discussion, this finding suggests that the communication involved more interaction in the VMC condition. The fact that there were significantly more of certain Move types (*Explain* and *Instruct* Moves) in VMC suggests that the participants in this condition interacted and collaborated in different ways from face-to-face participants in order to achieve the same task outcome. The increased interactive work in the shared video technology context compared to face-to-face communication involved participants initiating more of all types of Moves or interactions, apart from *Check* Moves of which there were fewer in VMC. In particular, they initiated significantly more *Explain* and *Instruct* Moves, that is, interactions concerned with information sharing and issuing of instructions. What is more, it is the participants who play the role of the clients in this service encounter simulation who account for the greatest proportion of the increases in *Instruct* and *Explain* Moves in VMC. However, do the clients initiate these types of conversations cross-site with the remotely located travel agent or same-site with each other, that is, how is the distribution of technology affecting the content of discussions? Is the increase in Moves in VMC due to video-mediated or co-present interactions?

Two-party and three-party Conversational Games

In the analyses of the turn-taking behaviour of groups, it was found that in VMC the two co-present group members exchanged significantly more turns and words than in the face-to-face context to complete the task. Will this finding be corroborated by an examination of the content of communication? It is possible to examine who is involved in the resolution of each Conversational Game. If the Conversational Games Analysis supports the turn-taking data then there will be more Games involving the collaboration of the two co-present participants or clients in VMC than in the face-to-face context. This analysis is similar in concept to the pattern of participation analyses which look at collaboration between group members based on the order in which they exchanged turns in the conversation, however, CGA bases its analyses of patterns of interaction on the communication content and can track not only two-person but three-person collaboration. In this way the results of the patterns of turn-taking can be verified through analysing the dialogue at the level of its content and function. Previous applications of CGA have involved only dyadic communication (e.g. Doherty-Sneddon *et al.*, 1997), therefore exploring the structure of multiparty communication is a new way of using this coding method.

In addition, the extent of group as opposed to pairwise interaction in the two media can be investigated by comparing how often all three group members collaborate to achieve conversational goals, i.e., resolve Conversational Games. If characteristics of the technology in VMC are hindering group communication, then fewer three-person interactions or Games would be expected in comparison to face-to-face group communication. However, from the analyses performed so far it does not appear that the cross video link communication is greatly affected by mediation.

For each Conversational Game in the dialogues it was noted which participants in the group took part, regardless of who initiated and who responded. It is possible for a Game to stand alone and receive no response and these Games with a single speaker were not of interest in this analysis. This involved the exclusion of, on average, 109.6 single speaker Games, or 33%, out of a total mean of 331.2 Games in VMC, and, on average, 96.5 single speaker Games, or 36%, out of a total mean of 269.8 Games in face-to-face discussions. What was of interest was the number of Games that involved collaboration between participants. This analysis of collaborative Games can differentiate between video-mediated and co-present Games or interactions in the video context. If we take the example of a Conversational Game in Figure 3-5, the INSTRUCT Game is an example of a three-person Game as it involves all three group members collaborating to implement the instruction; the embedded CHECK Game is a two-party Game between the agent and one of the clients.

There are four combinations of conversational partners within groups who can collaborate within single Conversational Games: the two clients; client 1 and the travel agent; client 2 and the travel agent; and all three group members. The dependent variables are the total number of collaborative Games of any type and the six different types of Game separately, INSTRUCT, EXPLAIN, QUERY-W, QUERY-YN, ALIGN and CHECK. The six different types of collaborative Games were analysed, each one in a separate ANOVA. Some of the questions being addressed are as follow: does communication medium affect the frequency with which speakers collaborate within single Conversational Games? Does the nature of the communicative unit matter? Do the types of two- and three-party interactions differ between media, for example, will all three speakers participate more often in episodes of issuing and completing an instruction if they are interacting face-to-face? The hypotheses to be tested are:

- there will be more Conversational Games between the two co-present clients when the collaborator is remote than when he/she is face-to-face.
- the number of Conversational Games between agent and either client will remain constant between conditions

The effect of context upon group interaction was also explored: are there more three-party Games in face-to-face than in VMC contexts, that is, is the amount of multiparty conversation higher when there is no video-mediation of communication?

Mixed design 2 by 4 ANOVAs with communicative context as a between groups factor (two levels: face-to-face and video) and combination of conversational partners as a within dialogue repeated measure (four levels: client 1 and client 2, agent and client 1, agent and client 2, all three participants) were performed to compare the number of Games which involved each combination of participants for the total number of Conversational Games and for each of the six types of Conversational Game separately.

Total number of collaborative Conversational Games of all types

A mixed design ANOVA revealed a main effect of context ($\mathbf{F}(1,22)=6.8$, $\mathbf{p}<.05$), a main effect of conversational partners ($\mathbf{F}(3,66)=19.7$, $\mathbf{p}<.001$), and a significant interaction of the two variables ($\mathbf{F}(3,66)=3.1$, $\mathbf{p}<.05$). The interaction effect was explored using an analysis of the simple main effects of context for each level of conversational partner. This revealed that the two clients collaborated in significantly more Conversational Games of any kind - 69% more - in the VMC than in the face-to-face context ($\mathbf{F}(1,22)=8.3$, $\mathbf{p}<.01$). The numbers of two-party Games between the agent and each client did not differ between VMC and face-to-face contexts ($\mathbf{F}$s<1), despite these interactions being video-mediated in the former context. This was the predicted finding based on the results of the turn-taking pattern of participation analyses. The total number of three-party Games did not differ between conditions (F<1) and represents 26% and 33% of the total Collaborative Games in VMC and face-to-face conditions respectively, indicating that the majority of the interaction even in small groups is not true group interaction. The mean numbers of all types of Conversational Games for each combination of conversational partners are shown in Table 3.17.

Table 3.17 Mean number of two-party and three-party Conversational Games

Conversational partners	VMC	face-to-face
client1-client2	91.8 (39.3)	54.4 (21.6)**
agent-client1	47.2 (27.2)	43.1 (24.6)
agent-client2	25.6 (21.1)	18.3 (13.6)
three-party	57.1 (12.4)	57.4 (16.9)
total collaborative Games	**221.6 (53.8)**	**173.3 (34.7)***

*Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

Types of multiparty and two-party Conversational Games

Which types of Conversational Games account for the significantly higher number of Games between the two co-present participants in the video condition? The interactions between each combination of participants were analysed by type of Conversational Game in order to answer this question. Separate 2 by 4 mixed design ANOVAs were carried out with context as a between groups variable (two levels: VMC and face-to-face communication) and combination of conversational partners as a within dialogue variable (four levels: client 1 and client 2; agent and client 1; agent and client 2; all three participants)

INSTRUCT Games

An ANOVA revealed a significant effect of context on the number of collaborative INSTRUCT Games ($F(1,22)=8.9$, $p<.01$), there were significant differences in the number of Games the different combination of conversational partners were involved in (**F**(3,66)=13.8, **p**<.001), but there was no interaction effect (**F**<1). As can be seen from Table 3.18, there were 76% more collaborative INSTRUCT Games in the VMC than in the face-to-face context - this was not accounted for by any one combination of speakers collaboratively issuing and completing more instructions in the VMC condition, but was due to a general increase in the number of INSTRUCT Games for all combinations of conversational partners.

Table 3.18 Mean numbers of INSTRUCT Games

INSTRUCT Games	VMC	face-to-face
client 1 and client 2	1.7 (1.5)	0.3 (0.9)
client 1 and agent	6.3 (4.8)	3.4 (2.6)
client 2 and agent	2.3 (2.4)	1.3 (1.4)
three-party	5.3 (2.9)	3.7 (2.4)
Total	15.3 (7.1)	8.7 (2.9)**

** Significant at the 0.01 probability level.

EXPLAIN Games

Another ANOVA showed significantly more collaborative EXPLAIN Games in the VMC than in the face-to-face context (**F**(1,22)=8.9, **p**<.01), there were significant differences between the different combinations of conversational partners (**F**(3,66)=31.4, **p**<.001) and a significant interaction effect (**F**(3,66)=2.8, **p**<.05). The interaction effect was explored using a simple main effects analysis of context for each level of conversational partner. This revealed that significantly more EXPLAIN Games - 58% more- involved the collaboration of the two clients in the video than in the face-to-face context (**F**(1,22)=4.8, **p**<.05). The amount of collaboration in EXPLAIN Games between agent and clients (**Fs**<1) and between all three participants (**F**<1) did not differ in video-mediated and face-to-face communication. The increase in EXPLAIN Games is largely due to the two co-present clients exchanging more information in the VMC compared to the face-to-face context. Mean numbers of EXPLAIN Games are given in Table 3.19.

Table 3.19 Mean numbers of EXPLAIN Games

EXPLAIN Games	VMC	face-to-face
client 1 and client 2	51.9 (28.9)	32.8 (16.8)*
client 1 and agent	16.6 (12.1)	13.3 (7.0)
client 2 and agent	9.2 (9.4)	6.8 (7.9)
three-party	18.9 (7.7)	15.8 (9.4)
Total	96.6 (36.8)	68.7 (27.5)**

*Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

QUERY-W Games

As shown by a mixed design ANOVA, the effect of communicative context on the number of collaborative QUERY-W Games was almost statistically significant (**F**(1,22)=3.9, **p**=.062), there were significant differences in the number of QUERY-W Games the four combinations of conversational partners took part in (**F**(3,66)=52.4, **p**<.001) and a significant interaction effect (**F**(3,66)=14.2, **p**<.001). A simple main effects analysis of context for each level of conversational partner showed that the interaction is due to there being almost one-and-a-half times more QUERY-W Games involving collaboration between the two clients in the video than in the face-to-face context (**F**(1,22)=22.1, **p**<.001), and 35% more of this type of Game involving collaboration between all three participants in the face-to-face context (**F**(1,22)=4.9, **p**<.05), as shown by the means in Table 3.20. The amount of two-person interactions between the agent and either client involving the resolution of open-ended queries did not differ between the VMC and face-to-face context (**Fs**<1), despite these participants being video-mediated in the video context. It is the co-present clients who account for the greatest increase in interactions initiated with an open-ended question in VMC, while there were significantly more such queries which involve all three-participants in the face-to-face context.

Table 3.20 Mean numbers of QUERY-W Games

QUERY-W Games	VMC	face-to-face
client 1 and client 2	15.3 (6.1)	6.4 (2.4)***
client 1 and agent	4.1 (2.8)	3.9 (3.0)
client 2 and agent	1.8 (2.3)	1.4 (1.3)
three-party	10.2 (4.0)	13.8 (4.3)*
total	31.4 (8.8)	25.5 (5.5)

*Significant at the 0.05 probability level.

*** Significant at the 0.001 probability level.

QUERY-YN Games

Another ANOVA revealed that the effect of context on the number of collaborative QUERY-YN Games was not significant (**F**<1.5), there were significant differences between the number of QUERY-YN Games that the different combinations of speakers were involved in (**F**(3,66)=17.4, **p**<.001) and there was a significant interaction effect (**F**(3,66)=2.97, **p**<.05). A simple main effects analysis of context at each level of conversational partner revealed that there were significantly more QUERY-YN Games - almost 65% more - between the two clients in the video than in the face-to-face context (**F**(1,22)=6.2, **p**<.05). The amount that the agent and clients collaborated in both two- and three-party interactions to resolve yes-no questions did not differ in VMC and face-to-face conditions (**Fs**<1.5), although these interactions were video-mediated or, in the case of three-party conversations, partially video-mediated in VMC. It was the participants who were co-present in VMC who collaborated significantly more in the resolution of such queries than when face-to-face.

Table 3.21 Mean numbers of QUERY-YN Games

QUERY-YN Games	VMC	face-to-face
client 1 and client 2	17.2 (8.2)	10.5 (4.3)*
client 1 and agent	9.7 (5.3)	10.0 (7.3)
client 2 and agent	3.9 (3.7)	3.9 (3.1)
three-party	12.4 (4.5)	14.3 (4.1)
total	43.2 (12.2)	38.7 (7.9)

*Significant at the 0.05 probability level.

ALIGN Games

The effect of context on the number of collaborative ALIGN Games was nearly statistically significant (**F**(1,22)=3.9, **p**=.062), there were significant differences between the number of ALIGN Games each combination of participants was involved in (**F**(3,66)=7.0, **p**<.001) but no interaction effect (**F**<1). All combinations of conversational partners collaborated similar amounts in VMC and face-to-face contexts in order to resolve issues of checking another person's understanding or verifying the accomplishment of a goal. However as can be seen for the mean numbers of ALIGN Games given in Table 3.22, there was a tendency for almost twice as many collaborative ALIGN Games to occur in the shared VMC than the face-to-face condition, although the overall number of such Games is small.

Table 3.22 Mean numbers of ALIGN Games

ALIGN Games	VMC	face-to-face
client 1 and client 2 (2S)	0.1 (0.3)	0.2 (0.4)
client 1 and agent (2cb)	2.1 (1.2)	1.7 (1.9)
client 2 and agent (2cc)	1.2 (2.6)	0.3 (0.7)
three-party	1.6 (1.5)	0.4 (0.8)
total	4.9 (3.3)	2.6 (2.5)

CHECK Games

The effect of context on the number of collaborative CHECK Games was not significant (**F**<1) with very similar numbers of CHECK Games in both communicative media. There was a significant effect of who took part in the Games (**F**(3,66)=6.2, **p**<.001) but no interaction effect (**F**<1). This indicates that all the different combinations of participants collaborated similar amounts to resolve requests for confirmation of self-understanding in face-to-face and VMC conditions. The mean numbers of CHECK Games are given in Table 3.23. Thus, it seems that video-mediation did not impact the establishment of mutual understanding differently from face-to-face communication.

Table 3.23 Mean numbers of CHECK Games

CHECK Games	VMC	face-to-face
client 1 and client 2	5.4 (3.4)	3.6 (2.4)
client 1 and agent	7.5 (4.9)	10.1 (7.3)
client 2 and agent	4.3 (3.2)	4.2 (3.7)
three-party	7.5 (4.6)	8.8 (6.0)
total	24.8 (9.2)	26.6 (9.8)

Summary of Conversational Games Analysis results

In the above examination of the function of utterances within VMC and face-to-face dialogues, two levels of Conversational Games Analysis were undertaken: the first examined the initiation of conversations or the numbers of initiating Moves; the second focused on speaker collaboration in Conversational Games or, in other words, the patterns of participation in collaborative units of conversation. The analyses at the level of the initiating Move showed that it took more Moves of all types in VMC than in face-to-face communication to complete the task, but that it took significantly more *Explain* and *Instruct* Moves. Respectively, these Moves involve volunteering information and giving instructions and examples of these Moves taken from dialogues are shown in Figure 3-7 and Figure 3-8. The fact that there were more of these Move types in VMC shows that the participants in VMC interacted and collaborated in different ways from face-to-face participants. In particular, one client offered significantly more information (*Explain* Moves) and one client gave significantly more instructions (*Instruct* Moves). Thus, the introduction of video technology led to more interactive effort for two types of Move or conversational behaviour for two of the participants. However, this was not evident from an examination of the analysis of the numbers of words and turns; only by looking at the functions of the utterances could this significant difference be highlighted.

Figure 3-7 Examples of initiating Explain Moves by client 2

Florida's down there.
Well, it's quite nice for although it's a big city it's not, well, it's not actually that big city.
You want to go to Illinois, I bet Sue would like that.
But, but you can fly into Chicago and then go straight out, I mean they don't...
And it's a warm place, let's not forget that.

Figure 3-8 Examples of initiating Instruct Moves by client 1

Can we find out about Illinois?
Then em eh can we have information about the Colorado?
Can we see New Orleans?
After this do you think we could see Wyoming's video?
Stop calling them geysers!
A video please.
Wait, wait, wait, wait!
let's, can we see the little flick on New York now?

A further analysis at the level of the collaborative Game shows how technology impacted on patterns of interaction and indicated with whom clients were exchanging more Moves in VMC. It revealed that the two co-present clients interacted with each other within significantly more Games of all types in VMC, and in particular the effect of the technology was most marked on certain of their communicative behaviour: the clients took part together in significantly more collaborative QUERY-Y/N, QUERY-W and EXPLAIN Games, i.e., the types of conversations which involve requesting and volunteering information. Hence, it seems that the sharing of video communication technology skewed the interaction such that the two co-located same-role group members (the clients) interacted with each other significantly more when the third group member communicated via video rather than face-to-face communication. This is the same pattern of results as found in the 'content-free' analyses of speaker turn-taking behaviour, but here we see what they were achieving with this extra talk, namely they were collaborating in order to resolve open and closed questions and give each other unelicited information. Examples of these types of two-party conversational Games between clients taken from dialogues are given in Figure 3-9. QUERY-YN (see Game Z) and QUERY-W Games (see Game W) typically involved one client asking a task-related question, for example about choice of destination, and the other client responding, while EXPLAIN Games frequently involved one client offering information about some aspect of the task, as seen in Game Y, or about their preference of destination, such as in Game X, and the other client acknowledging this information.

These analyses show that face-to-face communication and VMC do differ in the amount of communicative work required in terms of the content of what is said: it takes significantly more initiating Moves and collaborative Conversational Games, especially by the clients, to complete the task via shared video conferencing technology when compared to face-to-face communication for the same level of performance. It seems that some aspect of the technology increases the clients' conversational dominance in interactions in VMC. Why should the two co-present participants interact more with one another when the other group member is remote rather than face-to-face? Perhaps the participants' subjective perceptions will help to explain this rather unusual and unexpected pattern of results. Do the clients feel less inhibited when the agent is remote and therefore more at ease to talk between themselves at greater length than when the agent is sitting next to them?

Figure 3-9 Examples of collaborative Games

Game W - example of a QUERY-W Game between the two clients from a VMC dialogue:

Client 2

QUERY-W

whaw what can we do in California?

Query-w Move

Client 1

well well I I I don't know if California's got much sort of /TB sense of culture

Reply-w Move

Client 2

no no

Acknowledge Move

End Game W

Game X - example of EXPLAIN Game between the two clients taken from a face-to-face dialogue:

Client 1

EXPLAIN

somewhere I wouldn't mind somewhere south>

Explain Move

Client 2

south would be nice yeah

Acknowledge Move

End Game x

Game Y - example of EXPLAIN Game between the two clients taken from a VMC dialogue:

Client 2

EXPLAIN

we've got to go from east to west

Explain Move

Client 1

east to west ok

Acknowledge Move

End Game y

Game Z - example of a QUERY-YN Game between the two clients taken from a VMC dialogue:

Client 1

QUERY-YN

can you not fly into somewhere in Pennsylvania like em like eh Philadelphia?

Query-yn Move

Client 2

sure you can fly into anywhere from there

Reply-yes Move

End Game z

3.5 User evaluation questionnaire data

Throughout this study multiple indicators of communication process and outcome have been analysed in order to arrive at conclusions about the effect of technology-mediation on group communication. A further type of data, the subjective views of the participants, were sought in the form of a post-task questionnaire (the collaborators were not included in these analyses). This analysis was included in order to complement the objective analyses to see if subjective and objective analyses converge in their results, for instance, do the participants in the VMC condition perceive the communication process to require greater verbal effort compared to the face-to-face participants?

The questionnaire requested information about subjects' computer experience, their perceptions of the ease of verbal and non-verbal communication, the level of perceived social presence, performance, satisfaction with the outcome, and quality of service and media preference. An example of a questionnaire is included in appendix F. Obviously, questions about non-verbal cues were excluded from the questionnaires administered to the audio conferencing groups. Responses were on a five-point Likert-type scale from 'very easy' to 'very difficult' for most questions, unless otherwise indicated. As the response scale is categorical, non-parametric statistics were used to analyse the resultant data from the seventy-two subjects, (twenty-four in each communicative context), specifically, chi-square tests for independent groups. For each question three chi-square analyses were performed, one to compare the responses of face-to-face and VMC groups, another to compare face-to-face and audio groups and one to compare VMC and audio groups.

In order to analyse the data by chi-square for independent groups it was sometimes necessary to combine cells in order to increase the expected frequencies to acceptable levels. Furthermore, for many questions the responses in the categories at one end of the scale used contained no responses or very low numbers with the result that too many expected frequencies fell below the acceptable level of five. As the number of extreme responses were equally rare across the three groups' responses, they were excluded from the analyses so that under 20% of cells contained a value of five or under and chi-square tests could be employed. Therefore the majority of tests carried out were 2 by 2 chi-square for independent groups while a few were 2 by 3 tests.
Questionnaire data were expected to reveal the following results in comparisons between face-to-face, audio-only and VMC conditions:

- social presence will be perceived as higher in face-to-face than in VMC and audio-only contexts; and higher in VMC than in the audio-only context

- communication and comprehension will be perceived as easier in the face-to-face condition than in the audio and video conferencing conditions; and easier in the VMC condition than in the audio conferencing condition

The effect of communication medium on satisfaction with communication outcome and with the consultation will also be explored. The following research questions will be addressed

- will satisfaction with the final holiday itinerary and the consultation differ between communication conditions?
- will the ease of performing the task be perceived differently in the three media?

3.6 Results

Computer experience

Participants' computer experience was checked to determine if people were similarly experienced in the use of computers in all contexts. Participants in face-to-face and VMC conditions were equally experienced in use of computers based on numbers of applications used. There were significant differences in frequency with which participants used computers - more face-to-face participants were occasional rather than frequent users compared to those in VMC category - (x^2 = (2) 7.04, $p < .05$). Of the participants involved in the VMC condition, 11 out of 24 had used VMC technology and 10 of them had used audio conferencing technology previously but only one of these people claimed to be experienced. In the audio conference condition, 5 out of 24 participants had taken part in a video conference and four had taken part in an audio conference but all were inexperienced users.

Ease of communication - non-verbal cues

The following questions concern the visual channel of communication hence compare only face-to-face and video conditions. Participants were asked *how easy was it to see the travel agent's facial expressions; to make eye-contact with the travel agent; and to see the travel agent's gestures?*

Facial expressions

Most participants, 63% of VMC participants and 58% of face-to-face subjects, found it easy or very easy to see the travel agent's facial expressions in the visual communication conditions and these responses did not differ between conditions ($p>.05$) (based on an analysis of the categories 'very easy/easy' and 'neither easy nor difficult'). See Table 3.24 for response rates. This finding is contrary to the experimental hypothesis that viewing facial expressions would be perceived as easier when communicating face-to-face rather than via video.

Table 3.24 Ease of seeing the travel agent's facial expressions

	VMC	**face-to-face**
very easy/ easy	15	14
neither easy nor difficult	5	7
difficult	3	3
very difficult	1	0

In each condition N=24

Eye-contact

Making eye-contact with the agent was reported to be difficult or very difficult by significantly more participants in the video condition than in the face-to-face condition (when a 2 by 3 chi-square test compared the response distributions between conditions in the categories 'very easy/easy', 'neither easy nor difficult' and 'difficult/very difficult') (x^2 (2)=16.9, $p < 0.001$). Significantly more participants in the VMC condition, 50%, found it difficult or very difficult to make eye-contact while less than 1% of participants in the face-to-face condition found this difficult. Response distributions are given in Table 3.25. This result was expected since it was not in fact possible to make direct eye-contact over the video link due to the camera being positioned at the side of the terminal. This could also explain why some VMC participants also found it difficult or very difficult to see the agent's facial expressions. Any difficulties in making eye-contact in the face-to-face condition could be explained by the side-by-side seating positions of agent and clients.

Table 3.25 Ease of making eye-contact with the travel agent

	VMC	face-to-face
very easy /easy	4	16
neither easy nor difficult	8	7
very difficult/ difficult	12	1

In each condition N=24

Gesture

Significantly more participants reported that it was difficult or very difficult to see the agent's gestures in the video condition than when conversing face-to-face (x^2 (2)=7.2, **p** < 0.05) (using a 2 by 3 chi-square test to compare responses between conditions in the categories 'very easy/easy', neither easy nor difficult' and 'difficult/very difficult'). Few participants in either the VMC or face-to-face condition reported it as very easy to see the agent's gestures but 38% of people in the video condition found this difficult or very difficult compared to less than 1% of people in the face-to-face condition. The restricted head-and-shoulders view in the video condition could explain why participants reported it as being difficult to see gestures while again the seating position in the face-to-face condition could explain why some clients found it difficult to see the agent's gestures. These results are given in Table 3.26.

Table 3.26 Ease of seeing the travel agent's gestures

	VMC	face-to-face
very easy /easy	10	10
neither easy nor difficult	5	12
difficult /very difficult	9	2

In each condition N=24

Summary of non-verbal cues

In the above comparisons of video-mediated and face-to-face communication, significantly more participants in the video condition perceived it to be difficult or more difficult to see the gestures of, and to make eye-contact with, the travel agent than did the face-to-face participants. These results were expected as the camera angle made direct eye-contact impossible and only showed the upper body. However, the two groups did not perceive it to be any more difficult to see facial expressions. Are these perceived difficulties in seeing gesture and making eye-contact during video-mediated communication reflected in the perceptions of the verbal communication process? This was explored in the following analyses of subjective data.

Comprehension and ease of communication

Is this disadvantage of VMC for observing non-verbal cues reflected in the participants' perceptions of the ease of verbal communication? It is expected that based on the availability and richness of non-verbal cues, significantly more face-to-face participants will perceive verbal communication as easy compared to technology-mediated participants and will be perceived as easy by the least participants in the audio conferencing condition. The next analyses compare all three communication contexts for how easy participants found it to communicate verbally. Participants were asked *how easy was it to hear the travel agent?; to get your questions across?; to take a turn in the conversation?; how often did the* *travel agent mistakenly think you were talking to her/him?*; and *how often did you feel excluded from the conversation?* (with answers on a three-point scale for the final question).

Ease of hearing

A 2 by 2 chi-square analysis revealed that significantly more participants in the face-to-face condition felt that it was very easy to hear the travel agent than did participants in the video condition (x^2 (1)=6.77, **p**<.01) (when comparing the response distributions in the two categories 'very easy' and 'easy'). However, there were no significant differences between audio and either face-to-face (**p**>.05) or video and face-to-face conditions (**p**>.05) in how easy participants found it to hear the agent. Despite the audio condition having the same audio quality and delay as the video condition, video participants found it least easy to hear the agent. Therefore, this pattern of responses is probably not attributable to the difficulties posed by the audio delay which was present in both the VMC and audio conditions, but it could be due to the lack of synchrony between video and audio signals in the VMC condition affecting perceptions of audio quality. See Table 3.27 for response rates.

Table 3.27 Ease of hearing the travel agent

	VMC	**audio**	**face-to-face**
very easy	9	16	20
easy	11	7	3
neither easy nor difficult	4	0	1
difficult	0	1	0
very difficult	0	0	0

In each condition N=24

Ease of getting questions across

When comparing the response distributions in the two categories 'very easy' and 'easy', more participants in the face-to-face condition also found it very easy to get their questions across than did VMC participants (x^2 (1)=5.0, **p**<.05), and participants in the audio condition (x^2 (1)=5.0, **p**<.05). There were no significant differences between audio and video-mediated communication (**p**>.05); as shown below in Table 3.28, results were remarkably similar for groups communicating via these two media.

Table 3.28 Ease of getting questions across

	VMC	audio	face-to-face
very easy	6	6	13
easy	13	13	8
neither easy nor difficult	3	5	3
difficult	2	0	0
very difficult	0	0	0

In each condition N=24

Ease of taking a turn in the conversation

It was perceived by significantly more participants to be very easy to take a turn in the conversation in the face-to-face condition than in the VMC condition (x^2 (1)=6.2, **p**<.05), and the audio-only condition (x^2 (1)=6.1, **p**<.05) upon comparison of the response distributions in the categories 'very easy' and 'easy'. However, taking a turn in the video and audio conditions was found to be very easy by similar numbers of participants (**p**>.05). Video communication does not show the same advantage over audio communication that face-to-face communication shows. A small minority of participants perceived difficulties in both remote conditions. The response rates are reported in Table 3.29. In addition, the majority of participants in all conditions - 23 in VMC, 22 in audio and 24 in face-to-face - never felt excluded from the discussion (**ps**>.05).

Table 3.29 Ease of taking a turn in the conversation

	VMC	audio	face-to-face
very easy	6	7	15
easy	13	14	8
neither easy nor difficult	3	2	1
difficult	2	1	0
very difficult	0	0	0

In each condition N=24

Frequency of mistaking the addressee

There were no significant differences between conditions, in response to the question *'how often did the travel agent mistakenly think you were talking to her/him?'* (with answers on a three-point scale) when responses in the categories 'never' and 'sometimes' were compared (ps>.05). In the majority of sessions the participants stated that this never occurred. See Table 3.30 for the data.

Table 3.30 Frequency with which the travel agent mistakenly thought she/he was being spoken to

	VMC	audio	face-to-face
never	16	18	20
sometimes	7	5	4
often	1	0	0

In each condition N=24

In sum, more participants in the face-to-face communication condition perceived it to be easy to take a turn in the conversation and to get questions across than participants in the technology conditions, and more of them found it very easy to hear the travel agent in the face-to-face and audio conditions than in the video condition. Nonetheless, there were no differences between the three conditions in the perceived ease of chatting informally, participant awareness of the presence of the agent and the frequency with which they felt excluded from the discussion.

'Social presence' in face-to-face and technology-mediated contexts

Do the perceived difficulties in non-verbal and verbal communication affect subjects' perceptions of psychological distance between themselves and the collaborator travel agent? The following questions addressed this issue. Participants were asked *how aware were you of the presence of the travel agent?; did you feel free to chat informally to the travel agent ?* (yes/no response); and *during the consultation were you worried at any point that you had lost contact with the travel agent?*

Social presence

Chi-square analyses revealed that there were no significant differences between face-to-face, VMC and audio conditions in participant awareness of the travel agent's presence for the response distributions in the two categories 'very aware' and fairly aware'(**ps**>.05). These results are contrary to the expectations that the face-to-face context would have significantly higher social presence than the audio or video contexts and that video would lead to significantly greater social presence than the audio context. However, the condition in which participants were most aware of the agent's presence was the video-mediated condition: nine VMC participants were very aware of the agent's presence compared to five participants in the face-to-face condition and only three in the audio-only condition. These data are presented in Table 3.31.

Table 3.31 Client awareness of travel agent's presence

	face-to-face	VMC	audio
very aware	5	9	3
fairly aware	17	14	20
neither aware nor unaware	2	0	1
fairly unaware	0	1	0
very unaware	0	0	0

In each condition N=24

Ease of chatting informally and perceived exclusion from discussion

Despite perceived difficulties in verbal and non-verbal communication, similar proportions of participants in each condition reported that they felt free to chat to the agent informally: 21 in VMC, 23 in the face-to-face condition and 22 in the audio condition (**ps**>.05).

Concerns over losing contact

However, significantly more participants in the video-conferencing condition (x^2 (1)=4.3, **p**<.05) were worried that they had lost contact with the agent than in the audio condition based on an analysis of the response distributions in the categories 'never worried' and 'sometimes worried'. 63% of people in the video condition compared to 92% of people in the audio-only condition were never worried they had lost contact with the travel agent. This information is summarised in Table 3.32. Surprisingly, it would appear that audio-conferencing may actually be better than VMC for feeling one is still in touch with the remote participant in this study.

Table 3.32 Frequency with which clients were worried they had lost contact with the travel agent

	VMC	audio
never worried	15	22
sometimes worried	9	2
often worried	0	0

In each condition N=24

Task performance

Analyses of objective performance data revealed no differences between communication conditions, but did the participants perceive performance to be equally successful? When asked *'how satisfied were you with the final holiday itinerary?'*, the majority of participants in all contexts reported their satisfaction with the final holiday itinerary to be high, with no significant differences between the conditions (ps>.05). (Only the categories 'very satisfied' and 'satisfied' were compared).

Table 3.33 Client satisfaction with final holiday itinerary

	VMC	audio	face-to-face
very satisfied	12	17	15
satisfied	11	6	9
neither satisfied nor dissatisfied	1	0	0
dissatisfied	0	0	0
very dissatisfied	0	0	0

In each condition N=24

Participants were also asked *how easy was it to make changes in your itinerary?'*. Similar numbers reported that it was very easy in VMC, audio and face-to-face conditions (ps>0.05). (Only the categories 'very easy' and easy' were compared). The response rates are shown in Table 3.34.

Table 3.34 Ease of making changes to holiday itinerary

	VMC	audio	face-to-face
very easy	9	11	11
easy	13	10	8
neither easy nor difficult	2	1	3
difficult	0	0	0
very difficult	0	0	0

In each condition N=24

Perceived quality of service

When asked *'how satisfied were you with the travel agent's consultation?'*, most participants in all conditions were satisfied or very satisfied with the travel agent's consultation (ps>.05). (Only the categories 'very satisfied' and 'satisfied' were compared). Table 3.35 gives the response rates.

Table 3.35 Client satisfaction with consultation

	VMC	audio	face-to-face
very satisfied	4	9	3
satisfied	13	11	16
neither satisfied nor dissatisfied	5	4	3
dissatisfied	0	0	1
very dissatisfied	2	0	1

In each condition N=24

Media preference

Subjects' perceptions of and satisfaction with the multimedia applications and tools were also explored in the questionnaires. In VMC, the majority of participants felt that the quality of the video image of the travel agent was good or very good but that the image was not the most valuable tool for completing the task, indeed they were willing to have a smaller image if necessary. Most participants felt that the video clips of the destinations were more important to the task than the agent's face in the video condition. This may be tied in to the quality ratings: the video clips were seen as being of higher quality than the video image of the travel agent, although the opposite was actually true (17/24 participants thought the video clips were good or very good compared to 14/24 who thought the agent's image was good or very good). A similar finding is reported in Anderson *et al.* (1999).

However, the most important tool for completing the task in both VMC and face-to-face conditions was considered to be the map of the States (17 out of 24 VMC participants and 16 out of 24 face-to-face participants rated this the most useful tool) and the least useful in all three conditions was the shared itinerary window (which was used mainly for updating the travel plan details and the justification). In the audio conferencing condition the most useful multimedia tool was thought to be the video clips of the destinations - rated the most useful tool by over 50% of participants - while over a third felt that the map of the States was the most useful tool.

Figure 3-10 Preference of multimedia tool

	VMC	**face-to-face**	**audio**
most useful tool	map of the States	map of the States	video clips
least useful tool	shared itinerary window	shared itinerary window	shared itinerary window

Asked which aspects of the technology they would improve, 21 out of 24 clients in the video condition would make some changes - one third of these clients wanted to improve the audio quality and one fifth to improve the video clips. Almost 30% of face-to-face clients wanted to improve the video clips by including more details or by adding a sound track. However, when participants were asked to rate the quality of the video clips of the destinations that they saw - there were no significant differences between conditions on ratings (**ps**>.05). Most participants in all conditions felt that the image quality was good or very good. The majority of audio participants wished to make no improvements (16 out of 24 people). Of those who would make a change (N=8) half the participants wanted to remove the audio delay.

Users were asked which medium they would prefer to use for planning a similar holiday. 19 out of 21 VMC participants who responded would rather use video conferencing than the telephone for planning a similar holiday, although face-to-face was preferred over video conferencing and the telephone by all participants in the VMC condition. In the audio condition the majority (75%) of participants said they would prefer face-to-face communication to either video or audio conferencing for planning a similar trip and would prefer VMC over audio-only communication (almost 90%), thus supporting the findings from the VMC condition. This suggests that although video communication was perceived to confer advantages that the telephone does not, video was not as satisfactory a medium as co-presence. In support of this finding, most users (66%) would only actively avoid video conferencing if the travelling time to a travel agency was less than half an hour, while 12.5% of participants would prefer a video consultation to travelling. In the audio-only condition 17% of users would prefer an audio conference to travelling to a travel agency, but almost 60% of users would rather travel up to half-an-hour to an agency instead of using audio conferencing to plan a similar holiday. No one in either remote condition would travel for more than two hours to avoid a conference. Bearing in mind that these were inexperienced users of video conferencing, these results are encouraging for the future use of video and audio conferencing for service encounters.

Summary of user evaluation data

After completing the experimental task, participants in the three communication conditions completed a questionnaire asking for their perceptions of the communication process and outcome. A variety of significant differences were found in the participants' perceptions of the communication in the three media. It was expected that it would be perceived to be easy to understand and communicate by more participants in the face-to-face condition than in the technology conditions, with face-to-face communication having the greatest advantage over the audio condition. Analyses revealed more participants in face-to-face communication than in the VMC and audio conditions perceived verbal communication to be easy in terms of getting their questions across and taking a turn in the conversation, however, the two technology-mediated contexts were remarkably similar in how easy participants perceived the verbal communication. Nonetheless, VMC was at a disadvantage to audio-only communication when it came to participants knowing whether or not they had lost contact with the agent, perhaps the lack of synchrony between audio and video signals led to this difficulty.

The non-verbal cues of eye-contact and gesture were reported as easy to observe by significantly more participants in the face-to-face than in the video condition, although the perceived ease of seeing the remote participant's facial expressions did not differ between these media. Despite these perceived differences between the face-to-face and technology-mediated contexts, there were no significant differences in subjects' awareness of the presence of the travel agent (i.e. perceptions of the level of social presence) (in fact, video showed a slight advantage over face-to-face communication in terms of being aware of the agent's presence, despite it being significantly more difficult to make eye-contact than in face-to-face communication); the frequency with which participants felt excluded from the conversation; and the ease of chatting informally with the agent. Although there were no differences in perceived social presence, the objective communication analyses have shown that participants interacted with each other significantly more when the collaborator was remote.

In addition, perceptions of the task performance and satisfaction with the task process did not differ between the three conditions: there were no significant differences in the perceived quality of service or in the ease of making changes to the holiday itinerary or in communication outcome as measured by perceived satisfaction with the final holiday itinerary, supporting objective performance data which also showed no differences between conditions. Overall, the results show that face-to-face interaction does result in more favourable perceptions of the communication process than both remote conditions, but the task outcome was not perceived differently by participants in the three communicative contexts for this collaborative task.

In terms of how participants perceived the technology, in VMC the video image of the agent's face was not considered the most useful tool for completing the task; this may reflect the information exchange nature of the task which would not necessarily require interactors to pay careful attention to the face of their conversational partner. It is known that such tasks do not rely on access to visual behavioural cues as heavily as 'social' tasks, for example, those involving negotiation. In the face-to-face and video contexts the map of the States was considered the most useful tool, but in audio conferencing the video clips of the destinations were found the most useful for completing the task. This could be related to the perceived quality of the video clips: participants in the audio condition perceived the video clips as being of higher quality compared to participants in the video condition, although the actual quality of video clips remained constant.

3.7 Discussion

This study investigated how unequally distributed multimedia communication technology affects the process and outcome of communication in small groups carrying out a collaborative problem-solving task. A review of the literature revealed very little existing research in the area of group mediated communication, especially that which investigates the sharing of technology. The questions being addressed in this study were: how successfully do small groups communicate and collaborate to perform a problem-solving task in three communication contexts? What is the effect of sharing video and audio conferencing technology on the communication process? Are all group members affected in the same way?

Multiple levels of detailed analysis were employed in this study to compare the video, audio and face-to-face conditions: the overall surface structure of dialogues was compared; analyses of the patterns of participation based on the turn-taking order were used to differentiate between technology-mediated and co-present interactions in the technology conditions; the function of utterances in the VMC and face-to-face conditions were compared and the patterns of interactions based on their content were analysed using Conversational Games Analysis; group performance was compared; and the participants' subjective perceptions of the communication process and outcome were ascertained by means of questionnaires.

The effect of shared technology on communication process and outcome

When investigating the effect of partial technology-mediation on the communication process and outcome, no differences were found between the three communication media for the amount of communicative effort expended in numbers of words and turns. This is in contrast to the finding from the two-person Travel Game study by Anderson *et al* (1996) that face-to-face dialogues were shorter in length than VMC dialogues compared to those in audio communication. Overall, in the three-person Travel Game the interactivity and speaker co-ordination of communication did not differ as revealed by interruption rate and turn length data, similarly, Sellen (1995) and O'Conaill *et al.* (1993) found face-to-face and technology-mediated communication to be equally interactive. The only significant difference at the level of dialogue surface structure in this Travel Game study was that audio conferences had a significantly lower rate of back channel responses compared to both VMC and face-to-face communication suggesting that interaction is more formal when there is no access to the visual cues of one group member. This is in contrast to Sellen's (1995) finding that VMC and audio conferencing were similarly formal, and O'Conaill *et al*'s (1993) discovery that VMC was more formal with fewer back channels than face-to-face communication.

Although the overall dialogue structure was not impacted differently by VMC, audio and face-to-face communication, the multimedia communications technology did impact the participant roles differently. In all three media, the travel agent said much the same amount in words and units of conversation (conversational Moves), whereas the two clients said more in the technology-mediated conditions, and in VMC both clients initiated significantly more conversational Moves. Thus, for certain task roles the presence of technology resulted in more verbal interaction being engaged in to complete the task. Furthermore, the equality of participation was affected in the technology-mediated conditions: within dialogues one speaker tended to dominate the conversation in the amount of words contributed while in face-to-face conversations there were no significant differences in the amount speakers with different roles said. Hence, the presence of technology appears to result in less equal participation in discussions.

The presence of unequally distributed video and audio conferencing technology resulted not only in a similar overall communication process to that of face-to-face groups, but the group performance was equally successful in terms of how well participants justified their holiday itineraries and participants were equally satisfied with the outcome in all conditions. This is similar to the finding of Olson *et al* (1994) that high quality VMC led to a communication outcome as good as face-to-face communication, but contradicts their finding that audio communication was inferior to face-to-face communication. Perhaps the contradictory findings are attributable to task differences: Olson *et al.* used a design task while the study reported here is a problem-solving task involving mostly information exchange. It also differs from the dyadic Travel Game study of Anderson *et al* (1996) which found performance via video was poorer than when communicating face-to-face, although the fact that their video image was of lower quality could explain this difference.

The effect of technology-mediation on patterns of participation

The above analyses looked at the effect of sharing technology therefore did not separate technology-mediated and co-present talk in the technology conditions. When technology-mediated exchanges were analysed separately in an investigation of the patterns of communication in VMC, audio and face-to-face communication, the exchanges and words between pairs of speakers across the video and audio links were relatively unaffected by the communications technology. However, the number of exchanges between same-site, same-role participants was significantly higher in VMC than in face-to-face communication and tended to rise in audio conferencing. The pattern of results is similar for both technology conditions but the biggest differences between media were found between VMC and face-to-face contexts. Co-ordination of speaker exchange in the truly technology-mediated communication was more problematic than in face-to-face communication - the interruption rate cross-site was significantly higher in audio than in face-to-face communication and significantly higher during exchanges between one client (the verbally dominant one) and the agent in VMC (the rate between agent and the other client approached statistical significance) - which suggests that the audio lag was having the expected disruptive effect on speaker synchrony as found by, for example, O'Malley *et al* (1996). This effect had not been apparent from an examination of the overall interruption rate between contexts, so the audio delay did have a subtle effect on the communication but did not seem to impact the communication process in general.

Communication content in VMC and face-to-face communication

The next analysis focused not on the surface structure of dialogues but on their content. Conversational Games Analysis (CGA) was identified as a suitable form of content analysis, however due to the very time-consuming nature of this coding method it was decided that only two out of the three communication conditions would be analysed in this fashion. An examination of communicative effort at the level of the number of words and turns showed that most words and turns were exchanged in the VMC context and the least in the face-to-face context; as these two conditions differed from each other the most, they were selected to be compared by means of CGA. In the Conversational Games Analysis of dialogue content it was revealed that VMC took significantly more interactive work than face-to-face communication (in initiating Moves) and significantly more collaborative work (in conversational Games) to complete the task to the same level of performance. This is in line with findings of other studies of mediated communication (e.g. Anderson *et al.*, 1996; Doherty-Sneddon *et al.*, 1997) which also found that VMC required more communicative effort to achieve the same level of performance as in face-to-face communication for dyads. The types of interactions of which there were significantly more in the video context did not involve checking of mutual understanding as might have been expected when visual cues are reduced, but more instructions were issued and more information was volunteered by speakers playing the role of the clients. Similarly, in two-party interactions Doherty-Sneddon *et al* (1997) found that there were comparable amounts of checking of mutual understanding in face-to-face and video contexts.

The technology had the greatest effect on interactions between the two co-present clients with them collaborating in significantly more conversational Games in the VMC than in the face-to-face condition which was an unexpected result. Overall, the amount of three-party collaboration in Games did not differ between shared VMC and face-to-face communication. However, partial video-mediation did have an effect on one type of collaborative communicative behaviour: it reduced the amount of collaboration between all three group members in the asking and resolution of open-ended questions; there were significantly more interactions involving all three participants starting with open-ended questions in face-to-face communication than in VMC. This suggests a tendency for a more interactive and open communication style between all three participants in face-to-face communication than when one member is remote across a video link.

In addition, Conversational Games Analysis has shown that most of the group collaboration in this service encounter simulation was not actually three-person group interaction but communication between dyads, thus supporting claims by, for instance, Parker (1988) based on analyses of speaker turn-taking patterns, that group communication is mostly communication between pairs of speakers. Only

26% and 33% of collaborative verbal interaction (in terms of Conversational Games) in VMC and face-to-face communication respectively involved the participation of all three group members.

Conclusions

The overall finding of this study is that the communication technology is affecting the distribution of the interaction even in a group as small as three people, with the two co-located group members, the clients, becoming more dominant in terms of the mean number of words and turns exchanged, Moves initiated and conversational Games in which they were jointly involved even though they were co-present. Thus it appears that some aspect of the video technology is subtly affecting the interaction, and that differences are only revealed to have a statistically significant effect at the level of the patterns of participation and the communication content. Perhaps a feeling of remoteness or distance is responsible for the greater interaction between clients when technology-mediated, although none was perceived by subjects in terms of their awareness of the travel agent's presence. However, more participants in the audio and video contexts did perceive verbal communication, gesture and eye contact to be more difficult than in the face-to-face context. This may have contributed to a feeling of 'distance' or the creation of a psychological barrier between clients and agent which could have led to the clients feeling less inhibited from spending a longer time discussing between themselves than when the agent was co-present. The majority of cross-site technology-mediated interaction was unaffected by the mediation and was more or less equivalent to face-to-face communication for objective indices of the communication process. This is a promising result for the use of shared multimedia technology, at least in information exchange situations. Perhaps in this simulated service encounter, more interaction between the clients although 'less effective' in terms of communicative effort, may be beneficial to the clients in terms of planning their holiday. This increased collaboration between clients has been discussed up until now in terms of extra interactive effort being expended in order to problem-solve. However, in real terms, although the clients are solving a problem, the opportunity to devote more discussion to the task can be viewed as the clients' preference in order to produce a travel plan to their satisfaction. From the travel industry's viewpoint, it is probably inevitable due to cost that customers of a remote travel agency will be sharing communications technology (such as a video conferencing booth); as this does not seem to lead to major disadvantages in terms of the impact on objective measures of the communication process, and objective and subjective measures of outcome, customers' sharing technology is a viable option to providing separate conference machines.

This laboratory study which explored the impact of sharing audio and video conferencing technology on small group problem-solving discussions has made novel and interesting contributions to the literature. It has reinforced the value of 'triangulation' or the implementation of multiple methods of analysis in communication research to give a holistic picture of the process and outcome of human interaction and to validate new methods of analysis. For instance, the study has confirmed that an exploration of the patterns of interaction using two different methods, one based on an analysis of turn-taking and the other on the function of utterances, converge in their findings that two group members interact more in technology conditions to complete the task and that most conversations in groups are two-party, not multiparty. In addition, Conversational Games Analysis has been applied to group interaction for the first time and it has been extended here to investigate patterns of speaker interaction, i.e., who converses with whom. Furthermore, the study reveals that small groups sharing multimedia communications technology can collaborate as effectively as face-to-face groups, albeit with slightly greater communicative effort expended.

What remains unclear is the extent to which the effect on small groups of sharing technology will be applicable to other types of task and groups, for example 'social' tasks and groups without role differences. In this study the effect of technology is to some extent confounded by the fact that group members who shared a conference site were familiar with each other and had the same task role which differed from that of the remote group member. The best way of investigating this further might be to examine the effect of shared multimedia communications technology on groups without role differences and existing relationships in the controlled conditions of the laboratory.

Due to the nature of the Travel Game, role and task are bound up together inextricably; in order to explore the effect of sharing conference sites on the communication patterns of groups whose members have similar roles in the next study a different task is required. Therefore, a new discussion task will be employed in order to investigate whether one person at a shared conference site will still dominate small group discussion when same-role individuals interact. This will help to illuminate which is having a bigger impact in the Travel Game, role or sharing a conference site.

In study 2, a laboratory experiment approach will be employed due to the need for tight control over variables, and analytical and methodological approaches similar to those of study 1 will be used to allow for comparison between the studies. As the largest differences in communication process and outcome in the Travel Game were between the face-to-face and VMC conditions in this chapter, these two communicative contexts will be compared in the next study.

4 Chapter 4. Study 2. Impact of video-mediation on four-person persuasive communication in the laboratory

4.1 Introduction

The first study reported in this thesis demonstrated that small groups could communicate as effectively in video, audio and face-to-face communication contexts. However, the patterns of speaker participation differed depending on whether the interaction had a technology-mediated element or not. In the audio and video conditions where the technology was unequally distributed, the two participants who shared a computer site interacted significantly more with each other than in the face-to-face context to complete the task, and one of these individuals dominated the discussion. The largest difference in communication process was between video and face-to-face communication. The skewed contribution rates could have been caused by the unequal distribution of technology between group members but there is another variable, the presence of role differences: the two co-located group members had equal roles and were familiar with one another while the remote participant had a different role and was unfamiliar to them. If participant roles had been homogeneous, would the participation still have been unequally distributed amongst speakers? This question is addressed in the next lab study which explores the effect of sharing multimedia video communication technology on communication patterns in groups without existing relationships or role differences for a persuasive decision-making task. In order to set the context for this study, the literature on technology-mediated peer interaction and the impact of sharing technology on patterns of communication is reviewed.

The effect of text-based communication technology on peer group interaction

In the workplace, group interaction often crosses organisational status or role boundaries, however, a large proportion also takes place between 'peers' or same status individuals. Increasingly, groups of workers are physically distributed often relying on communications technology in order to interact with one another. Much of the research into the effect of technology-mediation on group interaction between peers has been carried out in the laboratory and has tended to focus on synchronous text-based conferencing in which group members, who can be distributed in space, communicate by typing into and reading from a computer terminal. Many such studies have focused on the impact of this type of text conferencing on the equality of speaker participation since this has implications for communication effectiveness; when there is participation inequality, information important to decision-making may not get contributed to the discussion and the influence of group members may also be unequal with dominant speakers having more control over the discussion and hence the outcome (Bales, 1950; Berger, Fisek, Norman and Zelditch, 1977; Carletta, Garrod and Fraser-Krauss, 1998).

When groups of peers in the lab communicate electronically using text-based communications technology (CMC), various researchers have shown that participation is more equal than in face-to-face communication, this is generally referred to as the 'equalisation effect' of CMC. Siegel, Dubrovsky, Kiesler and McGuire (1986), for instance, found that three-person student groups had more equal participation in terms of the number of remarks made (a remark was defined as a stand-alone grammatical clause) in computer-mediated decision-making discussions (under conditions of anonymous, non-anonymous, sequential and simultaneous communication) than when communicating face-to-face for choice-dilemma problems. As for the effect on communication outcome, simultaneous text conferencing groups took more time to reach a decision and there was greater choice shift, that is, the group decisions deviated more from initial individual opinions. Nonetheless, computer-mediated groups were as task-orientated as face-to-face groups and in fact communicated more decision proposals as a proportion of remarks made than face-to-face groups. For sequential text communication, the decision-making was the same as for simultaneous CMC but the process of communication differed: there were more remarks concerned with managing turn-taking, fewer suggestions to compromise and fewer remarks supporting others' positions. The differences in decision-making processes and in the effects of communication medium on outcome are mainly attributable to the time-consuming nature of typing and reading compared to talking and listening, meaning that it takes more time to reach a decision in CMC. This also explains the greater proportion of decision proposals: participants maximise efficiency in CMC by using as few keystrokes as possible to get their main argument across.

However, in a lab study Hiltz, Johnson, and Turoff (1986) failed to find a significant difference between the equality of speaking turn distribution when comparing face-to-face and text conferencing five-person student groups for two different problem-solving tasks. They did find that dominant speakers (ones who contributed 33% or more turns) emerged in face-to-face groups for a human relations problem but not for computer-mediated groups or face-to-face groups for a different type of problem. The overall finding was that there was greater, but not significantly greater, inequality in face-to-face than computer-mediated groups. There was less agreement on the final group decision in CMC but no difference in decision quality in face-to-face and computer-mediated groups.

A lab study by Hiltz, Turoff and Johnson (1989) discovered that five-person peer groups of middle-managers from the same company did show a high degree of equality in number of comments contributed and lines typed for choice-dilemma problem-solving discussions in two types of text-based CMC (anonymous and non-anonymous). Participation equality in CMC was not compared to face-to-face communication. Other comparisons were made with face-to-face communication: face-to-face groups were more satisfied and there was more group agreement than in text groups, but text group discussions contained more types of communication that lead to high quality decisions. Nonetheless, decision quality did not differ from face-to-face communication.

In the lab, Lea and Spears (1991) found that certain variables affected equal participation in small, text-based CMC student discussion groups, specifically that communication was less equal when individuals were physically isolated, as opposed to co-located, and their individual rather than their group identity was made salient.

Straus (1996) found more equality in participation (in number of words) in synchronous text conferencing three-person groups of undergraduate peers than in face-to-face groups, for twenty-seven three-person groups of students performing idea generation, intellective and judgement tasks in the laboratory. There were however no differences in performance, although computer-mediated groups were less satisfied with the process than face-to-face groups. Straus (1997) discovered this to be the case in a similar lab study of problem solving: the most dominant individual in technology-mediated discussions contributed a lower proportion of words than the most dominant in face-to-face groups, and the least dominant speaker in mediated communication contributed a higher proportion of words than the least dominant participant in face-to-face groups. She found, however, that computer-mediated groups were less satisfied, less productive and they rated their groups as less cohesive than face-to-face groups. She suggests this is due to the different rates at which mediated and face-to-face groups operate and not because of any depersonalising feature of the technology.

Despite the many studies reporting greater equality of participation in text-based computer-mediated communication (CMC) than in face-to-face communication, Straus (1996; 1997) maintains that, in fact, participation is not equally distributed between speakers in either text conferences or face-to-face contexts: it is unequally distributed in both but to a greater extent in face-to-face communication. She argues that the analysis of equalisation effects at the group level in previous studies have masked this fact. However, Hiltz *et al.*'s (1989) finding of high equality in CMC groups of work colleagues contradicts this - perhaps shared history between group members influenced participation rates in this instance.

Summary of CMC research

The results of research into the effects of synchronous text conferencing on peer group communication are somewhat conflicting. However, one finding which appears well-supported by the majority of the lab studies reported above is that there is greater equality of participation between speakers in synchronous text-based conferencing than in face-to-face lab groups for a variety of indicators (numbers of words, comments and remarks contributed) and tasks, at least for small groups of students performing problem-solving tasks (Siegel *et al.*, 1986; Straus, 1996 and 1997; Hiltz *et al.*, 1989). Less clear is the extent of the equality between speakers: some studies discovered high equality in text-mediated communicative contexts (Hiltz *et al.*, 1989), while others have found low equality between speakers in both text conferencing and face-to-face groups (Straus, 1996, 1997), although these contrasting results could be explained by the different nature of the groups taking part in the studies.

The effect of technology mediation on communication outcome is inconsistent probably varying as a function of the measure of communication outcome and type of task: some studies have found equally high quality decisions in CMC groups as in face-to-face groups (Hiltz *et al.*, 1986), or that CMC is less productive (Straus, 1996 and 1997). There also appears to be a tendency for lower satisfaction in CMC groups (Hiltz *et al.*, 1989; Straus, 1997). It appears from these findings that the slower rate of communication in text conferences versus face-to-face communication rather than any effect of fewer cues (e.g. from voice, gesture, physical environment) has the major impact on communication outcome. However, there is evidence which suggests that perhaps decision-making is affected by some depersonalising feature of the technology: decisions by computer-mediated groups in the laboratory have been found to be more extreme or polarised (i.e., they are more risky than the decisions of individual group members) for groups of managers and university administrators (McGuire, Kiesler and Siegel, 1987), for peer groups of middle managers during anonymous communication (Hiltz, Turoff and Johnson, 1989), and for groups of students when social boundaries have been emphasised (Lea and Spears, 1991).

Audio conferencing and peer group interaction

One study which investigated a different communication channel, the audio channel, is that of Harmon, Schneer and Hoffman (1995). As part of a larger study, (reported in the introduction to the next chapter) thirty-one ad hoc groups of four students communicated face-to-face or via open-line audio in the lab to complete an intellective problem-solving task (which is a task with one correct solution). The authors maintain, based on team members' subjective perceptions of status differentiation and influence, that audio communication clearly equalised status structure, i.e., it tended to suppress the emergence of a dominant participant, and resulted in less differentiated influence than in face-to-face groups. There was nonetheless no effect of communication medium on decision quality or support for decisions.

Video conferencing and peer group interaction

Studies which have investigated the impact on peer group interaction of communication technologies with multiple channels have tended not to focus on patterns of speaker interaction and the 'equalisation phenomenon'. Instead, they have tended to compare the communication process in face-to-face and technology-mediated interactions in terms of its structure and content investigating, for example, numbers of words and turns contributed and speaker interruptions (O'Conaill, Whittaker and Wilbur, 1993; Sellen, 1995) and the types of talk engaged in (e.g. Olson *et al.*, 1994; 1997). One study of video technology which investigated a single indicator of participation equality is that of Sellen (1995) which looked at three VMC systems, face-to-face and audio-only communication. Twelve ad hoc groups of four adults took part in informal debates in the lab. She compared the turn distribution in the different communication modes and found no significant differences using Shannon and Weaver's (1949) equation for calculating information 'H' - this is a measure of the uncertainty about who has the floor at any given time. She also states that dominant speakers tended to dominate and quiet speakers remained quiet in the VMC and face-to-face conditions in the study. (All of these multimedia communication technology studies have been described in detail in the introduction to the preceding chapter).

Thus, there is very little existing research into the effect of multi-mediation on peer group communication. More is known about how text-based communication technology affects group contribution rates. Furthermore, in all of the above studies the communications technology investigated was equally distributed between group members, that is, each group member had their own equipment for communicating and did not share it with any other participant.

The effect of sharing of multimedia communications technology on group communication

Sharing of conferencing technology is sometimes necessary in real work situations when equipment with conferencing capabilities is limited in availability. A case study of four mediated and one face-to-face meeting of two geographically distributed work place supply-chain teams looked into the effects of multimedia technology on group processes (Carletta, McEwan and Anderson, 1998; Carletta, Anderson and McEwan, forthcoming). The desktop technology included 'postage stamp' video, audio and shared tools such as a whiteboard. There was only one access point per site, participants shared equipment and one person sat at the keyboard with the others in the periphery. The meetings were audio-recorded and transcribed and the patterns of interaction examined. The authors noted that the person at the keyboard sometimes acted as a conduit for information to and from the remote site despite audio being clear even for peripheral participants, and that there was more difficulty in addressing people in the technology-mediated than in the co-present interaction especially for those sharing equipment but not seated at the keyboard. There is some evidence that communication was channelled through one person although there was very equal participation in the meetings. The authors propose that differences in status and expertise may have interacted with the technology in their effect on equal speaker participation in the meeting, in the same way that role differences cloud the issue in the first lab study presented in chapter 3.

Monk and Watts (1998) looked at the effect of unequally distributed video technology on three-person student lab groups where two individuals were in the same room and the third was remote and connected via a high quality video link. One of the same-room participants was in a supportive, peripheral role, not directly involved in the task, i.e., there were role differences between participants. The authors report the effects on perceptions of social presence - the peripheral participant felt significantly higher social presence with the co-present participant than the remote one. Role also had an effect - there was higher social presence with the primary remote participant than the peripheral remote participant. However, co-present peripheral participants received significantly lower social presence ratings than remote primary participants. The conclusion is that role overrides the effects of remoteness on participant perceptions of social presence.

Daly-Jones, Monk and Watts (1998) compared high quality VMC (using a 26-inch TV monitor showing the head and upper torso) to full-duplex audio conferencing for four-person student groups sharing two computer sites, two members per site. The groups carried out a negotiation task using electronically shared data. The aim was to prioritise fictional support fund applications but no final agreement was necessary. They found that video communication was more 'fluent' than audio communication, that is, it had more speaker turns, shorter turns and more interruptions. However, the numbers of explicit questions asked and the time to reach agreement were similar in both contexts. Subjective questionnaire data revealed that participants' awareness of one another in video-mediated interaction was very similar to the level of awareness in the co-present interactions in both audio and video conditions. For remote partners there was lower presence and awareness of other group members' attentional focus. No conventional measure of communication outcome was taken.

These studies suggest that in a context where communication technology is shared, co-present participants may have higher social presence (Monk and Watts, 1998), however this may be affected by the size of the video image; for large-screen video conferencing, video-mediated and co-present interactions appear to have similar levels of social presence (Daly-Jones *et al.*, 1998). The addition of a visual channel does seem to have an effect on the overall fluency of the conversation even when some of the communication is co-present (Daly-Jones *et al.*, 1998). When participants share sites one person will tend to dominate talk (Carletta *et al.*, 1998).

Persuasion and Technology-Mediated Communication

In the first lab study in this thesis, the collaborative problem-solving task performed by groups involved information exchange in order to reach a decision. In the study described in this chapter, the aim is to explore a task which has a more 'social' nature in which group members must use persuasion in order to arrive at a resolution to the discussion. What will be the effect of communication medium upon the outcome and effectiveness of such a task? Research has shown that the non-verbal behavioural cues of gaze, smiling and head nodding are associated with perceived persuasiveness, and a sideways lean, leg and arm symmetry, and arm openness are associated with being persuasive and perceiving persuasiveness (Mehrabian and Williams, 1969). Short, Williams and Christie (1976) maintain that social tasks are more sensitive to communication medium due to the importance of the visual channel for expressing and perceiving socio-emotional expression, such as attitudes, moods and reactions. They state that tasks in which there is a need to manipulate others, such as in persuasion or negotiation, are likely to be sensitive to communication medium as they rely more heavily on non-verbal cues than other types of tasks (refer to chapter 2 for a description of Short *et al.*'s theory of differences between communication media). It is likely, therefore, that in a communicative mode in which visual cues are restricted, such as in video communication, persuasion will be less effective than in face-to-face communication.

Indeed, this is the view expounded in Media Richness Theory (MRT) (Hollingshead *et al*, 1993; McGrath, 1993), described in chapter 2, which predicts a relationship between the richness of the information transmitted by the communication medium and the bandwidth requirements of the task type. Richness is defined in terms of the social and emotional content of the communication associated with, for example, disagreements, bargaining, persuasion and getting to know someone which help the addressee to arrive at a single interpretation of the message and thus reduce equivocality (Daft and Lengel, 1986). Hence, the theory has two dimensions: the increasing potential richness required for task success and the increasing potential richness for information transmitted. For negotiating conflicts of interest, audio systems are considered a poor fit as the medium is too constrained, video systems are considered a marginal fit for the same reason whereas face-to-face communication is considered a good fit according to this approach (Hollingshead *et al*, 1993). However, Suh (1999) argues that there is not strong support for such a theory.

The suitability of communications technology for social tasks has been investigated in the lab. Although the focus of this study is on VMC, as there are few studies in the area of technology-mediation and persuasion, research into the impact of three communication modalities - text-based, audio, and video communication technologies - is reviewed below.

Text conferencing and negotiation

In a longitudinal lab study, eleven face-to-face and eleven synchronous text conferencing groups of three to four students carried out negotiation tasks - labour grievance cases - in which there were three or four different participant roles. Face-to-face groups performed better than their CMC counterparts, although this advantage of face-to-face communication disappeared over time. Face-to-face groups were also more satisfied with their performance than CMC groups (Hollingshead, McGrath and O'Connor, 1993; McGrath, 1993).

Audio conferencing and equivocal tasks

Other investigators have focused on negotiation in a richer communication medium: audio communication. In the laboratory, Morley and Stephenson (1969, 1970), for example, compared the negotiation success of dyads (it was unspecified whether or not these were students) under four experimental conditions (with five dyads in each): telephone or face-to-face communication with either freedom to interrupt restricted or not restricted. The most formal condition was telephone communication with no interruptions allowed and the least formal was face-to-face communication with interruptions allowed. Participants took roles representing either management or the union in an industrial dispute over wages. The strength of the case was either stronger for the management (Morley and Stephenson, 1969) or for the union (Morley and Stephenson, 1970). The researchers found that victory for the side with the stronger case was positively associated with the formality of the communication system used to conduct the negotiation. This would seem to suggest that for the side with a stronger case, communication without a visual channel is a better choice. The authors propose that in a more formal communication system, negotiators are less likely to be concerned with presentation of the self, pay more attention to what is said and to be more task-orientated, i.e., there is less emphasis on interpersonal aspects of the interaction or, to state this in a different way, communication is more depersonalised. Consequently, the more formal the system the more objective the process and outcome of the negotiation settlement. According to the authors, the less formal the system, the more the norm of 'reciprocity' will influence the outcome of the negotiations.

In another lab experiment (Sheffield, 1995) fifty-five pairs of students carried out a negotiation task in one of four communication conditions: text-based conferencing with or without visual access to other group members, audio conferencing or face-to-face communication. Pairs were instructed to either maximise joint profit (a 'win-win' orientation) or individual profit (participants have conflicting objectives). When there was a visual channel, the joint profit was significantly lower for individualistic negotiators than for co-operative negotiators, however, there was no difference between the types of negotiators in the amount of joint profit when there was no visual channel. This is interpreted as the multiple cues available in rich media increasing the impact of negotiators' individualistic bargaining orientation. Hence, visual cues moderate the impact of bargaining orientation on negotiation outcome. In this task, the optimal settlement is when both negotiators have high profits.

The above studies of audio communication look at dyadic communication, a study of *group* communication was carried out in the lab by Harmon (1998) who investigated the effect of audio and face-to-face communication when negotiating conflicts of interest about the acceptability of nuclear power plant proposals. Forty-four four-person groups of undergraduates with similar task roles participated. There were two dependent variables both based on subjective participant data: participant satisfaction and group agreement. There was higher satisfaction in audio than in face-to-face communication but the same amount of agreement in both communication contexts. Audio communication was as good as face-to-face communication for building interpersonal agreement and support for group decisions, even though 'lean' media are thought to be less suitable than rich media like face-to-face communication for such highly equivocal tasks (at least, from a media richness theory perspective).

In sum, the above studies show that for subjective measures of outcome, audio and face-to-face communication appear to be equally successful for tasks in which there is negotiation and persuasion (Harmon, 1998); the absence of a visual channel is beneficial for negotiators with the stronger case (Morley and Stephenson, 1969, 1970); and the presence of a visual channel is disadvantageous for achieving optimal settlement between individualistic negotiators, i.e., ones with conflicting objectives (Sheffield, 1995).

The effect of VMC on negotiation tasks

There are few studies into the impact of video-mediation on highly equivocal tasks such as those involving persuasion and negotiation. One exception is a laboratory experiment by Valacich, Mennecke, Wachter and Wheeler (1994) in which student dyads carried out an intellective task and a cognitive conflict task in text-based CMC, low quality VMC, face-to-face or audio-only communication modes. In the cognitive conflict task, there were significant differences between the four media in time to reach a decision with VMC taking the longest and CMC the least time. There were also significant differences in satisfaction with the process of communication - face-to-face and VMC were similar and resulted in greater satisfaction than audio only and CMC. Unfortunately, no post hoc statistics were reported so it is not known which media differ significantly from one another. There were no differences between media for the following subjective perceptions of performance: the amount of group consensus, satisfaction with the solution and amount of task focus. There were no statistically significant differences between contexts for perceived equality of communication but there were for social presence and media richness- face-to-face was rated highest and CMC lowest - again no post hoc analyses were reported and means were not given.

In a lab experiment, Kinney and Dennis (1994) compared high quality VMC, simultaneous text CMC and face-to-face communication. Student dyads took part in two tasks one of which was a negotiation task. The dependent variables were a mixture of subjective and objective measures: perceived media richness and social presence, communication satisfaction, decision time, decision quality and group consensus. There were no significant differences between VMC and face-to-face on any of these measures, while face-to-face communication was rated as having significantly higher social presence and media richness than CMC, and the decision time was significantly shorter.

In the laboratory, Suh (1999) investigated the performance and satisfaction of student dyads, forty in each of four communication modes - face-to-face, text, audio and high quality video - for an intellective and a negotiation task. The negotiation task was a bargaining game where members competed for individual pay-offs and the intellective task was an inheritance tax calculation problem where each party had half the necessary information. For the objective measures of performance of decision quality and decision time, there was no difference between VMC and face-to-face communication and task did not interact with medium. CMC took the most and audio the least time and the media differed significantly from each other on this measure. For both negotiation and intellective types of task, face-to-face groups had higher task satisfaction than audio groups but face-to-face and VMC groups were similar on this measure. There was no effect of medium on satisfaction with outcome. So VMC and face-to-face groups had similar performance and were equally satisfied in both tasks.

In the above three laboratory studies of video-mediated negotiations between pairs of peers, high quality VMC and face-to-face communication are remarkably similar in their impact on task outcome and satisfaction, while low quality VMC may lead to longer decision times than other media.

As can be seen from the above review of persuasion and negotiation literature, there are few studies which examine the effects of communication technology on peer group persuasive communication, particularly the impact of multimedia technology upon this. This study aims to explore the impact of technology mediation, notably VMC when sharing conference equipment, on tasks involving persuasion and to examine the effects on groups with no role or status differences.

The existing research findings suggest that in the study which will be reported here, the high quality video technology will not adversely affect performance compared to face-to-face communication. However, the small size of the image (showing only the face and upper body) will probably provide fewer of the non-verbal cues used in persuasion than face-to-face communication, therefore may affect perceptions of persuasion effectiveness.

4.2 Study 2. The impact of shared video conferencing technology on peer group persuasive communication

In lab study 1 it was discovered that in face-to-face communication the participation was more equally distributed among group members than in audio and video communication, and there was significantly more communication between same-site participants with similar roles in the technology-mediated conditions. The largest difference in patterns of participation was between video and face-to-face communication. However, it is not clear to what extent the results were influenced by the presence of role differences between group members rather than the sharing of communications technology. If there had been no role differences among group members would the sharing of multimedia communications technology still have resulted in skewed patterns of speaker participation? This is one of the research questions addressed in study 2 which examines the communication of peer groups during face-to-face and shared video communication. Due to the need for tight controls, a lab experiment was carried out.

Lab research investigating text conferencing and audio conferencing peer communication suggests that speakers in mediated groups will contribute more equally to conversations than face-to-face groups. On the other hand, the findings of the first lab study presented in this thesis indicate that the sharing of technology, hence the physical co-presence of some participants, might result in less equal patterns of participation with one or more individuals dominating the conversation.

The predictions for this study have been based on lab study 1 for the following reasons: firstly, in common with study 1, this experiment explores the communication of small groups interacting face-to-face or via high quality video when the technology is shared between participants; secondly, other communications technology research has not investigated the impact of multimedia video technology but text or audio conferencing technology, and has examined groups whose participants were all physically isolated from one another, each at their own computer terminal. The experimental hypotheses to be tested are:

- speakers will contribute words less equally in partially video-mediated discussions than in face-to-face discussions
- there will be more communication between same-site participants (co-present participants who share a computer site) than between cross-site pairs of participants (who communicate across the video link)
- co-ordinating speaker exchange will be more difficult cross-site than same-site as revealed by longer speaking turns
- cross-site communication will be more formal with fewer speaker interruptions than same-site communication
- people will be more persuaded by the same-site group member than by cross-site group members

Furthermore, based on evidence from a field study of VMC (Carletta *et al.*, 1998), it is expected that one of the two people at each shared site will act as a channel for cross-site talk. The hypothesis being tested is:

- one participant at each conference site will dominate the cross-site interaction

Further research questions being addressed are: what are the effects of sharing video technology on task performance and persuasion, the amount of communicative effort required (in words and turns) to complete the task, and the interactivity (turn length) and formality (speaker interruptions) of the communication? These questions can be answered by comparing objective and subjective measures of communication process and outcome in face-to-face and video-mediated communication.

The Task

In this study, group discussions with a video-mediated element were compared to face-to-face discussions. This involved seventeen four-person groups (the data from three of the groups had to be excluded from analyses due to either problems with the video technology or experimenter error) taking part in a simulation of a workplace design meeting where participants act as members of a design team each advocating her/his own design to the other group members for a future product development. The participants had homogeneous roles and in the VMC condition, two participants shared a computer terminal at each of two sites in order to simulate a distributed product design meeting. The task involves promoting ones own assigned product design to the other group members, and then the group votes for the best design to carry forward to the management as the new product. Each group member must vote for a design other than his/her own in order to reveal the effect of persuasion on product choices, for instance, are group members more persuaded by co-present group members than by remote members?

4.3 Method

Subjects

Sixty-eight students and staff of the University of Glasgow participated in this study for £5 in cash and the chance of winning £40 for the best group.

Experimental design

The design was mixed with communication condition as a repeated measure (two levels: video-mediated and face-to-face communication) and speaker (four levels: speakers A, B C and D) as a between subject variable. Half of the groups carried out the face-to-face discussion first and half the VMC discussion first. There were two sets of four products to be discussed- either Palmpilot PCs or digital cameras, the order in which the groups discussed the two product types was counter-balanced.

Procedure

Each of the members in each four-person group was allocated a letter A, B, C or D arbitrarily and given a badge with this letter on. They were each given the same pictures and descriptions of the four products which they subsequently discussed, a brief which explained a bit about the product, and some market information about the type of customers who buy the product (see Appendices G and H for copies of this information). They each made private pre-discussion votes: they were told to choose one product that they would take forward to their manager as the new product for 1999 and to write their choice on a slip of paper.

Then each person in the group was given a folder containing a description of the task and one of the products A, B, C or D that they had just seen (the one that corresponds to their badge letter such that person A promoted product A etc.), including a copy of the brief and market information they had just read.
They were given the following written instructions:

> You are part of a group of four designers each of whom has designed a product. You must decide **as a group** which **one** you will take to your manager as the new product design for winter 1999.
>
> Your job is to **persuade** the other group members that your product is the best - designers of chosen products always receive a large pay bonus. You must **not** under any circumstances show your product description sheet to the others in the group - you must describe it verbally only. You have only **10 minutes** in which to decide.
>
> The alarm will sound **after 8 minutes**. You now have 2 minutes left in which you must all **vote out loud for someone else's product**. **After 10 minutes** the final alarm will sound and you should end the discussion at this point.
>
> The majority vote decides the group choice. If there is no majority the group members must reconsider their choices until a majority has been achieved.

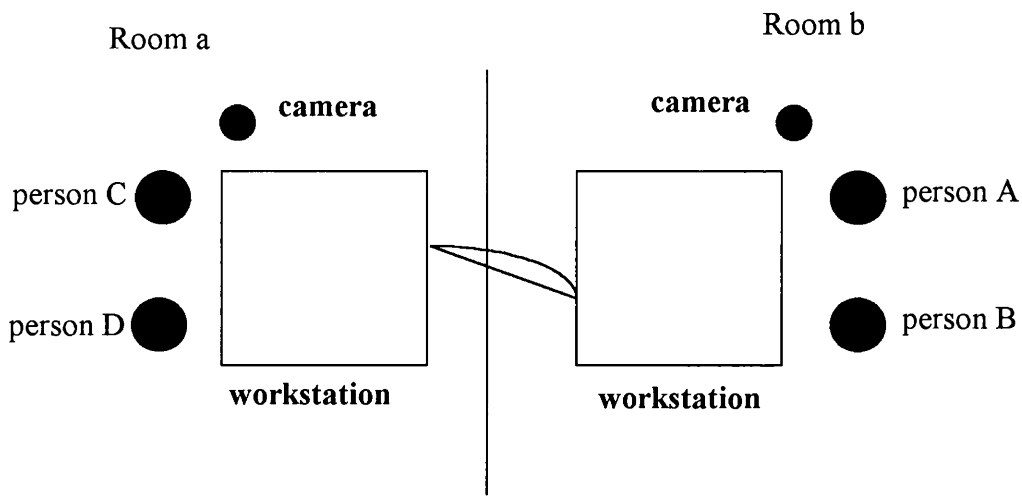
After the discussion, you will be asked

- to justify the group's choice
- which design you personally voted for. **You are not allowed to vote for your own design.**

They were asked not to show their sheets to the other group members to avoid participants simply swapping and reading information sheets rather than discussing the products. In addition, participants were told that the best group (for purposes of the prize) was one in which everyone participated and in which they made the best-reasoned group choice. Following the discussion they were asked to fill in a sheet individually stating which product they had just voted for, what the group chose and to justify in up to sixty words why the group chose that product. The same procedure was carried out for the second communication condition - the identification/product letters with which participants were allocated stayed the same. The participants then filled out a questionnaire comparing their experience of the technology and the communication in VMC and face-to-face communication and a questionnaire on their computer experience. They were then given the debrief and paid.

In the face-to-face condition participants were seated around a table and chose their own seats. There was a summary of the product information and images on an A4 colour sheet on the desk for all to view. In the VMC condition, participants A and B were placed in one room and C and D in an adjacent room, they spoke to each other via microphones attached to headphones and saw the other pair of group members across the video link (see Figure 4-1). The room in which the alarms were placed was alternated in the VMC condition. In the VMC context the product images and summary of the product information were displayed on the screens of both terminals. Copies of the product summary sheets are provided in Appendices Q and R.

Figure 4-1 Video-mediated communication set-up



Apparatus

In the shared video condition, two adjacent rooms were each equipped with Sun Ultra 1 Creator workstations linked by a dedicated LAN run via the ATM network providing high quality video with a frame rate of 25 frames per second, with 400 by 600 pixels, displayed in a window of size 5.3 inches wide by 3.9 inches high in the top left-hand corner of the screen. Video encoding was Sun's CellB encoding of a PAL video stream. Colour images and text descriptions of the four products to be discussed were displayed in Netscape on the right-hand half of both computer screens. Two participants sat at each terminal and communicated with the remote group members via video and audio. All participants wore headphones with one earpiece and a microphone. The audio was high quality, full-duplex (open channel) with no delay and was run directly between the two rooms. The audio output from the two rooms was combined (using a MACKIE Micro series 1202 12-channel Mic/line mixer) and an analogue recording made via an AIWA XK-007 Excelia stereo cassette recorder. The video signal was transmitted via two JVC videomovie GR-AX60 camcorders placed to the right of one terminal and the left of the other, as close as possible to the screen while still allowing both participants' images to be seen clearly. Face-to-face discussions were recorded onto two channels of a Sony Walkman using PZM desk microphones.

Pilot study

To ensure that the mix of products would provoke sufficient debate, being neither too difficult nor too easy to chose between them, a pilot test was carried out. Two relatively new products were identified and chosen to be discussed - palm pilot PCs and digital cameras. Four images of each product type were collected and fictional but realistic capabilities and sizes were attributed to each. Initially, images and descriptions of four Palmpilot PCs were shown to twelve staff and students of Glasgow University and they were asked to choose the product they, as the head of a team of designers, would take forward to their manager as the new product for winter 1999. Eleven out of twelve people chose the same product. This indicated that one product was obviously superior to the others and discussions about which product was best would be too short and the decision too straightforward. Therefore the product descriptions were changed to make the PCs more equal and twenty different staff and students of Glasgow University were asked which one they would choose to take forward to their manager as the new product. There was no significant difference between the number of votes for the four products as shown by a chi-square one sample test (x^2 (3)=1.2, p=n.s.). This indicated that the range of products should provoke sufficient debate to fill the allocated ten minutes discussion time. See Table 4.1 for the voting distribution.

Table 4.1 Number of votes for four Palmpilot PCs

PC product A	PC product B	PC product C	PC product D
6	5	3	6

Nineteen staff and students were asked to choose their preferred product from four digital cameras based on colour images and descriptions of their functions. There was a sufficient spread of choices - a chi-square one sample test showed that there was no significant difference in the numbers of votes for the four products (x^2 (3)=1.4, p=n.s.). The distribution of choices is shown in Table 4.2.

Table 4.2 Number of votes for four digital cameras

Camera product A	Camera product B	Camera product C	Camera product D
6	3	4	6

Communication analyses

All twenty-eight discussion sessions were orthographically transcribed (including back channel utterances) from audio-recordings. The dialogues were then coded for interruptions and the VMC and face-to-face dialogues were first of all compared using the same sort of objective verbal communication analyses as in the first lab study in the thesis. This involves counting the number of words uttered, speaking turns taken, the length of the turns and the number and rate of speaker interruptions. Such analyses can reveal the communicative effort required to complete the task, for instance, a longer dialogue is less efficient at conveying information than a shorter one for a given level of performance. The interactivity and formality of the communication style can be revealed by turn length and interruption rate: shorter speaking turns generally indicate no difficulties with co-ordination of speaker exchange and fewer interruptions usually indicate formality. The initial analyses take the dialogues as a whole and compare those with a video-mediated aspect to those which took place face-to-face round the table. The subsequent analyses break down the technology-mediated dialogues into communication which was video-mediated and that which was co-present.

4.4 Results

Comparison of two communication modes: face-to-face and shared VMC technology

Seventeen four-person groups each took part in both an across the table face-to-face discussion and one which was partly video-mediated (three groups were excluded from the analyses due to technological difficulties or experimenter error). The effect of sharing communications technology on the communication process and outcome will be explored including the impact on group performance, the equality of speaker participation, dialogue length in words and speaker turns, and the interactivity and formality of communication in terms of length of speaking turns and amount of speaker interruptions. As only some of the interaction in the video condition was actually video-mediated it was not certain whether the impact of video on turn length and number of interruptions would be apparent in the dialogues which combined both video-mediated and co-present communication (it was expected that video-mediated exchanges would be more formal and less interactive communication than face-to-face interactions).

For each measure of dialogue structure - dialogue length in words and turns, turn length, and interruptions - a 4 by 2 by 2 mixed design ANOVA was carried out with communicative context as a repeated measure (two levels: face-to-face and VMC), speaker as a between subject variable (four levels: the four speakers in each discussion were labelled A, B, C or D according to which product she/he was promoting) and order as between groups measures (two levels: VMC discussion first or face-to-face discussion first).

Dialogue length: number of words uttered

The number of words spoken in dialogues was calculated and compared by means of a 4 by 2 by 2 mixed design ANOVA as described above. This revealed that the length of dialogues in number of words spoken did not differ significantly between communication contexts (**F**<1). There were no differences between speakers in the number of words uttered in order to promote the four different products (**F**<1)

and there was no interaction of speaker (A, B, C or D) and the communication context (**F**<1.5). There was no main effect of order on amount of words said (**F**<1) and no interaction of speaker and order (**F** (3, 48)=2.4, **p**=.08 n.s.), order and communication medium (**F**<1) or interaction of speaker, order and medium (**F**<1). The mean numbers of words spoken are shown in Table 4.3.

The near significant interaction of speaker and order is due to speaker A saying more words when the face-to-face discussion was first (**F**(1,51)=6.5, **p**<.01) (when face-to-face discussion was first, the mean dialogue length is 685.1 words and 380.95 words when VMC was first).

Table 4.3 Number of words spoken

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	377.3 (143.0)	390.6 (188.8)
	face-to-face first	628.8 (194.7)	741.3 (278.7)
B	VMC first	610.9 (313.3)	624.1 (359.4)
	face-to-face first	447.5 (254.0)	520.3 (338.9)
C	VMC first	657.8 (282.1)	610.4 (267.0)
	face-to-face first	562.2 (167.8)	483.0 (181.6)
D	VMC first	593.1 (283.2)	598.0 (232.9)
	face-to-face first	518.2 (206.2)	518.3 (354.3)
mean words per dialogue		**2204 (342.8)**	**2169 (560.6)**

Dialogue length: number of speaking turns taken

The way in which speech (words) was (were) distributed in speaking turns throughout the discussion was also explored. A mixed design ANOVA confirmed that the number of turns did not differ between communication conditions (**F**<1) and also showed no significant differences between speakers in the number of speaking turns taken in the conversations (**F**<1). No interaction of speaker and context was found (**F**<1). There was a main effect of order of discussion (**F** (1, 48)=5.8, **p**<.05) -discussions had significantly more speaking turns when a VMC discussion was carried out first rather than a face-to-face discussion (VMC first: mean - 169.2 turns; face-to-face first: mean - 128.8 turns). There was, however, no interaction of order and communication medium (**F**<1) or order and speaker (**F**<1.5). and no interaction of speaker, context and order (**F**<1). The mean numbers of speaking turns are given in Table 4.4.

Table 4.4 Number of speaking turns

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	32.3 (15.8)	34.1 (17.1)
	face-to-face first	34.5 (12.3)	38.5 (17.1)
B	VMC first	45.4 (19.4)	42.0 (24.1)
	face-to-face first	29.5 (16.9)	28.0 (11.8)
C	VMC first	51.3 (19.0)	45.9 (21.1)
	face-to-face first	31.3 (15.7)	32.2 (11.0)
D	VMC first	41.1 (14.1)	43.8 (21.7)
	face-to-face first	31.8 (11.2)	31.7 (10.4)
mean turns per dialogue		**151.6 (55.5)**	**150.6 (59.4)**

Length of speaking turns

What effect will shared video technology have on communication interactivity in terms of length of speaking turns? A mixed design ANOVA showed no significant difference between communication contexts in length (in words) of speaking turns in dialogues (**F**<1) and no significant differences between speakers (**F**<1). Neither was there a combined effect of speaker and context (**F**<1). There was a main effect of order on length of speaking turns (**F**(1, 48)=4.7, **p**<.05) but no interaction of order with speaker (**F**<1) or with medium (**F**<1) and no three-way interaction of order, medium and speaker (**F**<1). Table 4.5 shows that turn length was almost identical in VMC and face-to-face conditions.

The order effect shows that when face-to-face discussions were carried out first, the turn length in dialogues was significantly longer than when VMC discussions were first (face-to-face discussion first, mean - 18.4 words per turn, VMC discussion first, mean - 14.9 words per turn).

Table 4.5 Length of speaking turns

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	14.4 (8.7)	12.9 (5.8)
	face-to-face first	19.6 (6.5)	20.9 (5.8)
B	VMC first	14.1 (5.1)	15.8 (5.1)
	face-to-face first	18.3 (10.3)	18.3 (6.2)
C	VMC first	13.1 (3.4)	14.8 (6.5)
	face-to-face first	19.7 (4.97)	16.1 (6.2)
D	VMC first	16.5 (11.2)	15.6 (7.8)
	face-to-face first	17.1 (6.1)	17.0 (11.7)
mean turn length per dialogue		**16.3 (5.5)**	**16.6 (5.8)**

Interruptions by each speaker

Another indicator of communication style is the number of interruptions made by speakers. It has been established that there are fewer interruptions in video-mediated than in face-to-face communication even when the audio link is of high quality (e.g. O'Conaill *et al.*, 1993; Sellen, 1995). This has been interpreted as indicating the formal style of mediated communication. However, in this analysis as the video context has elements of both co-present and video-mediated communication it was not certain how interruption behaviour would be affected, therefore no hypotheses were formulated. The effect of partial video-mediation on interruptions in comparison to face-to-face communication was explored. A mixed design ANOVA revealed no significant difference between communication contexts in number of interruptions made by participants (**F**<1.5), no significant differences between speakers (**F**<1), and no combined effect of speaker and context (**F**<1). There was a main effect of order on number of interruptions (**F**(1, 48)=8.5, **p**<.01) with significantly fewer interruptions when face-to-face discussions were first (mean - 27.6 interruptions per dialogue) rather than VMC first (mean - 58.6). There was no interaction of order with speaker (**F**<1) or with medium (**F**<2.5) and no three-way interaction of order, medium and speaker (**F**<1). The mean numbers of interruptions in Table 4.6 show that face-to-face communication has slightly more - 12% more - interruptions than VMC.

Table 4.6 Mean number of interruptions

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	12.8 (5.4)	14.4 (10.1)
	face-to-face first	5.7 (4.0)	5.7 (4.0)
B	VMC first	12.5 (7.0)	13.1 (7.2)
	face-to-face first	10.8 (8.2)	8.5 (5.7)
C	VMC first	14.5 (10.7)	18.9 (13.2)
	face-to-face first	8.7 (6.5)	8.0 (6.1)
D	VMC first	12.6 (10.0)	16.9 (15.8)
	face-to-face first	8.3 (2.9)	9.5 (7.1)
overall per dialogue		**44.3 (27.0)**	**49.7 (36.6)**

Summary of results of objective analyses of communication process

These results show that it did not take any more communicative effort overall- in numbers of words and turns - to complete the task when some participants were communicating across video than it did when all participants were communicating face-to-face round the table. Overall, the interactivity of conversation, based on length of speaker turns (in words), and its formality, based on numbers of interruptions, were similar in both communicative contexts. There was an effect of whether discussions were carried out first - when a face-to-face discussion was carried out first, the communication was less interactive and more formal regardless of communication medium or speaker but this did not interact with the variables of interest. Do participants' subjective perceptions of the communication process reflect the objective similarities observed? Questionnaires filled in by participants included questions about ease of taking part in, and feelings of being excluded from, the discussion, the results of which are described below.

Subjective comparisons of face-to-face and partly video-mediated communication

In order to go beyond the objective data, the participants' subjective perceptions of the communication process were sought by means of a single post-task questionnaire which asked them to compare their experiences in the face-to-face and partially video-mediated conditions. Appendix S contains an example of a questionnaire. Only one questionnaire was administered subsequent to participation in both communication conditions as it was thought that the participants' behaviour in the second communication condition would be affected by knowledge of the purpose of the study. The majority of the questions required respondents to compare round-the-table face-to-face communication with both video-mediated and co-present interactions in the technology context, and the results of these analyses will be reported shortly. However, two questions concerning ease of communication required respondents to compare the communication in the video context overall with that of the face-to-face condition, the results of these questions are presented below. As data are categorical and participants each responded only once to the questions, non-parametric chi-square one sample tests were used for these analyses.

Ease of taking a turn in the conversation

Participants were asked how easy it was to take a turn in the conversation when they wanted to when communicating with all group members face-to-face compared to when some group members were communicating via video technology. They responded on a five-point scale from 'much easier when face-to-face' to 'much more difficult when face-to-face'. A Chi-square one sample test revealed that there were greater than chance responses in two categories: a large proportion of subjects, 43%, felt that is was equally easy to take a turn in both contexts but a similar amount, 41%, found this easier when face-to-face (x^2 (4)=48.5, **p**<.05). The response distribution is shown in Table 4.7.

Table 4.7 Ease of taking a turn

how easy was it to take a turn in the discussion?	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N
	8	23	24	1	0	56

Participants were also asked to compare how often they felt excluded from partly video-mediated and face-to-face across-the-table discussions. Responses were on five-point scale from 'much more often when face-to-face' to 'much less often when face-to-face'. The responses from all participants were summed and analysed by means of a Chi-square one sample test which revealed that there were significantly greater than chance numbers of responses in two categories (x^2 (4)=49.1, p<.01). As can be seen in Table 4.8, 44% of participants felt excluded from the discussion equally often in both communication contexts and 42% felt excluded less often in face-to-face communication.

Table 4.8 Frequency of feeling excluded from conversation

how often did you feel excluded from the discussion?	much more often when face-to-face	more often when face-to-face	equally often when face-to-face and VMC	less often when face-to-face	much less often when face-to-face	N
	0	6	24	23	2	55

From the questionnaire data it seems that around half the participants in the study perceived it to be no more difficult to contribute to the conversation when sharing video communication technology than when communicating face-to-face with all group members. However, a similar number of participants felt that it was easier to contribute to the discussion in the face-to-face communication condition. Hence, the impact of sharing communication technology on ease of participation is perceived as problematic by a large proportion of subjects. This is in contrast to the findings of the objective analyses of the communication process carried out thus far which show no differences between contexts in ease of co-ordinating conversation as evidenced by their similar length of speaking turns and numbers of speaker interruptions.

Equality of participation between speakers in shared VMC and face-to-face communication

In the comparisons of face-to-face group communication with that which was partly video-mediated, the amount contributed to the discussions by the four different speakers was compared. However, the speaker labels A, B, C and D upon which the comparisons so far have been based were assigned to speakers arbitrarily with the result that dominance by any one speaker within a group may have been obscured. For this reason, the equality between the contributions of speakers within groups was investigated. Face-to-face conversations and those with some video-mediation were compared by calculating an equality of participation score for each discussion. Equality was measured in terms of how many words speakers uttered. It was expected that there would be greater equality of participation in face-to-face discussions than in shared video communication based on the finding from study 1 in which there were significant differences between speakers in the amount said in the VMC context but not in the face-to-face context.

The first index of equality is the Gini co-efficient which was originally developed by Alker (1965) to measure political inequality, e.g. in wealth distribution, but it has been used subsequently by Weisband, Schneider and Connolly (1995) to compare the equality in number of remarks contributed in three-person CMC and face-to-face laboratory groups. The Gini co-efficient was computed for each group. It sums, over all group members, the deviation of each from equal participation (E), this is then divided by the maximum possible value of the deviation (the maximum is found by dividing the total number of words spoken in the discussion by the number of words each person would have said if they had all contributed equally). The co-efficient thus takes a value between 0 and 1 where 0 means perfect equality. For an observed set of participation rates, X_1, X_2, X_3 and X_4, the Gini co-efficient (G) is calculated as

$$G=\sum_{I=1}^{N} |X_i - E|$$

The face-to-face and VMC Gini co-efficients were compared. A repeated measures t-test revealed that the equality with which speakers took part in the discussions did not differ between the two communication contexts (**t**<2), contrary to expectations. As the possible scores range from 0 to 1, the mean scores of 0.512 (SD 0.149) for face-to-face discussions and 0.438 (SD 0.186) for partly video-mediated discussions show that there was a moderate amount of inequality in both contexts.

The second index is based on the method of Straus (1997) who compared the proportion of words uttered by the most and least dominant participants in CMC and face-to-face lab groups, however, here ratios and not proportions are compared. The difference in number of words uttered by the most and least frequent speakers in each session was calculated by dividing the former by the latter to give one ratio for each session. The face-to-face and VMC conditions were then compared by means of a repeated measures t-test. Again no statistically significant difference was found (**t**<1.5) The mean ratios were very similar, in VMC it was 3.12 (SD 1.5) and in face-to-face 3.61 (SD 1.9). This shows that there is inequality in speaker participation with roughly three times more being said by the most frequent speaker than by the least frequent speaker whether there is a video-mediated element to the communication or not.

Group performance

The above objective analyses of the communication process show that when some participants communicate via technology it does not take any more communicative effort in terms of words and turns contributed by speakers to complete the task compared to face-to-face interaction. But are the groups performing equally well in the two communication modes? Group performance was measured objectively by how well participants justified their group choice of product. At the end of each discussion session, each participant was asked to write a justification of no more than sixty words stating why their group chose one product rather than one of the other three products (hence there were four justifications written per discussion session). The justifications were awarded marks by an independent judge, who was blind to the conditions and experimental hypotheses of the study, according to whether they included reference to the core customer requirements included in the market information and on the number of other valid reasons given for choosing that product. The judge followed a marking scheme, a copy of which is provided in Appendix U, which awards scores on an ordinal scale. For discussions about digital cameras, the product chosen by the group was required to satisfy three core requirements based on fictional customer profiles and needs which were conveyed to the groups as market research information. The three requirements were: the product must be suitable for customers between the ages of 23 and 50; appeal to the environmentally conscious customer; and appeal to the image conscious customer. For palm pilot PCs the three core requirements were: convenience of use; compatibility with Windows; and communications capability (email, fax, Internet). Any reasons not covered by the core requirements were given five points each. There was a ceiling to the marks that could be awarded which depended upon the number of core requirements that had been met so that

- if no core requirement was met the minimum score was 0 and the maximum was 25
- if only one core requirement was met the minimum score was 26 and the maximum was 50
- if only two requirements were met the minimum score was 51 and the maximum score was 75
- if all three requirements were met the minimum score was 76 and the maximum score was 100

This method of scoring was decided upon so that a justification providing many valid reasons for the product selection but satisfying none of the market requirements could not receive a higher score than a product which had met some or all of the core requirements. An example of how justifications were scored is given below in Figure 4-2 and examples of good and poor justifications are given in Figure 4-3.

Figure 4-2 Example of the scoring method for a justification

Justification for a Palmpilot PC	Score break down	Points
Large visible accessible touch-sensitive screen,	1 reason	5
not too small	1 reason	5
had the most memory	1 reason	5
and not significantly bigger or heavier than the others.	1 reason	5
Had above advantages and all the other benefits of the others such as email	meets core requirement of communications capability	51 (2 core requirements - min. score 51, overall max. possible score 75)
and Windows compatibility.	meets core requirement of Windows compatibility	
	Total score	71

The intra- and inter-judge reliability of the scoring scheme were assessed by having the principal independent judge re-mark a random sample of ten justifications after a period of two weeks and by having a second judge independently rate the same ten justifications. The correlation between the scores was assessed by means of Spearman rank-order coefficients which show that the inter-judge reliability was sufficiently high with the marks given by the two judges being significantly positively correlated (r_s=0.84, **p**=.001, 1 tailed). Intra-judge reliability was also significantly positively correlated (r_s=0.55, **p**=.05, 1 tailed).

Following reliability tests, the principal independent judge (who was unaware of the study hypotheses and conditions) went on to score all one hundred and twelve justifications (28 discussions with four justifications per discussion). A 4 by 2 by 2 mixed design ANOVA was carried out with communicative context as a repeated measure (two levels: face-to-face and VMC) and speaker (four levels: A, B, C or D) and order as between groups measures (two levels: VMC discussion first or face-to-face discussion first). This showed a significant difference between how well participants justified their group choices in face-to-face and VMC sessions with face-to-face justifications scoring significantly higher ($\mathbf{F}(1,48)=4.1$, $\mathbf{p}<.05$). There was no effect of discussion order ($\mathbf{F}<1$) and no interaction of communication mode and order ($\mathbf{F}<1$), no effect of speaker ($\mathbf{F}<1$), no interaction of speaker and order ($\mathbf{F}<1$) and no three-way interaction of order, speaker and context ($\mathbf{F}<1.5$). As seen in Table 4.9, the mean group score for face-to-face discussions is 23% higher than that for VMC discussions.

Table 4.9 Mean performance scores

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	47.5 (27.7)	40.4 (28.6)
	face-to-face first	34.3 (28.9)	55.3 (21.6)
B	VMC first	34.1 (25.4)	50.5 (28.4)
	face-to-face first	31.0 (22.7)	42.2 (22.8)
C	VMC first	38.0 (19.9)	44.3 (21.1)
	face-to-face first	41.3 (23.4)	38.8 (17.1)
D	VMC first	29.6 (14.5)	43.6 (28.3)
	face-to-face first	36.2 (21.1)	46.3 (13.4)
overall per dialogue		**36.6 (13.7)**	**45.1 (6.2)**

Examples of the scores given to a good and poor justification for participants in each communication medium are given below.

Figure 4-3 Examples of good and poor justifications in VMC and face-to-face discussions

Session	Product discussed	Justification	Scoring explanation	Total
example of a poor face-to-face justification	PC	Product A seemed to be the preferable choice because it wasn't too far away from the old laptop style. It also had touch screen - quite advanced - and a good memory. Although it was expensive the benefits of it outweighed the costs. Product C was deemed too tedious to deal with, product D didn't have touch screen and product B was too small.	no core requirements (min. 0, max. 25) but 7 reasons for choice at 5 points each up to a max. of 25	25
example of a poor VMC justification	camera	in colour. infra red transfer, larger keyboard, easier to use	no core requirements (min. 0, max. 25) but 4 reasons for choice at 5 points each	20
example of a good face-to-face justification	PC	A had touch screen and keyboard facilities- provided advantage over the other 3 which only had 1 of the above. slightly heavier but looked easier to use - not as fiddley - good memory capability etc. and had all required communications and windows requirements.	gave 3 core requirements (min. 76, max. 100) and 2 reasons for choice at 5 points each	86
example of a good VMC justification	PC	Large visible accessible touch-sensitive screen, not too small had the most memory and not significantly bigger or heavier than the others. Had above advantages and all the other benefits of the others such as email and windows compatibility.	gave 2 core requirements (min. 51, max. 75) plus 4 other reasons for choice at 5 points each	71

These results show that there is a performance advantage of face-to-face communication over that which is partly video-mediated for a more 'social' task to the extent that participants were better able to justify their group choices following face-to-face rather than video-mediated discussions. The order in which participants took part in the communication conditions did not have an impact on performance.

Subjective performance measures were also analysed to assess how participants perceived the group decision-making process and outcome. Do they perceive a disadvantage of partly video-mediated communication?

Subjective perceptions of group performance and decision process

Two questions about performance were presented in the post-task questionnaire. Participants were asked *how satisfied were you with the final product choice?* and *how satisfied were you with the decision process by which you arrived at the final choice?* They responded on a five-point scale from 'much more satisfied in face-to-face communication ' to 'much more dissatisfied in face-to-face communication'. Responses from all participants were summed and analysed using chi-square one sample tests which revealed that most participants - over 40% of them (significantly greater than chance) - were equally satisfied with the final product choice made by the group in video and face-to-face contexts (x^2 (4)=28.2, **p**<.05). The response distribution is shown in Table 4.10. In response to the question about how satisfied they were with the decision process, the number of responses in the five categories differed significantly from chance with the majority of responses split between two categories: 43% of respondents were equally satisfied in face-to-face and VMC but 39% were more satisfied when communicating face-to-face (x^2 (4)=42.1, **p**<.05), as can be seen in Table 4.11.

Table 4.10 Satisfaction with the final product choice

how satisfied are you with the final product choice?	much more satisfied when face-to-face	more satisfied when face-to-face	equally satisfied when face-to-face and VMC	more dissatisfied when face-to-face	much more dissatisfied when face-to-face	N
	4	12	23	15	1	55

Table 4.11 Satisfaction with the decision process

How satisfied are you with the decision process?	much more satisfied when face-to-face	more satisfied when face-to-face	equally satisfied when face-to-face and VMC	more dissatisfied when face-to-face	much more dissatisfied when face-to-face	N
	2	21	23	8	0	54

4.5 Summary of analyses so far

Thus far, the communication in face-to-face and shared video contexts has been compared at the level of dialogue structure, equality of speaker participation, group performance, and participants' subjective impressions of the communication and outcome. When some group members were remote, the discussion did not take any more communicative effort in terms of words and turns to complete the task than in face-to-face round the table communication, however, performance was significantly better in face-to-face communication in terms of how well participants justified their group's product choice. Participant satisfaction data analysed up to this point are equivocal with high proportions of participants feeling either more satisfied with the decision process during face-to-face interaction or equally satisfied in both communication contexts. Nonetheless, the majority of participants were equally satisfied with the final product choice. The communication was similarly interactive and informal in both media as shown by turn length and numbers of interruptions, indeed, many participants perceived taking a turn in the conversation equally easy in either context.

These findings appear to indicate that face-to-face communication is more effective than communication with a video-mediated aspect. Whether this is due to difficulties communicating over the video link is not clear from the above analyses as they do not differentiate between interaction in the video sessions which was in fact co-present (same-site) and that which was truly video-mediated (cross-site). Perhaps the measures of communication processes analysed so far are obscuring inequality in communication across the video link. As already described, the two conference sites in the technology-mediated discussions were shared - each pair of participants sat side-by-side and communicated across the video link with the other pair. Therefore, further analyses will be undertaken to examine the patterns of interaction comparing communication across the video link with same-site face-to-face communication. This involves calculating the amounts of video-mediated and co-present conversation. Since there was the opportunity for twice as much cross-site as same-site conversation, (since each participant could speak to two group members across the video link but to only one at the same site), proportions of same-site and cross-site talk are compared.

4.6 Patterns of interaction cross- and same-site

Communication analyses

Various analyses were employed successfully in lab study 1 to ascertain the impact of technology-mediation on the patterns of group communication. Similar methods are employed here to gauge the impact of video-mediation on interaction in four-person groups. If the video technology is creating a barrier to free communication making it more difficult to communicate with video-mediated group members and resulting in poorer justifications of group choices, then there should be proportionally less interaction across the video link than between co-present group members. A variety of indices will be examined to verify this.

These analyses focus on the patterns of turn-taking or speaker exchange. Group conversation tends to be made up of a series of conversations between pairs of participants (Parker, 1988; Stasser and Taylor, 1991; Carletta, Garrod and Fraser-Krauss, 1998). Since contributions tend to be relevant to preceding ones (Clark and Schaefer, 1989), it is possible to use the order of speaker exchanges to identify who is addressing whom and with what frequency, that is, the number of times each group member speaks after each other group member can be calculated to give an indication of how much all the different pairs of participants interact. A related measure involves identifying how often all the different pairs of participants engage in conversations with each other. This is achieved by counting sequences of three or more turns exchanged between pairs of participants, referred to as pairwise conversations (Parker, 1988; Carletta *et al.*, 1998). The number of words and speaking turns exchanged within these conversations can also be calculated.

It is predicted that a greater proportion of the interaction will be between co-present (same-site) speakers than between video-mediated (cross-site) speakers, as was found in study 1, if the multimedia technology is indeed a barrier to interaction. The following hypotheses were tested:

- there will be proportionally more pairwise conversations between same-site co-present participants than between cross-site video-mediated participants
- there will be a greater proportion of words and turns exchanged in same-site compared to cross-site pairwise conversations

In addition, as an indicator of the interactivity and formality of exchanges, the length of turns exchanged in pairwise conversations and the numbers of interruptions speakers made across the video link (cross-site) and when co-present at a shared terminal (same-site) were compared. Longer speaking turns usually indicate a less interactive communication style and fewer interruptions a more formal style. In line with findings from previous studies of VMC (e.g. Sellen, 1995), it is expected that

- communication across the video link will be less interactive and more formal having longer speaking turns and fewer interruptions than same-site co-present communication.

Video-mediated versus same-site co-present communication

Since there were twice as many opportunities to speak across the link, i.e., there were two possible conversational partners over the video link and only one co-located, the *proportions* of cross- and same-site interaction are compared. This involves dividing the amount of same-site interaction by two and the cross interaction by four since there were two pairs of speakers who were same-site and interacted face-to-face (A and B, and C and D) and four possible cross-link pairs of speakers (A and C, A and D, B and C, and B and D) in each discussion. Hence, these comparisons include twenty-eight same-site pairs of speakers and fifty-six cross-site pairs of speakers. Repeated measures statistical tests are used since all the participants take part in both video-mediated and co-present conversations, albeit with different conversational partners.

Who speaks after whom

The number of times each participant spoke after each other participant was calculated then the proportions of such exchanges between pairs communicating via video and those communicating at the same computer site were computed as described above. It was expected that video-mediated or 'cross-site' pairs of speakers would exchange fewer turns of conversation than co-located or 'same-site' pairs of participants. However, a repeated measures t-test revealed no significant difference in the proportion of exchanges between same-site and cross-site participants (**t** <1). Table 4.12 shows that the proportions are very similar.

Table 4.12 Proportion of same- and cross-site conversational exchanges

Direction of communication	proportion of exchanges per pair of speakers (SD)
same-site	23.6 (8.7)
cross-site	24.9 (9.9)

Conversations between pairs of co-present and remote speakers

Another index of interaction is the proportion of pairwise conversations (sequences of three plus exchanges) between pairs of speakers. It was expected that co-present pairs of participants would engage in a greater proportion of such conversations than would technology-mediated participants. This prediction was disconfirmed by a repeated measures t-test which showed no difference between same-site and cross-site communication on this measure (**t**<1.5). The mean number of conversations per pair of speakers are shown to be very alike in Table 4.13.

Table 4.13 Proportion of same- and cross-site pairwise conversations

Direction of communication	proportion of pairwise conversations per pair of speakers (SD)
same-site	4.5 (1.9)
cross-site	5.1 (2.0)

Words exchanged in pairwise conversations

Although the number of conversations between co-present and video-mediated pairs did not differ, it is possible that the number of words uttered during such conversations did differ. Therefore the number of words spoken in the context of pairwise conversations was calculated and compared for the two communication modes. A repeated measures t-test revealed the same pattern of results as before: there is no significant difference in the number of words exchanged between co-located and cross site pairs of participants ($t<1$), although numerically there were 18% more words in same-site than in cross-site talk as can be seen from Table 4.14.

Table 4.14 Proportion of words exchanged in same- and cross-site pairwise conversations

Direction of communication	proportion of words in pairwise conversations (SD)
same-site	301 (136)
cross-site	256 (86)

Turns exchanged in pairwise conversations

A further measure of the length of pairwise conversations is the number of speaking turns exchanged during these conversations. There was no difference in the average number of speaking turns in same-site versus cross-site two-person conversations ($t<1$). The mean number of turns per pair are shown in Table 4.15.

Table 4.15 Proportion of turns exchanged in same-and cross-site pairwise conversations

Direction of communication	proportion of turns in pairwise conversations (SD)
same-site	16.9 (5.8)
cross-site	18.3 (7.7)

In sum, the amount of communicative effort appears to be similar whether interacting across the video link or face-to-face at the same computer site. Is there any effect of video on the interactivity and formality of the communication?

Length of turns in pairwise conversations

For a measure of communication interactivity - turn length - shorter turns were expected in conversations between co-present same-site speakers than in conversations across the video link. However, a repeated measures t-test showed no statistically significant difference between the average length of turns in pairwise conversations during same-site and cross-site conversation ($t<2$). The video technology does not appear to have a negative impact upon the interactivity of the interaction, in fact, as the data in Table 4.16 show, there is a tendency for co-present participants to exchange 36% longer turns with one another, that is, their interaction appears to be somewhat less interactive. In study 1, a similar result was found: same-site group members exchanged significantly longer turns than cross-site members. Mean turn length is shown in Table 4.16

Table 4.16 Length of turns (in words) in same-and cross-site pairwise conversations

Direction of communication	mean length of turns (SD)
same-site	20.5 (13.2)
cross-site	15.1 (4.3)

Despite predictions that there would more same-site than cross-site interruptions, there were not significantly more interruptions between same-site face-to-face group members than between cross-site remote members ($t<1.5$). Therefore, mediation did not make the communication significantly more formal in this study contrary to what has been found previously by Sellen (1995) for example, although there was a 20% higher proportion of interruptions same-site as can be seen from Table 4.17.

Table 4.17 Proportion of interruptions between same-and cross-site speakers

Direction of communication	Mean proportion of interruptions (SD)
same-site	8.3 (6.7)
cross-site	6.9 (3.9)

From the above analyses of the patterns of interaction, all group members seem equally involved in discussions, and communication is as co-ordinated and informal in both same- and cross-site conversation. Hence, it does not appear to be the case that poorer performance in VMC can be explained by less interaction occurring over the video link or indeed, by less interaction between same-site members; if some group members spoke less to other group members then it is reasonable to assume that they would have a poorer understanding of all the reasons for the group choice of product with the result that VMC justifications would be of lower quality. However, the above analyses have compared speakers in terms of the labels arbitrarily assigned to them, therefore, a different approach is adopted in the next analysis which investigates speaker dominance in video-mediated conversations.

Dominance of one person at each shared site

A further analysis will be carried out to identify whether there was a dominant individual in each pair of group members who shared conferencing equipment, i.e., is there inequality of participation in video-mediated conversations which could perhaps explain the poorer performance of groups in the shared VMC context. In lab study 1, one of the same-role co-present participants was dominant in VMC. Carletta and colleagues (Carletta, McEwan and Anderson, 1998; Carletta, Anderson and McEwan, forthcoming) field study of shared video technology also found a tendency for one person to act as the main channel for communication with cross video link participants. Therefore, in the study presented here, it was expected that one person at each site would be dominant (in words spoken) in interactions with video participants.

The number of words uttered in pairwise conversations initiated with group members over the video link was calculated. For each discussion, the dominant speaker in cross-site conversations at each of the two computer sites was identified (regardless of which product they promoted). Dominance was defined as uttering more words cross-site. The number of words uttered in conversations across the video link was then compared between dominant and non-dominant speakers for each site. For both sites there was a dominant speaker (the speaker promoting product A was dominant in 8 of the discussions and speaker for product B in 6 discussions, the speaker for product C was dominant in 10 dialogues and speaker D was dominant in 4 of them). Hence the dependent variable is the number of words uttered across the video link and the independent variable is speaker dominance (two levels: dominant or non-dominant).

At site 1 where participants promoting products A and B were seated, on average, one person said significantly more words than the other (**t**(13)=4.1, **p**<.001). At site 2 where participants promoting products C and D were seated, the same pattern was found (**t**(13)=3.3, **p**<.01). As can be seen in table 4.18, the more dominant individual at site 1 said over three times as much to the cross-site participants as the less vocal person, and at site 2 the more dominant speaker said around twice as many words to the cross-site participants as the non-dominant speaker. Overall, dominant cross-site speakers say almost four times more in cross-site conversations than non-dominant group members. This seems to suggest that one person acts as the main channel for communication over the video link.

This verbal dominance was not influenced by who used the computer keyboard or mouse as there was no need for participants to use either in this study. Moreover, there was no difference in dominant and non-dominant cross-site speakers' level of general computer experience or experience in using video communications technology, as shown by chi-square analyses of their questionnaire responses ($ps > .05$). Therefore the reasons for this dominance effect are uncertain but confirm Carletta *et al.*'s (1998; forthcoming) finding in the field that one person at each computer site seems to act as a conduit for communication with the remote participants.

Table 4.18 Mean words uttered in cross-site conversations by dominant and non-dominant speakers

	mean words uttered in cross-site conversation by dominant speaker (SD)	mean words uttered in cross-site conversation by non-dominant speaker (SD)
site 1 (speakers A and B)	422.2 (249.6)	28.6 (78.7)
site 2 (speakers C and D)	316.5 (128.4)	162.1 (112.9)

Participation in same-site conversations

In order to verify whether this dominance in cross-site conversations was a result of personality differences rather than technology-mediation, it was assessed whether the same individual who dominated in cross-site conversation also said significantly more than the co-present participant in same-site conversations. Hence the independent variable is whether the group member was dominant or non-dominant in *cross-site* conversations and the dependent variable is the number of words spoken in co-present *same-site* conversation. For site 1 (where A and B were seated), the individuals who were dominant in cross-site conversation did not say significantly more than the co-present group member in their same-site conversations ($t<1$). The same result was found for site 2 (where C and D were seated) ($t<1$). The individual who dominated cross-site conversations did not dominate same-site talk. This suggests that cross-site dominance is an effect of the technology-mediation rather than simply personality factors. Table 4.19 below gives the mean number of words uttered in same-site conversations.

Table 4.19 Mean words uttered in same-site conversation by dominant and non-dominant cross-site speakers

	mean words uttered in same-site conversation by dominant cross-site speaker (SD)	mean words uttered in same-site conversation by non-dominant cross-site speaker (SD)
site 1 (speakers A and B)	106.9 (145)	88.1 (116.2)
site 2 (speakers C and D)	292.4 (233.6)	216.7 (173.5)

Justifications of dominant and non dominant cross-site speakers

In shared VMC discussions, cross-site talk accounted for 42% of the discussion. This means that non-dominant cross-site speakers were less involved than dominant cross-site speakers in around two fifths of the discussion. Does verbal dominance in conversations across the video link give group members an advantage over non-dominant speakers in terms of their performance? The performance measure was based on the quality of participants' justifications of their groups' choice of product. Since all four members of each group justified the group choice independently, it is possible to compare the justification scores of participants who were and were not dominant in cross-site conversations. Speakers who had a higher level of involvement in conversations with group members across the video link may have had a better understanding of the group's decision resulting in them producing a better (higher scoring) post-discussion justification. In order to explore this possibility, the justification scores of the dominant and non-dominant cross-site speakers were compared separately for conference sites 1 and 2. Independent t-tests showed no significant differences between the mean justification scores of the dominant and non-dominant individuals for site 1 (**t**<1) or site 2 (**t**<1.5). In fact, the mean score for non-dominant speakers tended to be slightly higher than that of the dominant speakers, as can be seen from the mean scores below. Hence, it appears that group members who contributed less to cross-site conversation were not disadvantaged by this in terms of the quality of their justifications. Mean scores are given in Table 4.20

Table 4.20 Mean performance scores of verbally dominant and non-dominant cross-site speakers

	mean justification score of dominant cross-site speakers (SD)	mean justification score of non-dominant cross-site speaker (SD)
site 1 (speakers A and B)	36.4 (27.5)	38.3 (24.8)
site 2 (speakers C and D)	31.0 (17.6)	40.9 (19.7)

Summary of patterns of interaction

The above analyses of the patterns of interaction focus on turn-taking behaviour in the shared video-mediated mode of communication. They show that although, on average, groups performed more poorly in VMC than in the face-to-face context, this does not seem to be attributable to differences in the communication process in the truly video-mediated conversations and the same-site co-present conversations in the shared VMC context in terms of the amount of verbal interaction in words and turns, co-ordination of turn-taking or formality of communication. This is contrary to predictions that there would be a greater proportion of cross-site (video-mediated) than same-site (co-present) interaction, and that video-mediated conversation would be more formal and less co-ordinated. However, a further analysis which examined speakers' involvement in video-mediated conversations in the shared VMC context revealed inequality in how much group members participated in these cross-site conversations. Thus some group members were less involved in a substantial proportion of the discussion. Nevertheless, this did not lead to these speakers performing more poorly than the dominant speakers (in terms of justification scores). All of the analyses performed thus far do not take into account the content of the interaction. This may clarify the better performance in face-to-face communication.

4.7 Questions across the video link and with same site participant in VMC

The interactivity of communication can also be analysed by examining the content of the dialogues. In the laboratory study described in the previous chapter, the chosen method of analysing dialogue content was Conversational Games Analysis (CGA). While this proved to be very informative it was also extremely labour intensive and time-consuming to perform. Furthermore, the analysis was applied to a different task and it was not clear whether CGA would apply to the persuasion task carried out in this study. For these reasons it was decided not to carry out this type of content analysis in this study. However, it was possible to explore one of the features shown to differ between communication media in the previous study which could be analysed more easily: the number of questions asked. These could be gathered easily and were standard across the task (see examples of questions in Figure 4-4). In study 1, same-role co-present participants asked each other significantly more questions in VMC sessions (when the third group member, the collaborator, communicated via video) than in face-to-face sessions. However, the numbers of questions between the collaborator and the other two participants, i.e., during the actual technology-mediated interactions, did not differ when compared to face-to-face communication. If the sharing of technology is the crucial factor affecting communication in study 2 presented in this chapter, then co-present participants should ask one another proportionally more questions than video-mediated participants, i.e., co-present interaction should be more interactive. Intonation was used to judge whether an utterance was a question. The reliability between two independent coders for one randomly selected dialogue was 92%. The correlation was acceptably high and reached statistical significance as shown by a Pearson's correlation co-efficient test (r=.563, p=.01 one-tailed, N=127).

Number of questions in VMC and face-to-face communication

Firstly, the face-to-face and shared VMC dialogues were compared overall to ascertain the effect of partial video-mediation on the number of questions asked compared to around the table face-to-face communication. No differences between media were expected since in the previous laboratory experiment presented in chapter 3, no differences between shared VMC and face-to-face communication were found in numbers of questions asked. The number of questions in face-to-face and VMC dialogues were compared using a 4 by 2 by 2 mixed design ANOVA with communication context as a repeated measures factor (two levels: VMC and face-to-face), order of communication context as a between subject factor (two levels: VMC first or face-to-face first) and speaker as a between groups factor (four levels: speakers A, B, C and D each promoting different products). There was no main effect of context (**F**<1) or of speaker (**F**<1) and no interaction of speaker and context (**F**<1). There was no effect of order (**F**<1.5), no interaction of speaker and order (**F**<2), no order-by-communication medium interaction (**F**= 2.6), and no three-way interaction (**F**<1). Table 4.21 shows the mean numbers of questions to be almost identical in face-to-face and video-mediated contexts. Thus, sharing of video technology did not affect the amount of speaker interaction in terms of the number of questions asked compared to face-to-face communication, and all speakers were equally interrogative.

Table 4.21 Mean numbers of questions in face-to-face and video-mediated contexts.

speaker	order	VMC mean (SD)	face-to-face mean (SD)
A	VMC first	2.6 (2.4)	2.9 (2.2)
	face-to-face first	3.8 (1.7)	6.5 (3.0)
B	VMC first	6.6 (4.0)	4.4 (3.7)
	face-to-face first	4.5 (4.5)	6.5 (7.0)
C	VMC first	8.8 (8.0)	5.6 (5.3)
	face-to-face first	3.7 (2.0)	3.8 (2.6)
D	VMC first	6.5 (5.6)	7.6 (6.9)
	face-to-face first	3.8 (2.6)	3.5 (2.8)
overall per dialogue		**20.8 (9.8)**	**20.4 (9.4)**

Questions directed cross- and same-site in VMC

The overall analysis above combines both cross- and same-site questions in the video context therefore the next analysis differentiates between these. To compare cross video link and same-site face-to-face communication, repeated measures t-tests (repeated measures since participants took part in both cross- and same-site communication) were performed for both raw numbers of questions asked and proportion of questions asked. More questions were expected between same-site participants than video-mediated participants since video-mediation was expected to reduce the interactivity of the conversation due to the expectation of difficulties in co-ordinating turn-taking caused by lack of eye-contact. It was established to whom each question was directed by observing who responded to the question. A repeated measures t-test, however, revealed a significantly greater number of questions were directed across the video link than to same site group members (**t** (13)= 6.2, **p**<.001). There were, on average, almost three times more questions cross-site than same-site, as shown below in Table 4.22. This is contrary to expectations that co-present same-site communication would be more interactive for this measure. Hence, video does not appear to disadvantage interactivity, on the contrary, it seems encourage it to a greater extent than when group members are co-present and seated side-by-side. This analysis of course includes questions asked of the two cross-site participants compared to one co-present participant, therefore a further analysis was performed.

Table 4.22 Mean number of questions same- and cross-site

Direction of communication	mean number of questions (SD)
same-site	5.6 (4.0)
cross-site	15.1 (7.0)

To check this surprising finding more thoroughly, a second analysis compared the proportions of questions by means of a repeated measures t-test. This revealed a near significant effect with more cross-site than same-site questions (**t** (13)= 2.1, **p**=.06). There is, on average, a 36% higher proportion of questions asked across the video link as can be seen from the mean proportions given below in Table 4.23. The sorts of questions asked are similar in each context and examples can be seen in Figure 4-4.

Table 4.23 Mean proportions of questions same- and cross-site

Direction of communication	mean proportion of questions (SD)
same-site	2.8 (2.0)
cross-site	3.8 (1.7)

Figure 4-4 Examples of cross- and same-site and face-to-face questions

same-site questions	cross-site questions	face-to-face questions
right who's going to start off?	em who wants to start?	who wants to go first in in describing their product?
yeah but I mean is anybody going to actually want that?	do we really want to be appealing to the big huge camera market?	but has it got an automatic zoom lens?
do you think that looks the best?	don't you think its a bit fiddley?	what do you mean it's energy efficient?
how much is your camera going to cost to produce?	how much does it cost?	have you got a touch screen?
right well em so you're not allowed to vote for your own one are you?	shouldn't we vote?	so we have to make a decision now do we?

Types of questions in VMC and face-to-face communication

From the examples of questions above, it can be seen that there is a mixture of task-orientated (e.g. how much is your camera going to cost to produce?) and meeting management-type questions (e.g. shouldn't we vote?). Researchers such as Olson *et al.* (1992) have highlighted the importance of such a distinction in content analysis. Therefore, all the questions in the face-to-face and VMC dialogues were classified according to whether they concerned the task or how to manage the interaction, for example, deciding what to do next. It was decided that all questions regarding the products being discussed, questions about the task rules, and what products to vote for and why would be coded as task-related, while questions intended to manage the conversation and the voting procedure would be classified as meeting management. It is hypothesised that there will be more meeting management in VMC than in face-to-face meetings based on the findings of Olson *et al*'s (1994) finding that participants in VMC spent more time managing their interactions. The effect of context on task-related questions will also be explored.

Upon classifying the questions in the dialogues, it became apparent that a very small number of questions in the VMC discussions fell into neither the meeting management nor the task-orientated category; such questions related to the communications technology or its presence (e.g. 'can you hear me?), of which there were only six questions in fourteen dialogues, or greetings, of which there were two instances. As these question types were so rare and applied only to VMC dialogues, they were not analysed further in comparing shared VMC and face-to-face conditions.

A 2 by 2 repeated measures ANOVA with two levels of communication context (face-to-face and shared VMC) and two levels of question type (task-related and meeting management questions) was performed. This revealed no significant effect of context ($\mathbf{F}<1$), a significant effect of question type ($\mathbf{F}(1,13)=26.0$, $\mathbf{p}<.001$) with four times more task-focused than meeting management questions, and no significant interaction effect ($\mathbf{F}(1,13)=3.3$, $\mathbf{p}=.093$). As the interaction approached significance, and due to the strong expectation that there would be differences between media in the amount of meeting management type questions, a simple main effects analysis of context at each level of question type was carried out. This revealed that there were indeed significantly more meeting management questions in shared VMC than in face-to-face discussions ($\mathbf{F}(1,13)=5.3$, $\mathbf{p}<.05$), but no difference between contexts in the amount of task-focused questions ($\mathbf{F}<1$). The mean numbers of questions of different types are shown below. There were 76% more meeting management questions in the shared VMC context, although the numbers of these were quite low in both contexts. The majority of questions in both media were concerned with task-related issues, there were slightly less of these in VMC (14% less) but this difference did not reach statistical significance. Thus, it appears that participants adopt a more explicit style for managing their interactions in the shared VMC context compared to face-to-face communication, asking significantly more questions related to this.

Table 4.24 Mean number of task-related and meeting management questions in face-to-face and shared VMC contexts

Communication context	meeting management questions	task-related questions
shared VMC	5.1 (2.5)	15.1 (8.5)
face-to-face	2.9 (2.2)	17.5 (10.4)

What is the effect of video-mediation on the type of questions being asked? Is the difference in the number of meeting management questions due to group members being more explicit about managing their interactions over the video link? The next analysis compares the amount of cross-site and same-site task-related and conversation management-type questions. As there were very few instances of questions concerning the technology (six overall) and all of these were cross-site, these questions were excluded from further analyses.

Direction of communication and type of questions

A 2 by 2 repeated measures design ANOVA was carried out on the raw numbers of questions with direction of communication (cross- and same-site) and question type (meeting management and task-related) as the variables. Again, the recipient of the question was determined by who took a turn immediately following the question. It is expected that there will be more meeting management questions directed across the video link than to co-present group members. The ANOVA revealed that there was a significant effect of communication direction ($\mathbf{F}(1,13)=40.3$, $\mathbf{p}<.001$), a significant effect of question type ($\mathbf{F}(1,13)=19.3$, $\mathbf{p}<.01$), and a significant interaction effect ($\mathbf{F}(1,13)=10.4$, $\mathbf{p}<.01$). An analysis of the simple main effects of communication direction at each level of question type showed that there were significantly more meeting management questions directed cross-site than same-site ($\mathbf{F}(1,13)=9.8$, $\mathbf{p}<.01$) and significantly more task-related questions directed cross- than same-site ($\mathbf{F}(1,13)=28.4$, $\mathbf{p}<.001$). As expected, it took a significantly greater amount of questions - over twice as many - directed to group participants across the video link than to co-located participants to manage interactions. There were also around two-and-a-half times more task-related questions directed across the video link than same-site. The mean numbers of meeting management and task-related questions are given in Table 4.25 below.

Table 4.25 Mean number of task-related and meeting management questions same- and cross-site

Communication direction	meeting management questions	task-related questions
cross-site	3.5 (2.0)	10.9 (5.5)
same-site	1.5 (1.6)	4.3 (4.1)

It can be seen that even when technology-related questions are excluded from the analysis, video mediation is still affecting the interrogative behaviour, leading to an increase in both task-related and meeting management types of questions. These results appear to indicate that participants manage their interactions more explicitly in partly video-mediated than in face-to-face discussions, and this is largely due to the number of queries about how to manage the interaction which are directed across the video link. They also ask significantly more questions related to the task over the video link. Will this pattern of results be confirmed when the proportions of these question types are compared?

Proportions of different question types in cross- and same-site communication

The numbers of cross-site questions were divided by two since there were two conversational partners who could respond to questions asked across the video link and only one at the same site. A 2 by 2 repeated measures ANOVA was carried out on the proportions of questions with direction of communication (cross- and same-site) and question type (meeting management and task-related) as the variables. It is expected that there will be a greater proportion of meeting management questions directed across the video link than to co-present group members. The ANOVA revealed that there was no significant effect of communication direction ($F<2.5$), a significant effect of question type with approximately three times more questions about the task than about how to manage the interaction ($F(1,13)=14.2$, $p<.01$), but no interaction effect ($F<1$). The mean proportions of questions are given below in Table 4.26. This analysis shows that the proportions of task and meeting management questions asked of same- or cross-site participants do not differ.

Table 4.26 Mean number of task-related and meeting management questions same- and cross-site

Communication direction	meeting management questions	task-related questions
cross-site	1.8 (1.0)	5.5 (2.8)
same-site	1.5 (1.6)	4.3 (4.1)

Summary of content analysis

The amount of questions asked by participants was identified as a possible source of differences between media on the basis of the findings of the Travel Game study (chapter 3). Surprisingly, there were significantly more questions asked of cross- than same-site group members which is the opposite of what was expected. When proportions of questions were compared the effect was somewhat attenuated with the comparison approaching statistical significance. Nevertheless, the results suggest that video-mediation does not lead to less interactive conversations and may in fact encourage interactivity to a greater extent than side-by-side face-to-face communication. This is despite no significant differences having been found in the patterns of interaction across the video link and between same-site co-present participants when examining turn-taking behaviour. However, an alternative interpretation is that the greater proportion of questions reflects greater verbal effort, perhaps in order to compensate for participants' perceived difficulties in observing visual behavioural cues in the video context which will be described shortly.

When the types of questions participants asked were explored, it was discovered that there were significantly more questions concerning the management of the interaction in shared VMC than face-to-face communication, and that this increase was largely due to more such questions being directed across the video link. This suggests that video communication led speakers to be more explicit in the management of their discussion as previously found by Olson *et al* (1994, 1997), or, as the Olsons would say, these interactions were somewhat more 'effortful'. However, when the proportions of questions were compared, this effect disappeared. Overall, the majority of questions asked were task-related but did not differ significantly in number between the face-to-face and shared VMC contexts. There were, however, significantly more task-related questions addressed to group members across the video link than to same-site participants. These findings show that video mediation was having an effect on asking of questions and that most questions were task-related rather than aimed at managing the conversations, a sign that video-mediated interactions were more interactive than same-site interactions. To some extent it is true that video interactions took more effort since there were significantly more questions concerned with managing the conversation in video-mediated exchanges, however, the majority of questions were task-related and there were significantly more of these questions cross- than same-site.

Summary of analyses so far

Various methods of analysis have been employed thus far to explore the process and outcome of communication in four-person peer groups interacting via shared VMC technology and face-to-face. Performance for this persuasion task (in which there was a time limit on discussion) in terms of the quality of participant justifications of the group choice of product was better in face-to-face communication. Nonetheless, subjective measures show equal satisfaction with group choice of product in both communicative contexts, although participants were divided in terms of their satisfaction with the decision process - significant numbers were both equally satisfied in face-to-face and video-mediated contexts and more satisfied face-to-face. Despite the performance advantage of face-to-face communication, overall no differences were found between the structure of face-to-face and partly video-mediated dialogues: there was a similar amount of communicative effort expended in terms of words uttered and speaking turns taken and discussions were similarly interactive in terms of turn length and numbers of speaker interruptions. Furthermore, the distribution of contributions amongst speakers was similar in both face-to-face and shared VMC sessions.

However, the above-described analyses did not differentiate between communication in the video context which was truly video-mediated (cross-site) and that which was between co-present participants (same-site), yet when such an analysis was performed the communication patterns were found to be remarkably similar. Thus, the actual video-mediation does not appear to be causing difficulties for groups. However, there were differences between speakers in the amount of cross-site talk they engaged in: when video-mediated and co-present communication were compared, one member at each site dominated exchanges over the video channel. Yet this dominance did not lead to these speakers performing better in terms of the quality of their justifications of their group's decision.

4.8 Questionnaire analysis

As previously mentioned, in order to complement the objective analyses of the communication process and outcome, participants' subjective perceptions of the communication were ascertained by means of questionnaires. For instance, do the participants perceive the communication process to be as easy in video-mediated as in face-to-face communication as the objective data suggest, or do they perceive disadvantages of technology-mediated communication that may illuminate the poorer group performance in the shared video technology condition?

A questionnaire was completed once by each subject (N=56) subsequent to participation in both VMC and face-to-face sessions. A questionnaire example is given in Appendix S. Several questions were asked of participants under the headings of social presence; ease of communication and comprehension; group performance (results have been reported already); perceived quality and usefulness of technology and media preference. As questions were asked only once, these were comparative questions. On all questions participants responded on a five-point Likert-type scale, unless otherwise indicated.

Experience of technology-mediated communication

The majority of participants in this study were novice users of video conferencing technology. Twelve out of fifty-three people who responded had used such technology before but only one person considered himself to be a very experienced user and two said they were experienced users (when responding on a five point scale from 'very experienced' to 'very inexperienced'). Ten out of twenty-six people who responded had used audio conferencing technology before but only two of these people claimed to be experienced users. Therefore experience of using multimedia technology should have little impact upon communication.

Questions about video communication

Perceptions of multimedia communications technology

Participants were asked to rate the quality of the video image and product images and to indicate how satisfied they were with the quality of audio and video. They were asked how useful the video image and the product images were for completing the task and which was more useful. They were also asked which improvements they would like to make to the technology, if any. Chi-square one sample tests were used to verify whether the distribution of responses in the five response categories differed significantly from chance. For the following questions response distributions did differ significantly from chance. The majority of participants, 56%, thought that the video image of the other participants was good (on a response scale from 'very good' to 'very poor') (x^2 (4)=62.4, **p**<.01) and most participants (56%) were satisfied with the video quality (on a response scale from 'very satisfied' to 'very dissatisfied') (x^2 (4)=66.7, **p**<.01). The majority of the participants (39%) found the video useful for completing the task (on a scale of five from 'very useful' to 'not at all useful') (x^2 (4)=23.1, **p**<.01). The quality of the on-screen product images was rated as good by the majority of participants (46%) (on a response scale from 'very good' to 'very poor') (x^2 (4)=40.4, **p**<.01) and most participants (46%) found them very useful for completing the task (on a scale of five from 'very useful' to 'not at all useful') (x^2 (4)=54.2, **p**<.01). Most participants found the product images more useful for completing the task (55%) than the video, only 13% found the video image of the other participants more useful and 32% found the two equally useful (x^2 (2)=15.4, **p**=.01). See Table 4.27 below for the response distribution.

Table 4.27 Preference of tools for completing task

	video image	product images	both equally useful	N
which was more useful for completing the task?	7	31	18	56

The majority of participants (46%) were satisfied with the audio quality (on a five category response scale from 'very satisfied' to 'very dissatisfied') (x^2 (4)=53.8, **p**<.01) and almost three fifths of participants were never worried they had lost contact with the remote site (x^2 (5)=81.9, **p**<.01). The response distribution is given in Table 4.28.

Table 4.28 Contact with remote group members

	very often	often	sometimes	in-frequently	very in-frequently	never	N
How often were you worried you had lost contact with the remote group members?	0	0	7	5	11	33	56

60% of participants wanted to make improvements to the technology - of these approximately 70% wanted to improve the video image either by allowing eye-contact, changing the camera angle, increasing the video quality, changing the position of the video window on the screen or by making the image bigger - this last improvement was the most frequently cited one with 30% of those who wanted to make a change stating this as the desired improvement.

Media preference

Participants were asked *which did you prefer for carrying out the discussion - face-to-face communication, video communication or did you like them both equally?* The majority of participants (significantly more than chance), approximately 50%, preferred face-to-face communication for carrying out this task while 20% preferred VMC and 30% liked both communication modes equally for this task (x^2 (2)=7.1, **p**=.05). The response distribution is given in Table 4.29.

Table 4.29 Media preference

	face-to-face	VMC	liked both equally	N
which did you prefer for carrying out the discussions?	27	11	17	55

In sum, while participants were satisfied with the quality of the video image and found it useful for completing the task, the majority of participants found the product images more useful than the video image of remote participants. Furthermore, of the 60% of participants who wanted to improve the technology 70% wished to improve the video in some way, usually by making the video image bigger. For completing this task, the majority of these novice users preferred face-to-face communication although fair numbers preferred VMC or liked face-to-face and VMC equally.

Communication across the video link versus across the table face-to-face

In the technology condition, communication between some pairs of group members was face-to-face but communication between others was video-mediated. The following analyses compare the participants' perceptions of the communication with group members who were across the video link compared to when they were face-to-face across the table. Each subject was asked to compare the video-mediated communication (with the two remote participants) with the interaction face-to-face around the table. As there were four speakers per group there were four sets of responses to each question, that is, participants A and B responded to questions about C and D and vice versa (A and B were co-located in the technology condition, as were C and D). As the five point response scale is categorical, non-parametric statistics were used, specifically chi-square one sample tests. A separate chi-square analysis was performed on each set of responses since each person responded twice - once about each of the two participants who were remote in VMC - to verify whether the distribution of responses in the five different response categories differed significantly from expected frequencies. For all the calculations below, the critical value of chi-square at the .01 level for 4 degrees of freedom is 13.28.

Participants were asked the following questions concerning ease of communication:

how easy was it to

hear the other participant?
get your questions across to the other participant?
get her/his attention?
resolve differences of opinion?
assess her/his reactions?
see her/his facial expressions?
make eye-contact with her/him?
see her/his gestures

Responses were on a five-point scale from ‘much easier when face-to-face around the table’ to ‘much more difficult when face-to-face around the table’.

Ease of hearing

No difference was expected between face-to-face and video-mediated communication for how easy it was to hear group members as the audio was of high quality. Chi-square one sample tests showed that the numbers of responses in the five categories differed significantly from chance with the majority of responses in the expected category. Most respondents found that it was equally easy to hear participants in either communicative context as expected thus confirming that the audio link was of very high quality. Table 4.30 shows the distribution of responses concerning each group member and the results of the chi-square analyses.

Table 4.30 Ease of hearing in face-to-face and video-mediated communication

ease of hearing	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	5	11	12	0	0	28	x^2 (4)=23.8, p<.01
participant B	2	14	11	0	0	27	x^2 (4)=32.4, p<.01
participant C	7	3	17	0	0	27	x^2 (4)=37.3, p<.01
participant D	6	4	16	1	0	27	x^2 (4)=30.2, p<.01

Ease of making eye-contact

It was expected to be easier to make eye-contact face-to-face since the camera position did not allow for direct eye-contact in VMC. The results confirm this hypothesis. Chi-square one sample tests showed that the numbers of responses in the five categories differed significantly from chance. Around two thirds of respondents (significantly more than chance) found that it was much easier to make eye-contact with other participants when they were face-to-face across the table rather than across the video link. Table 4.31 gives the response distributions and the results of the chi-square analyses.

Table 4.31 Ease of making eye-contact when face-to-face and video-mediated

ease of making eye-contact with	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	18	7	2	1	0	28	x^2 (4)=39.5, p<.01
participant B	18	7	3	0	0	27	x^2 (4)=40.2, p<.01
participant C	16	6	3	1	1	27	x^2 (4)=29.1, p<.01
participant D	16	7	2	1	1	27	x^2 (4)=30.6, p<.01

Ease of seeing gestures

It was expected to be easier to see gestures when face-to-face since the video window allowed visual access to the upper body only. The pattern of results confirms this. Chi-square one sample tests show the numbers of responses in the five categories differ significantly from chance with the majority of participants finding it easier or much easier to see the gestures of participants when face-to-face compared to across the video link. below shows the response distributions and the results of the chi-square analyses.

Table 4.32 Ease of seeing gestures across video and when face-to-face

how easy was it to see the gestures of	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	7	13	6	2	0	28	x^2 (4)=18.1, p<.01
participant B	8	13	5	2	0	28	x^2 (4)=18.8, p<.01
participant C	12	10	6	0	0	28	x^2 (4)=22.0, p<.01
participant D	11	11	6	0	0	28	x^2 (4)=21.6, p<.01

Ease of seeing facial expressions

It was expected to be equally easy to see facial expressions in video-mediated and face-to-face round the table communication. However, the results of the chi-square one sample tests show that the majority of respondents (significantly more than chance) found that it was easier or much easier to see the facial expressions of participants when communicating face-to-face across the table rather than across the video link. Perhaps the small size of the video image or the camera angle contributed to the greater difficulty of seeing facial expressions in video-mediated communication.

Table 4.33 Ease of seeing facial expressions across video and when face-to-face

how easy was it to see the facial expressions of	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	8	14	4	2	0	28	x^2 (4)=22.0, p<.01
participant B	7	15	5	1	0	28	x^2 (4)=25.6, p<.01
participant C	9	10	7	2	0	28	x^2 (4)=13.8, p<.01
participant D	9	10	6	2	0	27	x^2 (4)=13.9, p<.01

Summary of non-verbal cues

In the above comparisons of video-mediated and face-to-face communication, the study participants perceived it to be less easy to see the non-verbal behaviours - gestures and facial expressions- of group members communicating over a small but high quality video link. They also perceived it to be more difficult to make eye-contact which was expected as the camera angle made direct eye-contact impossible. Is the perceived advantage of face-to-face over video communication for providing visual behavioural cues reflected in the perceptions of the verbal communication process? This was explored in the following analyses of subjective data.

Ease of getting questions across

Participants were expected to perceive it to be easier to get questions across in face-to-face communication than in VMC due to the richer non-verbal cues aiding co-ordination of conversational exchange. However, the results of chi-square one sample tests show that the majority of respondents, over 50% (significantly more than chance), found it equally easy to get their questions across in either communicative context. The results of the Chi^2 analyses and the distribution of responses are shown in Table 4.34.

Table 4.34 Ease of getting questions across via video and when face-to-face

ease of getting questions across to	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	3	10	14	1	0	28	x^2 (4)=26.6, **p**<.01
participant B	2	11	15	0	0	28	x^2 (4)=34.5, **p**<.01
participant C	4	8	16	0	0	28	x^2 (4)=32.0, **p**<.01
participant D	5	7	15	0	0	27	x^2 (4)=28.4, **p**<.01

Ease of resolving differences

Confirming predictions, chi-square one sample tests show that most participants, around 50% (significantly more than chance), found it equally easy to resolve differences with participants whether face-to-face or via video, as shown in Table 4.35.

Table 4.35 Ease of resolving differences across video and when face-to-face

ease of resolving differences with	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	3	8	15	1	0	27	x^2 (4)=28.4, p<.01
participant B	2	10	15	0	0	27	x^2 (4)=33.9, p<.01
participant C	3	10	15	0	0	28	x^2 (4)=31.6, p<.01
participant D	3	9	13	1	2	28	x^2 (4)=19.1, p<.01

Ease of assessing reactions

Participants were expected to find it equally easy to assess reactions of group members when communicating face-to-face across the table and via video. However, the chi-square one sample tests show that significantly more than chance numbers of respondents found that it was easier to assess the reactions of participants when face-to-face across the table than across the video link. Table 4.36 gives the results of the chi-square analyses and the response distributions.

Table 4.36 Ease of assessing reactions across video and when face-to-face

ease of assessing reactions of	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	10	14	3	0	0	27	x^2 (4)=29.5, p<.01
participant B	10	11	5	1	0	27	x^2 (4)=18.7, p<.01
participant C	8	13	7	0	0	28	x^2 (4)=22.4, p<.01
participant D	8	13	6	1	0	28	x^2 (4)=20.2, p<.01

Ease of getting attention

It was expected to be more difficult for participants to attract the attention of other group members over the video link than when across the table due to the lack of ability to make eye-contact in the VMC condition. The chi-square one sample tests confirm this: significantly more than chance numbers of respondents (around half) found that it was easier to get the attention of participants when face-to-face across the table than across the video link. Chi-square values and response distributions are given in Table 4.37.

Table 4.37 Ease of getting attention across video and when face-to-face

ease of getting attention of	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	9	14	4	0	0	27	x^2 (4)=27.3, p<.01
participant B	9	13	5	0	0	27	x^2 (4)=23.9, p<.01
participant C	7	14	7	0	0	28	x^2 (4)=24.5, p<.01
participant D	7	13	8	0	0	28	x^2 (4)=22.4, p<.01

Social presence

Questions were asked about subject perceptions of social presence: *how aware were you of the presence of the other participant? how easy was it to chat informally to the other participant?* with responses on five point scales.

Awareness of presence of others

Participants were expected to be equally aware of the presence of the other participants in VMC and face-to-face interactions based on the Travel Game study results in chapter 3. However, the four chi-square one sample tests show that the overall pattern of results is that significantly more than chance numbers of respondents felt that they were more aware of the presence of participants when communicating with them face-to-face across the table than across the video link. See Table 4.38 for exact chi-square values and response distributions.

Table 4.38 Awareness of presence of others across video and when face-to-face

awareness of	much more aware when face-to-face	more aware when face-to-face	equally aware when face-to-face	more unaware when face-to-face	much more unaware when face-to-face	N	x^2
participant A	8	12	7	0	0	27	x^2 (4)=20.6, p<.01
participant B	6	12	8	1	0	27	x^2 (4)=18.4, p<.01
participant C	7	10	8	2	1	28	x^2 (4)=10.9, p<.05
participant D	8	9	6	3	2	28	x^2 (4)=6.6, p>.05

Ease of chatting informally

It was expected to be equally easy to chat informally in face-to-face and VMC based on the results from a similar question asked in lab study 1 in chapter 3. The overall pattern of results from the chi-square one sample tests disconfirms this hypothesis: the majority of respondents found it easier to chat informally when face-to-face across the table than across the video link. Table 4.39 gives the chi-square results and the response distributions.

Table 4.39 Ease of chatting informally across video and when face-to-face

ease of chatting informally to	much easier when face-to-face	easier when face-to-face	equally easy when face-to-face	more difficult when face-to-face	much more difficult when face-to-face	N	x^2
participant A	7	11	9	0	0	27	x^2 (4)=19.5, p<.01
participant B	7	9	11	0	0	27	x^2 (4)=19.5, p<.01
participant C	6	15	6	1	0	28	x^2 (4)=25.2, p<.01
participant D	6	15	7	0	0	28	x^2 (4)=27.4, p<.01

Persuasiveness of others

How does VMC affect how persuasive participants are perceived to be? Are the perceived difficulties in observing non-verbal cues reflected in the perceptions of participants' persuasiveness? Since it has been found that gaze is an important factor in the perception of persuasion (Argyle, 1988) and eye-contact was not possible in VMC, it was predicted that participants would be perceived as more persuasive in face-to-face communication than in video-mediated communication. Contrary to expectations, chi-square one sample tests show that the majority of respondents, approximately 55% (significantly greater than chance), felt that participants were equally persuasive in both communication conditions. Response rates are given in Table 4.40.

Table 4.40 Persuasiveness of others across video and when face-to-face

persuasiveness of	much more persuasive when face-to-face	more persuasive when face-to-face	equally persuasive when face-to-face	more persuasive when face-to-face	much more persuasive when face-to-face	N	x^2
participant A	3	6	15	2	0	26	x^2 (4)=26.7, p<.01
participant B	2	7	16	1	0	26	x^2 (4)=33.6, p<.01
participant C	2	7	15	3	1	28	x^2 (4)=23.4, p<.01
participant D	0	7	15	6	0	28	x^2 (4)= 27.4, p<.01

Summary of subjective data video-mediated versus cross-table face-to-face communication

The above analyses of questionnaire data reveal that, in general, discussion participants perceived it to be easier to see the non-verbal behaviours of other group members when they were face-to-face around a table than when they were interacting via a high quality video link. Participants felt that they were missing out on a lot of visual cues yet they did not perceive it to be any more difficult to get their questions across in VMC than when face-to-face, and nor was it any more difficult to resolve differences of opinion. They did, however, find it more difficult to assess the reactions of group members and to get their attention when they were communicating remotely. In addition, they were less aware of the presence of the other group members when they were interacting via video. In general, the majority of all participants found it equally easy to hear participants in either communication medium as was expected of such a high quality audio link.

Despite the participant perceptions of some difficulties in reading non-verbal behavioural cues, this was not reflected in the actual communication process as revealed by the majority of the objective analyses of dialogues which showed face-to-face communication and VMC to be very similar. There was, however, a greater proportion of questions (approaching statistical significance) directed to group members communicating over the video link than to co-present group members; perhaps participants were asking more questions in order to compensate for some of the difficulties in reading non-verbal cues. Such difficulties in seeing non-verbal behaviour could be related to the novelty of the communication medium since most participants were inexperienced in using multimedia communications technology. However, with more experience participants may learn to utilise non-verbal cues more effectively. Indeed, there is research (mentioned in chapter 2) to indicate that over time, participants are able to adapt their non-verbal behaviour in video conferences to be more effective (Rudman and Dykstra-Erickson, 1994), and that in the long term users can adapt to the inability to make eye-contact, for example, they can learn to tell whether someone is attempting to make eye-contact or not (Tang and Isaacs, 1993).

Surprisingly, considering previous research findings (e.g. Mehrabian and Williams, 1969) and despite the perceived advantage of face-to-face communication for seeing visual cues, participants were not perceived as being any more or less persuasive in either communication medium, although the outcomes of the group discussions were judged more highly following face-to-face discussions. It had been anticipated that group members would be perceived as less persuasive in VMC.

In addition to face-to-face communication being carried out around the table, some face-to-face communication occurred during the video communication condition. In the VMC sessions, the technology was shared between group members with each pair of participants seated side-by-side in front of the computer screen. Is this type of side-by-side face-to-face communication equivalent to face-to-face communication around the table, that is, does orientation have an effect on the participant perceptions of the communication process? The following analyses of questionnaire data address this question.

Side by side face-to-face communication compared to across table face-to-face communication (orientation effect)

The same questionnaires asked participants to compare the communication with their co-located group member in the VMC session to communication with the same individual when he/she was face-to-face across a table. Hence, each subject responded only once to each question, therefore responses from all participants were summed for analysis by chi-square one sample tests.

Ease of communication

Participants were asked the same questions as before concerning ease of communication, but this time they compared the communication with the co-located group member when seated side-by-side in front of the computer terminal to communication with her or him face-to-face across the table. Responses were on a five-point scale from 'much easier when face-to-face around the table' to 'much more difficult when face-to-face around the table'.

Hypotheses

For all questions it was expected that participants would find it equally easy to see non-verbal cues in the two types of face-to-face communication since in the side-by-side context participants could easily turn to look at the co-present group member. It was expected that it would be equally easy to hear the other person and equally easy to communicate in both types of face-to-face interaction in terms of getting questions across, resolving differences of opinion, assessing reactions and getting attention.

No difference in awareness of the other person's presence was expected and no difference in ease of chatting informally was expected. Perceived persuasiveness was expected to be similar in the cross table face-to-face condition since gaze has been positively associated with perceived persuasiveness (Mehrabian and Williams, 1969) and ease of eye-contact was not expected to differ between the two contexts.

Ease of hearing

When communicating face-to-face across the table compared to side-by-side in front of the computer, how easy was it to hear the other person? The majority of respondents (over 70%) found that it was equally easy to hear the other person regardless of orientation, as expected ($x^2(4)=100.2$, $p<.01$). The distribution of responses are shown in Table 4.41.

Table 4.41 Ease of hearing

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
5	9	40	1	0	55

Ease of making eye-contact

Respondents were divided over the issue of how easy it was to make eye-contact, with greater than chance numbers of subjects, 37.5%, finding this much easier across the table than side-by-side and 36% finding it equally easy in either orientation (x^2 (4)= 36.7 , $p<.01$). It appears that the side-by-side seating position did make eye-contact more difficult for some participants but was not considered an obstacle by others. See Table 4.42

Table 4.42 Ease of making eye contact

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
21	14	20	1	0	56

Ease of seeing gestures

The majority of respondents (43%) found that it was equally easy to see the gestures of the other group member whether they were side-by-side or across the table, although quite a large proportion found this easier when communicating across the table, as can be seen from Table 4.43 (x^2 (4)=39.5 , **p**<.01).

Table 4.43 Ease of seeing gestures

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
13	18	24	1	0	56

Ease of seeing facial expressions

From Table 4.44 it can be seen that almost half of the respondents, more than expected by chance, found that it was equally easy to see the facial expressions of the other group member when they were side-by-side or across the table, as predicted (x^2 (4)=45.4 , **p**<.01).

Table 4.44 Ease of seeing facial expressions

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
9	18	27	1	1	56

Summary of orientation effect on ease of observing non-verbal cues

Overall, the two types of face-to-face communication are considered to be equivalent in terms of how easy participants found it to observe the non-verbal cues of the group member with whom they shared a computer terminal. The side-by-side orientation was not problematic for the majority of participants, thus confirming the experimental hypotheses. The next analyses verify whether this similar ease of observing non-verbal cues is reflected in participants' perceptions of the verbal communication process.

Ease of getting questions across

As shown in Table 4.45, significantly more respondents, over two thirds, found that it was equally easy to get their questions across to the person sitting next to them in front of the computer screen as when he or she was across the table (x^2 (4)=79.5 , **p**<.01). This was the expected pattern of results.

Table 4.45 Ease of getting questions across

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
5	14	36	1	0	56

Ease of resolving differences of opinion

Almost 70% of participants found that it was equally easy to resolve differences of opinion when sitting next to another participant in front of the computer or when she/he was across the table (x^2 (4)= 80.9, **p**<.01), thus confirming the prediction. Table 4.46 shows the response distribution.

Table 4.46 Ease of resolving differences of opinion

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
6	9	37	3	0	55

Ease of assessing reactions

As expected, most respondents, nearly 50% of them, found that it was just as easy to assess the reactions of the other person whether they were seated side-by-side or over the table, as shown below in Table 4.47 (x^2 (4)= 42.4, **p**<.01).

Table 4.47 Ease of assessing reactions

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
13	15	26	1	0	55

Ease of getting attention

Roughly half of the participants (see Table 4.48) considered it to be just as easy to get the attention of the other participant when face-to-face regardless of their orientation, as expected (x^2 (4)=45.6 , **p**<.01).

Table 4.48 Ease of getting attention

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
11	16	27	0	1	55

Social presence

Further questions were asked of the participants to assess how aware they were of the presence of the other group member in the two types of face-to-face communication. It was predicted that the communication in both contexts would be equivalent on these measures. Questions asked were *how aware were you of the presence of the other participant? how easy was it to chat informally to the other participant?* when communicating face-to-face side-by-side compared to across the table. Responses were on a five-point scale from 'much more aware when face-to-face across the table' to 'much less aware when face-to-face across the table' and have been analysed by means of chi-square one sample tests.

Approximately half of the respondents, significantly more than expected by chance, found that they were equally aware of the presence of the person in both face-to-face contexts, as predicted (x^2 (4)= 46.4, **p**<.01). Table 4.49 shows the response distribution.

Table 4.49 Awareness of presence of others

much more aware when face-to-face across the table	more aware when face-to-face across the table	equally aware when face-to-face across the table	more unaware when face-to-face across the table	much more unaware when face-to-face across the table	N
5	17	28	4	1	55

Ease of chatting informally

As Table 4.50 shows, around two fifths of participants, more than expected by chance, found that it was equally easy to chat informally in both face-to-face conditions although a large proportion - 32% - found this to be easier when seated around the table (x^2 (4)=27.4 , **p**<.01). Hence, face-to-face orientation did not affect participant perceptions of social presence or ease of chatting informally.

Table 4.50 Ease of chatting informally

much easier when face-to-face across the table	easier when face-to-face across the table	equally easy when face-to-face across the table	more difficult when face-to-face across the table	much more difficult when face-to-face across the table	N
10	18	22	5	1	56

Persuasiveness of participants

A further question concerns perceptions of persuasiveness. Participants were asked how persuasive they found the arguments of the co-located group member in the video session compared to how persuasive they appeared to be when seated across the table. Again responses were on a five-point scale from 'much more persuasive when face-to-face across the table' to 'much less persuasive when face-to-face across the table'. A chi-square one sample test revealed that the majority of participants found the arguments equally persuasive regardless of face-to-face communication orientation (x^2 (4)=67.3, p<.01). See Table 4.51 for response rates.

Table 4.51 Perceptions of participant persuasiveness

much more persuasive when face-to-face across the table	more persuasive when face-to-face across the table	equally persuasive when face-to-face across the table	more persuasive when face-to-face across the table	much more persuasive when face-to-face across the table	N
4	14	33	3	0	54

Summary of orientation effect on subjective perceptions of communication

Overall, the subjective data confirm predictions that the face-to-face orientation of group members would not alter the ease of perceiving visual cues. Non-verbal cues were perceived by the majority of participants as being similarly easy to see whether communicating with the other group members side-by-side or across a table, with the exception of eye-contact which was felt to be much easier across the table. Furthermore, it was perceived to be just as easy to get their attention, get questions across to them, resolve differences of opinion, and the feeling of social presence was equally high. Neither did face-to-face orientation adversely affect how persuasive the other group member was perceived to be. Thus, sharing a conference terminal was not generally perceived as disadvantageous for communication compared to round the table discussions.

Comparison of video-mediated and side-by-side face-to-face communication

The following analyses were intended to compare subjective perceptions of the communication which was video-mediated with that which was side-by-side and co-present in front of the conferencing technology, however, participants did not directly compare the two communication contexts. They did compare both video-mediated and side-by-side face-to-face communication with across table face-to-face communication in two sets of comparative questions as described in the preceding two sections, therefore it was possible to compare the distribution of responses to these two sets of questions to see if cross-site or same-site communication differed more from face-to-face across table communication. This allows one to determine whether it was perceived to be any easier or more difficult to communicate via video than it was to communicate when side-by-side and co-present at the terminal compared to cross table face-to-face communication.

In order to analyse the data by chi-square for independent groups, it was sometimes necessary to combine cells in order to increase the expected frequencies to acceptable levels. Furthermore, for almost all questions the responses in the categories 'more difficult when face-to-face' and 'much more difficult when face-to-face' contained no responses or very low numbers with the result that too many expected frequencies fell below the acceptable level of five. As the responses in these extreme categories were similarly rare for the two sets of responses, (those about VMC and those about side-by-side face-to-face), they were excluded from the chi-square analyses so that under 20% of cells contained a value of five or under and a chi-square test could be employed. Therefore, the tests carried out were 2 by 2 chi-square for independent groups.

Ease of hearing

As the audio link was of high quality, no difference in the distribution of responses was expected between the group comparing video communication and cross table face-to-face and the group comparing side-by-side face-to-face with cross table face-to-face. The response distributions, as seen in Table 4.52, show that most participants tended to feel that is was easier to hear across the table than across the video link and that it was equally easy to hear in both face-to-face contexts. However, a chi-square test shows that in general the response distributions do not differ, thus supporting the experimental hypothesis. The high quality audio signal meant that most participants found it equally easy to hear when communicating via video or side-by-side face-to-face compared to face-to-face communication across a table.

Table 4.52 Ease of hearing

		much easier/ easier when across table face-to-face	equally easy when across table face-to-face	N	x^2
ease of hearing A	across video link versus cross table face-to-face	16	12	28	x^2 (1)=2.02, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	4	10	14	
ease of hearing B	across video link versus cross table face-to-face	16	11	27	x^2 (1)=0.8, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	5	8	13	
ease of hearing C	across video link versus cross table face-to-face	15	12	27	x^2 (1)=2.5, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	3	10	13	
ease of hearing D	across video link versus cross table face-to-face	15	11	26	x^2 (1)=5.4, p<.05, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	2	12	14	

Ease of making eye-contact

It was expected that making eye-contact would be perceived as easier between same-site than between cross-site participants in the video condition when compared to across the table face-to-face communication since video-mediation did not allow direct eye-contact whereas same-site participants could shift their orientation to look at one another. The response distributions in Table 4.53 show that most participants found it easier or much easier to make eye-contact face-to-face across a table than in either of the other two conditions. However, chi-square analyses (values are given in Table 4.53) reveal that more people found it difficult to make eye-contact in video-mediated than in face-to-face side-by-side communication compared to face-to-face communication around a table.

Table 4.53 Ease of making eye-contact

		much easier/ easier when across table face-to-face	equally easy when across table face-to-face	N	x^2
ease of making eye-contact with A	across video link versus cross table face-to-face	25	2	27	x^2 (1)=3.91, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	8	5	13	
ease of making eye-contact with B	across video link versus cross table face-to-face	25	3	28	x^2 (1)=2.34, p<.1 1 tailed
	side-by-side face-to-face versus cross table face-to-face	9	5	14	
ease of making eye-contact C	across video link versus cross table face-to-face	23	1	24	x^2 (1)=4.46, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	9	5	14	
ease of making eye-contact with D	across video link versus cross table face-to-face	22	2	24	x^2 (1)=2.78, p<.05
	side-by-side face-to-face versus cross table face-to-face	9	5	14	

Ease of seeing gestures

It was expected that there would be an advantage of side-by-side face-to-face communication over video-mediated communication (when compared to across table face-to-face communication) for the ability to see gestures. In general the pattern of results disconfirms this hypothesis. The response distributions in Table 4.54 show that most participants found it easier or much easier to see gestures face-to-face across a table than when communicating face-to-face side-by-side or over the video link. Chi-square analyses (values are given in Table 4.54) reveal that proportionally more people reported that it was easier or much easier to see gestures in face-to-face communication across the table than in VMC compared to those who reported that it was easier or much easier face-to-face across the table than in side-by-side face-to-face communication.

Table 4.54 Ease of seeing gestures

		much easier/ easier when across table face-to-face	equally easy when across table face-to-face	N	x^2
ease of seeing gestures of A	across video link versus cross table face-to-face	20	6	26	x^2 (1)=1.91, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	7	7	14	
ease of seeing gestures of B	across video link versus cross table face-to-face	21	5	26	x^2 (1)=0.59 p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	9	5	14	
ease of seeing gestures of C	across video link versus cross table face-to-face	21	5	26	x^2 (1)=2.77, $p<.05$, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	7	7	14	
ease of seeing gestures of D	across video link versus cross table face-to-face	23	4	27	x^2 (1)=1.62, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	8	5	13	

Ease of seeing facial expressions

The perceived ease of seeing facial expressions was not expected to differ between video-mediated and co-present side-by-side communication (compared to across the table face-to-face interactions). The response distributions in Table 4.55 show that most people perceived it to be easier to see facial expressions when communicating face-to-face across the table than during video-mediated communication. A similar number of people thought seeing expressions was equally easy in both face-to-face contexts as those who thought it was easier across the table. Chi-square results, shown in Table 4.55, are equivocal revealing that in some interactions more participants reported an advantage of same-site over cross-site communication, but in other interactions there was no difference in the perceived ease of seeing facial expressions in the communicative contexts.

Table 4.55 Ease of seeing facial expressions

		much easier/ easier when across table face-to-face	**equally easy when across table face-to-face**	N	x^2
ease of seeing facial expressions of A	across video link versus cross table face-to-face	22	4	26	x^2 (1)=6.64, p<.01, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	5	8	13	
ease of seeing facial expressions of B	across video link versus cross table face-to-face	22	5	27	x^2 (1)=1.68, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	8	6	14	
ease of seeing facial expressions of C	across video link versus cross table face-to-face	21	4	25	x^2 (1)=2.61, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	7	6	13	
ease of seeing facial expressions of D	across video link versus cross table face-to-face	21	3	24	x^2 (1)=4.62, p<.05
	side-by-side face-to-face versus cross table face-to-face	7	7	14	

Summary of non-verbal cues

There is an advantage of being side-by-side face-to-face over video communication for seeing non-verbal cues of other group members. What is the impact on the participant perceptions of the verbal communication process?

Ease of getting questions across

It was expected that there would be no difference in the perceived ease of conveying questions in same- and cross-site communication (in comparison to face-to-face communication across a table); the chi-square results confirm this. However, the distributions of responses show a tendency for more people to find the two face-to-face conditions equally easy for getting questions across than those who found VMC and face-to-face across the table communication equally easy.

Table 4.56 Ease of getting questions across

		much easier/ easier when across table face-to-face	equally easy when across table face-to-face	N	x^2
ease of getting questions across to A	across video link versus cross table face-to-face	13	14	27	x^2 (1)=0.76, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	4	10	14	
ease of getting questions across to B	across video link versus cross table face-to-face	13	15	28	x^2 (1)=0.11, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	5	9	14	
ease of getting questions across to C	across video link versus cross table face-to-face	15	12	27	x^2 (1)=1.28, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	4	9	13	
ease of getting questions across to D	across video link versus cross table face-to-face	15	11	26	x^2 (1)=0.32, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	6	8	14	

Ease of resolving differences

It was expected that it would be equally easy to resolve differences of opinion when interacting across the video link than when doing so side-by-side face-to-face (compared to communication face-to-face across the table). Indeed, this is what the chi-square analyses show: similar proportions of people found it equally easy to resolve differences via video or when side-by-side face-to-face versus cross table face-to-face communication. The chi-square values and distributions of responses are given in Table 4.57.

Table 4.57 Ease of resolving differences

		much easier/ easier when across table face-to-face	**equally easy when across table face-to-face**	**N**	x^2
ease of resolving differences with A	across video link versus cross table face-to-face	11	15	26	x^2 (1)=1.75, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	2	11	13	
ease of resolving differences with B	across video link versus cross table face-to-face	12	15	27	x^2 (1)=0.04, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	5	9	14	
ease of resolving differences with C	across video link versus cross table face-to-face	13	15	28	x^2 (1)=0.61, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	4	10	14	
ease of resolving differences with D	across video link versus cross table face-to-face	12	13	25	x^2 (1)=0.08, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	4	7	11	

Ease of assessing reactions

The perceived ease with which group members assessed each other's reactions was not expected to differ significantly during discussions side-by-side face-to-face and across the video link (compared to communication across the table face-to-face). In general this is what the chi-square tests reveal (see Table 4.58): the majority of participants found face-to-face round the table communication advantageous for assessing other's reactions compared to both video-mediated and side-by-side face-to-face communication.

Table 4.58 Ease of assessing reactions

		much easier/ easier when across table face-to-face	equally easy when across table face-to-face	N	x^2
ease of assessing reactions of A	across video link versus cross table face-to-face	24	3	27	x^2 (1)=17.7, p<.01, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	2	11	13	
ease of assessing reactions of B	across video link versus cross table face-to-face	21	5	26	x^2 (1)=0.59, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	9	5	14	
ease of assessing reactions of C	across video link versus cross table face-to-face	21	7	28	x^2 (1)=0.13, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	9	5	14	
ease of assessing reactions of D	across video link versus cross table face-to-face	21	6	27	x^2 (1)=0.49, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	8	5	13	

Ease of getting attention

It was expected that it would be relatively more difficult to get a group member's attention cross-site than same-site compared to face-to-face communication across a table. The results were mixed: the response distributions in Table 4.59 show that most people perceived it to be easier to get attention when communicating face-to-face across the table than during video-mediated communication, while the perceived difference between cross-table face-to-face communication over side-by-side face-to-face communication is less clear cut. Chi-square results, which are shown in Table 4.59, are equivocal revealing some significant differences in response distributions with some participants perceiving an advantage of cross table face-to-face communication over video communication, but no advantage over side-by-side face-to-face communication, for certain interactions.

Table 4.59 Ease of getting attention

		much easier/ easier when across table face-to-face	**equally easy when across table face-to-face**	**N**	$\mathbf{x^2}$
ease of getting attention of A	across video link versus cross table face-to-face	23	4	27	x^2 (1)=7.03, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	5	8	13	
ease of getting attention of B	across video link versus cross table face-to-face	22	5	27	x^2 (1)=0. 12, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	10	4	14	
ease of getting attention of C	across video link versus cross table face-to-face	21	7	28	x^2 (1)=6.2, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	5	9	14	
ease of getting attention of D	across video link versus cross table face-to-face	20	5	27	x^2 (1)=0.56, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	7	6	13	

Summary of communication ease

Overall, there is no perceived advantage of communicating side-by-side face-to-face over doing so via video for the following measures: the ease of getting questions across, of chatting informally, and of resolving differences of opinion. There were, however, more mixed results in terms of how easy participants perceived it to be to get attention and assess others' reactions, with some people finding side-by-side face-to-face and VMC equivalent and others perceiving an advantage of co-present side-by-side communication.

Awareness of presence

What is the impact of communication medium on perceptions of social presence and persuasion? It was expected that participants would be less aware of the presence of cross-site group members than co-present group members seated by their side (compared to face-to-face communication across a table). Overall, the results are supportive of this hypothesis, more participants reported being equally aware of the presence of other group members during both face-to-face conditions (side-by-side and across a table) than participants who felt equally aware in technology-mediated and cross-table face-to-face communication. The distribution of responses and chi-square results are given in Table 4.60. It seems that the presence of technology does lead to a lower feeling of presence.

Table 4.60 Awareness of presence

		more aware/much more aware when across table face-to-face	equally aware when across table face-to-face	N	x^2
awareness of presence of A	across video link versus cross table face-to-face	20	7	27	x^2 (1)=7.86, p<.01, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	2	9	11	
awareness of presence of B	across video link versus cross table face-to-face	18	8	26	x^2 (1)=0.26, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	10	4	14	
awareness of presence of C	across video link versus cross table face-to-face	16	7	23	x^2 (1)=2.80, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	5	9	14	
awareness of presence of D	across video link versus cross table face-to-face	16	5	21	x^2 (1)=3.33, p<.05, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	4	7	11	

Ease of chatting informally

It was expected that the distribution of responses would not differ significantly with it being as easy to chat informally to people across the video link as to those side-by-side face-to-face (compared to communication across the table face-to-face); this is what was found overall. In general, most people found it easier to chat informally when interacting face-to-face across a table than either by video or when side-by-side face-to-face. Table 4.61 gives the results of the chi-square analyses and the response distributions.

Table 4.61 Ease of chatting informally

		much easier/ easier when across table face-to-face	**equally easy when across table face-to-face**	**N**	**x^2**
ease of chatting informally to A	across video link versus cross table face-to-face	18	9	27	x^2 (1)=0.72, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	5	6	11	
ease of chatting informally to B	across video link versus cross table face-to-face	16	11	27	x^2 (1)=0.0003, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	7	6	13	
ease of chatting informally to C	across video link versus cross table face-to-face	21	4	25	x^2 (1)=5.33, $p<.05$, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	6	8	14	
ease of chatting informally to D	across video link versus cross table face-to-face	21	5	26	x^2 (1)=.41, p=ns, 2 tailed
	side-by-side face-to-face versus cross table face-to-face	10	2	12	

Persuasiveness

It was expected that group members would be perceived as being relatively less persuasive across the video link than when side-by-side face-to-face. However, as can be seen in Table 4.62, chi-square analyses show that this is not the case - the majority of participants found other participants equally persuasive over the video and when side-by-side face-to-face compared to face-to-face communication over the table. There is no disadvantage of video-mediated communication compared to side-by-side face-to-face communication for how persuasive group members were perceived to be in comparison to when they were face-to-face across a table.

Table 4.62 Perceived persuasiveness

		much easier/ easier when across table face-to-face	**equally easy when across table face-to-face**	**N**	**x^2**
Persuasiveness of A	across video link versus cross table face-to-face	9	15	24	x^2 (1)=0.14, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	3	9	12	
Persuasiveness of B	across video link versus cross table face-to-face	9	16	25	x^2 (1)=2.61, $p>.05$ $p<.1$ ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	8	6	14	
Persuasiveness of C	across video link versus cross table face-to-face	9	15	24	x^2 (1)=0.80, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	2	10	12	
Persuasiveness of D	across video link versus cross table face-to-face	7	15	28	x^2 (1)=0.59, p=ns, 1 tailed
	side-by-side face-to-face versus cross table face-to-face	5	8	13	

Summary of subjective data

Perceptions of VMC versus face-to-face side-by-side communication

Video communication was judged by these users to be equivalent to side-by-side face-to-face communication in terms of how persuasive they perceived group members to be, for assessing their reactions, resolving differences of opinion, chatting informally, getting questions across and seeing gestures. There was a disadvantage of video for eye contact and feeling aware of the presence of other participants. The responses were divided concerning how easy it was to see people's facial expressions and how easy it was to get their attention - this was found to be more difficult in VMC for some participants but not for others. In general, communication which was same-site and cross-site in the technology sessions was very similar - there was difficulty for perceiving some non-verbal cues over the video which may have contributed to a lower feeling of social presence in VMC and more difficulty in getting the attention of other participants. In general, communication which was same-site and cross-site in the technology sessions was perceived by users to be very similar - this finding reflects the similarity of same- and cross-site communication revealed by the objective measures of communication process. This is a positive finding for sharing of video technology - there is no greater perceived advantage of communicating with the co-present rather than the remote individuals.

Perceptions of VMC versus cross table face-to-face communication

Questionnaire data reveal that, in general, discussion participants perceived it to be easier to see the non-verbal behaviours of other group members when they were face-to-face around a table than when they were interacting via a high quality video link. Participants felt that they missed out on a lot of the visual cues yet they did not perceive it to be any more difficult to get their questions across in VMC than when face-to-face and nor was it any more difficult to resolve differences of opinion. There was perceived difficulty for observing some non-verbal cues over the video which may have contributed to the lower feeling of social presence in

VMC and the greater difficulty in getting the attention of other participants when they were interacting via video. These findings suggest that participants may have needed to expend more effort in video-mediated interactions in order to read the non-verbal behaviour cues of group members, thus their concentration on the discussion could have been adversely affected. This could go some way to explaining the poorer performance in the shared video condition since good performance required participants to concentrate in order to understand and recall the group's reasons for favouring one of four products to be able to justify the group's choice.

Face-to-face orientation effect

How do the two types of face-to-face communication compare? Is there a disadvantage of being side-by-side for communicating compared to across a table? The face-to-face orientation of group members was found to have little effect on subjective perceptions of communication, as anticipated. Non-verbal cues were perceived by the majority of participants as being similarly easy to see whether side-by-side face-to-face or face-to-face across the table from the other group members. The exception is ease of making eye-contact which was felt by the majority to be much easier across the table than when side-by-side. Thus, sharing a terminal is not generally perceived as disadvantageous for non-verbal communication or for ease of verbal communication such as getting questions across, nor does it adversely affect social presence or perceptions of persuasiveness of group members. These are positive findings for those in the workplace who must share communications technology with another person when taking part in video conferences, in that communication with the co-present individual should feel equivalent to face-to-face communication across a table. Attending to a computer screen with images and a video window does not appear to interfere with the communication process between group members who are co-present and seated side-by-side, at least in terms of their perceptions of the communication process.

The largest differences in user perceptions of the ease of communicating are between cross table face-to-face communication and video-mediated communication, with the former having the advantage. Side-by-side face-to-face communication falls between the two and does not differ greatly from either of those two communication contexts. There are relatively few perceived advantages of cross table face-to-face communication over side-by-side face-to-face communication which in turn is perceived to be quite similar to VMC.

4.9 Persuasion

There is another dimension to the task - persuasion. In addition to subjective measures of persuasive behaviour, different kinds of objective data were analysed: participant voting behaviour and attempts at persuading group members. What will be the effect of communication medium on persuasion? Since non-verbal cues are known to be important for persuasion (e.g. Mehrabian and Williams, 1969) and the video link was expected to make the perception of some such cues more difficult, it was predicted that

- there would be (proportionally) more persuasion attempts directed to same-site face-to-face group members than to cross-site video-mediated group members
- there would be (proportionally) more votes for co-present participants than for video-mediated participants

The use of persuasion and the voting behaviour in face-to-face discussions and those with partial video-mediation were also investigated to address whether more persuasion was used in the face-to-face context and whether any products were more popular than others.

Persuasive behaviour in face-to-face discussions and discussions with some video-mediation

One measure of persuasion is the number of attempts made by speakers to persuade the other group members that their product should be the group choice to be presented to the manager. All the dialogue transcripts were examined for use of persuasion. Guidelines for assessing whether a comment was an attempt at persuasion or not were developed and are given in Appendix T. Purely descriptive statements by speakers about their product were not counted as attempts to persuade; descriptions had to be qualified by reasons as to why these characteristics were advantageous or superior to those of the other products, hence, descriptions such as 'light', 'big' or 'small' etceteras were not considered persuasion attempts. Neither were comparative statements such as 'lighter', 'bigger', 'smaller' (with the exception of price comparisons such as 'cheaper') considered persuasion attempts unless the speaker stated why that was an advantage. Examples of statements coded as persuasion attempts from VMC and face-to-face discussions are given below in Figure 4-5. The number of persuasion attempts by each speaker in each dialogue was counted to give the dependent variable in this analysis.

Figure 4-5 Examples of persuasion attempts

face-to-face persuasion attempts	video persuasion attempts
It's got a manual zoom lens so you can get a good picture.	I think maybe the colour would be useful because it be easier to navigate around ...make it easier to find things on it
It was compatible with everything that was required.	It has all the things that customers are looking for at the moment such as windows compatibility
It's got 40 characters 10 line display which again is probably best for ease.	Being able to touch the keys properly I think that might be im important to some of the consumers
The fact that's its energy efficient can be marketed.	It's got modem connection for email Internet and fax which obviously what our clients are looking for.

The reliability of intra- and inter-judge coding for persuasion attempts was verified. One randomly chosen dialogue was re-coded by the researcher after a period of several weeks; intra-coder agreement was high at 97%, with numbers of persuasion attempts being significantly positively correlated as shown by a Pearson's correlation coefficient test (r=.984, **p**<.001). The same dialogue was independently coded by another researcher and inter-coder agreement reached 94% (r=.955, **p**<.01).

The following analysis was carried out to explore whether more persuasion was used in the face-to-face context than in the shared video context. Dialogues were compared in a 2 by 4 mixed design ANOVA with communicative context as a repeated measure (face-to-face and VMC) and speaker as a between subject variable (speakers are labelled as A, B, C or D based on the product they were assigned). The dependent variable is number of persuasion attempts. This revealed no effect of communicative context (**F**<1), no significant differences between speakers in the number of persuasion attempts they made (**F**<1), and no interaction effect (**F**<1). The mean numbers of persuasion attempts given in Table 4.63 show very similar persuasion behaviour in both communication contexts and between speakers. However, as this analysis combines video-mediated and co-present communication in the shared video context, it does not reveal the effect of actual video-mediation on persuasion; this is the purpose of the next analysis.

Table 4.63 Number of persuasion attempts by communication context and speaker

speaker	VMC mean (SD)	face-to-face mean (SD)
A	6.6 (4.5)	6.6 (4.9)
B	6.7 (3.7)	6.1 (3.2)
C	6.9 (3.8)	6.6 (4.0)
D	6.6 (2.3)	6.3 (3.3)
overall per dialogue	**26.9 (10.6)**	**25.6 (6.9)**

Persuasion across video link and side-by-side face-to-face in VMC

In order to assess whether a persuasion attempt was directed across the video link or to the co-located participant in the sessions with a video-mediated element, the person who took a speaking turn directly following the persuasion attempt was taken as the addressee (since they responded to it). The raw numbers of attempts directed across the video link and to co-present group members are compared in a repeated measures t-test which shows that there were significantly more persuasion attempts across the video link than between same-site face-to-face group members (**t**(13)=2.2, **p**<.05). The mean numbers of persuasion attempts are given in Table 4.64 from which it can be seen there are 60% more attempts to persuade cross-site than same-site participants.

Table 4.64 Number of persuasion attempts in VMC across video link and same site side-by-side face-to-face in VMC

Direction of communication	mean persuasion attempts (SD)
co-present same-site	**10.2 (6.0)**
video-mediated cross-site	**16.6 (8.8)**

The above data do not take into account that there are two people over the video link but only one who is co-present who can respond to persuasion attempts, therefore the proportions of same- and cross-site persuasion attempts were also compared by dividing the number of cross-site attempts by two. A paired sample t-test revealed that there are no significant differences between the proportions of persuasion attempts in the two contexts (**t**<1). The mean proportions, as shown in Table 4.65, are very similar but are slightly higher in same-site interaction.

Table 4.65 Proportion of persuasion attempts in VMC across video link and same site side-by-side face-to-face in VMC

Direction of communication	mean persuasion attempts (SD)
co-present same-site	**10.2 (6.0)**
video-mediated cross-site	**8.1 (4.6)**

Hence, although there were over 60% more persuasion attempts directed across the video link than to same-site group members, when the data are proportionalised this effect disappears to reveal a similar pattern of persuasive behaviour in both co-present and video-mediated interactions with slightly more attempts made to persuade co-present group members. These findings are nonetheless surprising as they run counter to predictions that the video link would be a barrier to persuasion and that co-present interactions would show more instances of persuasive behaviour. Will the pattern of voting reflect these results and show similar voting behaviour cross- and same-site, or will they confirm the hypothesis that co-present participants will receive a greater proportion of votes than participants across the video link?

4.10 Voting behaviour cross and same-site

At the end of each discussion, participants were each required to vote for the one out of four products which they wanted to present to their manager as the new design for production. They were required to vote for a product promoted by someone other than themselves, in this way, the voting behaviour can give an indication of the persuasiveness of participants. It was hypothesised that participants would be more likely to vote for the person with whom they shared a site than for group members who were communicating via video. Do analyses of voting behaviour support the experimental hypothesis or will the proportion of votes be similar in both contexts, thus reflecting the subjective data (the subject perceptions of persuasiveness of co-present and cross-link group members did not differ significantly) and the persuasive behaviour data (there were similar proportions of persuasion attempts cross- and same-site)?

Firstly, in order to check that voting behaviour is not merely reflecting participants' initial product preference prior to group discussion, the association between votes prior to and after group discussions was explored.

Association between pre-discussion and post-discussion votes

The Lambda statistic L_B developed by Goodman and Kruskal (Siegel and Castellan, 1988, pp. 298-303) was used to measure the association between pre- and post-discussion voting behaviour. This statistical test, which is suitable for nominal data, measures the decrease in error in the predictability of B when A is known, that is, it measures if one variable predicts another with greater than chance probability. Here, it was measured to what extent votes made before the discussion predicted those made afterwards. It was anticipated that there would be no association between the two types of vote. Before the discussion, participants could vote for one of four products whereas after the discussion they voted for one of three (as they were not allowed to vote for the product that they had promoted in the group discussion). This analysis was performed to check that pre-discussion votes did not predict post-discussion votes with greater than chance probability. (These calculations were computed using subjects' first choice post-discussion votes before any of their votes were changed in order to reach a group majority as was occasionally necessary). The results show that this was the case - pre-discussion votes did not predict post-discussion votes with greater than chance probability for video-mediated sessions (L_B=0.2, z=0.9, p>.05, two-tailed) or for face-to-face sessions (L_B=0.1282, z=0.33, p>.05, two-tailed). This suggests that the voting behaviour is not merely reflecting subjects' initial independent choice of product and is affected, to some extent at least, by the use of persuasion during the discussion. Therefore, further analyses of voting behaviour were carried out.

Number of votes for products endorsed by cross- and same-site participants.

It was predicted that there would be more votes for co-present participants than for video-mediated participants if the video link was making persuasion less effective. In order to test this hypothesis, a 2 by 4 mixed design ANOVA was performed to compare the number of votes for products promoted across the video link and same-site. Speaker was a between subject variable (four levels: speakers A, B, C and D) and direction of communication a repeated measure (two levels: cross-site and same-site). This revealed a significant effect of communication direction with almost two-and-a-half times more votes for cross video link group members than for side-by-side face-to-face group members (**F**(1,52)=18.2, **p**<.001), no significant effect of speaker (**F**<2.5) and no speaker-by-communication direction interaction (**F**=2.0). The mean numbers of votes are given in Table 4.66 from which it can be seen that there are actually more votes for products endorsed by group members across the video link than for those endorsed by co-present participants. This surprising result is quite the opposite of what was expected. However, since there are twice as many opportunities to vote for products promoted cross-site than for those promoted same-site (there was a pair of participants at each conferencing site, therefore each participant could choose to vote for one of two group members across the video link but only one at the same-site), this finding was explored further by comparing proportions of cross- and same-site votes.

Table 4.66 Mean number of votes same- and cross-site

Direction of communication		
speaker	mean proportion cross-site votes (SD)	mean proportion same-site votes (SD)
A	1.1 (0.6)	0.4 (0.5)
B	0.4 (0.6)	0.3 (0.5)
C	0.5 (0.7)	0.2 (0.4)
D	0.8 (0.8)	0.3 (0.5)
overall mean	**2.7 (1.0)**	**1.2 (1.0)**

Proportion of votes for products endorsed by cross- and same-site participants.

In order to proportionalise the data, the number of cross-site votes was halved since there were two cross-site but only one same-site person for whom to vote. As with the analysis of the raw numbers of votes, a 2 by 4 mixed design ANOVA was employed to compare the proportion of votes made for products promoted across the video link and by same-site co-present group members. This revealed no main effect of communication direction ($F<1$), no effect of speaker ($F<2$) and no interaction of speaker and communication direction ($F<1$). It had been expected that there would be more same-site votes than votes across the video link but these results show that in fact the proportions of votes are very similar. The mean proportions of votes in Table 4.67 show that video-mediated speakers receive a 17% higher proportion of votes than co-located speakers indicating that persuasion during VMC has at least equal impact, and perhaps a greater impact, than during co-present communication.

Table 4.67 Mean proportion of 1st choice votes same- and cross-site

	Direction of communication	
speaker	mean proportion cross-site votes (SD)	mean proportion same-site votes (SD)
A	0.5 (0.3)	0.4 (0.5)
B	0.2 (0.3)	0.3 (0.5)
C	0.3 (0.3)	0.2 (0.4)
D	0.4 (0.4)	0.3 (0.5)
overall mean	**1.4 (0.5)**	**1.2 (1.0)**

Cross-site votes for dominant cross-site speakers

In a previous analysis of the communication process, it was discovered that one speaker at each conference site said significantly more to cross-site group members than did the co-located participant. It was investigated whether or not speakers who verbally dominated cross-site conversations (one per conference site) received more cross-site votes than non-dominant cross-site speakers, as may be expected if they were more active in conversations with cross-site group members. Two independent t-tests were carried out, one to compare speakers (A and B) at site 1 and another to compare speakers (C and D) at site 2. There were no significant differences between the numbers of cross-site votes received by dominant and non-dominant speakers at either site ($ts<1$). These results reveal that participating significantly more in conversations across the video link did not advantage group members in terms of the numbers of votes they subsequently received for their product from the remote group members. It appears that the greater numbers of cross-site than same-site votes cannot be explained in terms of group members who dominated the cross-site conversations getting more cross-site votes. Numbers of votes are shown in Table 4.68.

Table 4.68 Mean cross-site votes received by dominant and non-dominant cross-site speakers

	mean votes received by dominant cross-site speakers (SD)	mean votes received by non-dominant cross-site speakers (SD)
site 1 (speakers A and B)	0.9 (0.8)	0.6 (0.7)
site 2 (speakers C and D)	0.6 (0.7)	0.7 (0.8)

Voting behaviour in face-to-face and partly video-mediated communication

What is the effect of sharing video technology on the distribution of votes between speakers compared to during face-to-face discussions? To check whether communication context affects voting behaviour, further ANOVAs were carried out comparing the number of votes for the speakers promoting the different products in across-the-table face-to-face versus VMC conditions. All groups participated in both face-to-face and VMC discussions and each participant promoted one product either A, B, C or D, therefore speaker is a between subject variable and communication context a within groups variable. A 2 by 4 mixed design ANOVA was carried out with two levels of communication context as a repeated measure - face-to-face and VMC; and four levels of speaker - A, B, C, D - as a between subject variable. As the total number of votes in each condition is always four it was known that there would be no main effect of communication condition ($\mathbf{F}<1$), there were significant differences between the number of votes for the four different speakers received ($\mathbf{F}(3, 52)=4.04$, $\mathbf{p}<.05$) and no interaction effect ($\mathbf{F}<1$). Independent t-tests showed that speakers promoting product A received significantly more votes than those promoting product B ($\mathbf{t}(26)=2.98$, $\mathbf{p}<.05$) and C ($\mathbf{t}(26)=2.2$, $\mathbf{p}<.05$) and speakers promoting product D got significantly more votes than those promoting B ($\mathbf{t}(26)=2.2$, $\mathbf{p}<.05$). The results show that although individuals promoting certain products received more votes than others, the communication context did not affect the voting behaviour differently, therefore, the fact that some products were more popular than others does not pose a major problem for interpretation of the effect of communication context on the voting data. Data are given in Table 4.69.

Table 4.69 Mean number of votes in face-to-face and shared VMC contexts

speaker	shared video mean (SD)	face-to-face mean (SD)	mean per speaker
A	1.5 (0.9)	1.2 (1.2)	1.4 (0.7)
B	0.6 (0.9)	0.6 (0.8)	0.6 (0.6)
C	0.7 (0.9)	1.0 (0.9)	0.9 (0.5)
D	1.1 (1.1)	1.1 (0.9)	1.1 (0.5)

Relationship between cross- and same-site persuasion and voting data

It was predicted there would be more persuasive communication and more votes for co-present group members than for those communicating via video in the shared VMC context. The raw numbers of persuasion attempts and votes cross-site and same-site were compared to reveal that there were significantly more persuasion attempts - over 60% more - across the video link than between co-present group members and there were significantly more votes (more than twice as many) for products promoted across the video link than for those promoted same-site. When proportions of persuasion attempts and votes were compared no significant differences were found between the two communicative contexts, nonetheless, the results show that persuasion across the video link appears to be no less effective than that between co-present participants in this study. There was in fact a slightly lower proportion of persuasion attempts over the video link (20% lower) than same-site but slightly more votes (17% more) for products promoted via video; this suggests that persuasion over the video link may have been slightly more effective than persuasion between co-present participants.

Relationship between face-to-face and VMC persuasion and voting data

The persuasion and voting behaviour in the face-to-face and partly video-mediated contexts were compared to investigate whether there was more use of persuasion when all participants communicated face-to-face, and whether there were any differences between speakers. An analysis of the numbers of persuasion attempts revealed no differences between the two contexts and no differences between speakers in the amount of persuasion they used. There was nevertheless a difference between speakers in the number of votes they received. This suggests that certain products were simply more popular than others.

4.11 Exploration of performance difference

Thus far the analyses carried out have given few clues as to why groups should have performed more poorly in the shared video than in the face-to-face context. The communication process in both these conditions, and when comparing cross- and same-site communication, is very similar in the amount of verbal interaction, the interactivity and formality of conversations and the persuasive behaviour. The differences which do exist are that there is unequal participation in truly video-mediated exchanges, and the participants' perceived it to be more difficult to utilise non-verbal cues, more difficult to assess reactions and get attention, and perceived lower levels of social presence in video-mediated interactions than in face-to-face communication across a table.

In order to explore why performance in the VMC context was significantly poorer than in the face-to-face context, the justification scores of the individuals were examined more closely. The post-discussion justification of the group's decision could receive a score between 0 and 100 with scores falling into one of four categories: 0 to 25, 26 to 50, 51 to 75 or 76 to 100. In the VMC condition, twenty-seven (out of 56) participants received scores in the lowest category of 25 or under, while in the face-to-face condition nineteen people scored 25 or below. In both communication conditions, three participants scored in the top category of 76 or above. Thus it can be seen that there was not a general reduction in the quality of justifications, but the lower average justification score in VMC was due to a larger group of very low scoring individuals than in the face-to-face condition.

The lowest and highest scoring individuals in each condition were identified giving four groups roughly corresponding to the lower and upper quartiles. The communication process of the low scoring VMC individuals was investigated by comparing them to the lowest scoring face-to-face participants and the highest scoring face-to-face and VMC participants with a view to illuminating their poor performance. The high scoring VMC (high-VMC) group consisted of twelve individuals with scores between 56 and 91, the high scoring face-to-face (high-face-to-face) group consisted of sixteen people with scores from 66 to 96, the low scoring VMC (low-VMC) group had sixteen individuals with scores from 10 to 20 and the low scoring face-to-face (low-face-to-face) group was made up of nineteen individuals scoring between 5 and 25. The individuals' communication processes in these four groups were compared including number of words uttered, turns taken, the length of speaking turns, number of questions asked, number of interruptions made, the number of conversations engaged in, the number of pairwise conversations initiated, words said in these conversations and number of persuasion attempts. These analyses revealed that the low-VMC group was not any less verbally involved in the discussions, in fact this group said more than the high-VMC group and a similar amount to the high scoring face-to-face group. For example, the low scoring VMC individuals said on average 32% more words than high scoring individuals, and the high-face-to-face group said a mean of 51% more words than the low-face-to-face group (mean words: low-VMC - 636; high-VMC - 482; low-face-to-face - 469; high-face-to-face - 711). In sum, low scoring participants in VMC said more than high scoring VMC participants and low scoring face-to-face participants, therefore their poorer performance cannot be explained by them being isolated individuals who did not participate in the interaction, as this was not the case.

The communication process in cross- and same-site conversations was also compared. The amount of cross- and same-site talk, interruptions and questions asked were compared for the low- and high-VMC groups. It was not the case that poorly performing individuals said less to cross-site group members than the high scoring individuals, in fact, compared to the high-VMC group, there was a tendency for them to say more to both same- and cross-site group members (mean words uttered in cross-site pairwise conversations: low-VMC - 296, high-VMC - 257. Words in same-site conversations: low-VMC - 185, high-VMC - 89). Furthermore, there was no significant difference in the numbers of dominant and non-dominant cross-site speakers among the high and low scorers in VMC.

An analysis of subjective questionnaire data reveals, however, that more individuals in the low-VMC group than in the high-VMC group perceived it to be much easier to take a turn when communicating face-to-face than by shared video technology (x^2 (2)=5.0, **p**<.05, 1 tailed), and that significantly more of them were more or much more satisfied with the decision process (x^2 (1)=6.2, **p**<.05, 1 tailed) and the final product choice in the face-to-face than in the VMC discussion (x^2 (1)=4.8, **p**<.05, 1 tailed). This lower satisfaction does not appear to be related to them receiving less votes or fewer group votes as the low-VMC group does not differ significantly from the high-VMC group on these measures. Furthermore, the poorly performing VMC individuals did not particularly dislike the technology - a similar pattern of results to the rest of the group was found (63% of low-VMC and 63% of high scoring VMC people preferred face-to-face communication compared to 49% for whole group). Thus the subjective data show that poorly performing participants in VMC feel that the turn-taking process is not running as smoothly as in face-to-face communication, although this does not show up in the objective measures of communication process. More of them are also less satisfied with the decision process and outcome than in face-to-face discussion. This group seems to be compensating for the feeling that the communication process is not running smoothly by becoming more talkative; perhaps they talk too much and listen too little. This is not a general effect as there are individuals in the VMC condition who perform well, however some users are negatively affected by the technology, but not in an obvious way such as engaging in less verbal interaction. Rather, it seems that technology-mediation had a subtle effect on their perceptions of the communication which have interfered with their ability to concentrate on the discussion resulting in lower understanding of, therefore a poorer justification of the group's reasons for its decision.

4.12 Discussion

Study description, aim and hypotheses

This laboratory study explored the effects of sharing video technology on the communication process, outcome and patterns of participation of small groups of peers performing a persuasive discussion task. A combination of objective and subjective measures of communication process and outcome were explored to compare the communicative media. Two different levels of comparison have been employed throughout the study: comparisons of the overall group communication process and outcome when all members communicated face-to-face versus when some members communicated via high quality video; and comparisons of cross-site video-mediated and same-site co-present communication during shared VMC. Video-mediation was found to have an unexpected impact on some aspects of the communication: persuasion and participation in video-mediated interaction, it also adversely affected performance.

VMC and persuasion

An interesting and surprising finding was revealed regarding the impact of video technology on persuasion. The persuasion literature points to the importance of non-verbal behavioural cues in persuasive behaviour and suggests that in a communicative mode where visual cues are restricted, such as video communication, persuasion will be less effective than in face-to-face interaction (Mehrabian and Williams, 1969; Short, Williams and Christie, 1976). The empirical studies of technology-mediated persuasion and negotiation reviewed in the introduction have not assessed persuasive behaviour directly either subjectively or objectively. Here the persuasive behaviour of participants was explored in terms of the number of persuasion attempts they made and their pattern of voting for products. Contrary to what might have been expected, analyses revealed that there were just as many persuasion attempts by speakers in face-to-face and shared

VMC contexts and no differences between speakers promoting the four different products. There were, however, differences between speakers in the numbers of votes received, that is, some products were more popular than others. In sum, sharing video communications technology does not seem to adversely affect persuasive behaviour. This discovery is even more surprising in light of the participants' perceived difficulty in observing the non-verbal cues of group members communicating via video. The actual cross-site video-mediated communication led to a slightly but not significantly lower proportion of attempts at persuasion than co-present same-site communication. Despite this, when proportions of votes were compared there was a slightly higher proportion of cross-site than same-site votes; this shows, at best, an advantage of VMC for persuasion effectiveness, and at worst, that VMC is no less effective for persuasion than same-site communication. Furthermore, participants perceived other group members to be equally persuasive cross- and same-site. These findings are remarkable as generally it is thought that a less rich medium, such as video communication, will be less suitable for persuasion (e.g. Short *et al.*, 1976; Hollingshead *et al.*, 1993).

Dominance in video-mediated conversations

Another impact of video-mediation was discovered. An examination of participation in cross-site interactions revealed that one member at each video site dominated exchanges with participants over the video channel by contributing significantly more words than the co-located participant, but the same individual did not dominate same-site conversations. This finding of inequality amongst group participants in technology-mediated conversations confirms the finding of Carletta, McEwan and Anderson (1998) that one person at a shared conference site tended to be the channel for cross-site talk, and study 1's finding that one person at a shared site dominated cross-site conversation. Hence, there is an effect of technology on the patterns of interaction but this is subtle and only apparent from a detailed analysis of the communication process. This could have a negative impact on communication: those who interact less with each other are likely to share less information, thus have lower levels of mutual understanding and be less co-ordinated in their communicative goals (Clark and Wilkes-Gibbs, 1986; Clark and Schaefer, 1989; Clark and Brennan, 1991; Carletta *et al.*, 1998).

Performance

The outcome of communication in terms of how well participants justified their group's choice of product subsequent to discussions in the face-to-face and shared video contexts was compared. Contrary to evidence from research into the use of equally distributed VMC for tasks involving persuasion and negotiation (Kinney and Dennis, 1994; Suh, 1999), and in contrast to the finding of lab study 1 which found equal performance in VMC and face-to-face communication, this study found an advantage of face-to-face communication over that which was partly video-mediated. This finding is supportive of Media Richness Theory (Hollingshead *et al.*, 1993) which predicts that for such a task, video communication will be less suitable than face-to-face communication as it is too constrained a medium in terms of the richness of the information it transmits. In a previous study by Valacich *et al* (1994) which found a performance difference between VMC and face-to-face media, low quality VMC led to longer decision times, but why should sharing high quality VMC lead to poorer justification of group decisions?

An objective analysis of the dialogue structure indicated that the communication process of groups of same-role participants in both communicative media was very similar, despite the vast majority of the participants being novices at using VMC. The amount of communicative effort expended, the interactivity of conversations (turn length) and their formality (number of speaker interruptions) were similar in both communicative contexts; discussions were equally interactive in terms of the numbers of task-focused questions participants asked one another; and there was no difference between contexts in the amount of persuasion used by participants. Thus, for equal communicative effort (in words and turns) and similar patterns of participation and persuasive behaviour, communication with a video-mediated element led to poorer performance than when the same groups communicated face-to-face.

An examination of the actual video-mediated interactions in the video context did not reveal any differences from co-present interactions in terms of dialogue structure (words, turns, interruptions, turn length) or in the amount of persuasion used, although there was unequal participation in cross-site exchanges. Nevertheless, dominance in cross-site conversations did not lead to these individuals getting significantly more votes from cross-site group members than speakers who were not verbally dominant, nor did the justification quality of group members who were and were not verbally dominant in conversations across the video link differ significantly. Therefore, this effect does not appear to explain the disadvantage for communication outcome in VMC.

Indeed, sharing of VMC technology only had a negative effect on the performance of some users but had relatively little impact on the performance of others. What characterised the communication of these individuals? Those who performed poorly did not contribute any less to discussions in words spoken, turns taken or conversations engaged in, in fact quite the opposite was true, these individuals were more verbose than those who performed better. In addition, their turn-taking was equally co-ordinated. Moreover, the poor performers in shared VMC were not any less involved in cross-site conversations than the good performers. Thus they were negatively affected by the technology but not in terms of becoming any less talkative or less involved in the interaction (they actually talked more than high scorers in VMC and low scorers in the face-to-face context). There was however a subtle effect on the poorly performing VMC individuals' perceptions of the co-ordination of and satisfaction with the technology-mediated discussions; they felt that the communication process did not run smoothly and that the decision-making process and outcome did not proceed entirely to their satisfaction. Thus, the perception of communicative difficulties may have interfered with their ability to concentrate on the discussion by leading them to talk more and pay less attention to what others were saying. This may explain the inferior performance of some individuals in the shared VMC context; if concentration was poorer, this could have had a negative impact on participants' ability to assimilate and process reasons for the group choice resulting in production of lower quality post-task justifications. It is possible that with more experience of using such communications technology these users will adapt to the medium and learn to overcome their (perceived) difficulties.

Comparison of studies 1 and 2

This lab study of four-person peer groups performing a persuasion task face-to-face and via shared video communications technology follows on from a previous study presented in chapter 3 exploring face-to-face, audio communication and shared VMC in which there were role differences between group members. In contrast to study 1, the speaker participation rates in face-to-face and shared VMC discussions were similar; in the previous study, speaker contributions were more unequally distributed in the technology-mediated than in the face-to-face context. However, removal of role differences did not completely equalise the patterns of participation: speaker contributions to conversation in the VMC context were still unequal in study 2, with one individual at each shared site verbally dominating interactions over the video link. Thus, it appears that the combination of role differences and technology-mediation has a greater impact on participation rates than when role differences between group members are eliminated; only the video-mediated exchanges of peers were affected, their participation rates in the discussion as a whole were unaffected, while in study 1 there was disparity between speakers both in the overall speaker participation rates and participation in mediated conversations.

However, there is another variable in study 1 that was not present in study 2 which may have impacted speaker participation equality: the 'asymmetry' of access to on-screen data or 'teledata' between group members in the technology conditions of study 1. (In the technology context of study 2, all group members viewed the same teledata). The 'asymmetry' arose since the remotely located travel agent was unable to see the short (approximately 10 to 20 seconds long) action video clips of holiday destinations[1], instead seeing a still image of the first frame of the clip in the video and audio conditions; in contrast, the clients saw the moving pictures (there was no audio track). To what extent could this asymmetry of access to 'teledata'

[1] This was due to bandwidth restrictions.

between group participants have contributed to the significant differences between speaker contribution rates in study 1, that were not present in the VMC context of study 2? Due to his/her exclusion from this possible source of discussion, one might have expected the travel agent (who saw less rich data in the technology-mediated discussions) to have interacted less with the clients than in the face-to-face discussions in which they all viewed the same movie clips. Yet this was not the case: the amount he or she interacted with the clients did not differ significantly across conditions. In fact, in the video and audio contexts (but not in the face-to-face context) it was client 1 who said significantly more than the other group members, despite seeing moving shots of the destinations in all communication contexts. Therefore, the skewed patterns of participation in the technology-mediated conditions of study 1 do not seem to be explicable by the asymmetry of data access. In sum, when roles are equal and the group members have no pre-existing relationships then the general patterns of interaction are still unequal. Further comparisons of these two studies are found in the concluding chapter.

Implications of findings

The results of this research appear encouraging for the technology-mediation of groups of same-role participants, at least in a laboratory environment when the groups have no shared history. The shared use of video for communication did not lead to more effort in terms of words and turns to complete the task, although there was an advantage for face-to-face communication in terms of communication outcome. However, as the majority of the study participants were novice users, with extended exposure to the technology, given the overall similarity of patterns of communication in shared VMC and face-to-face communication, equally successful outcomes might be expected in multimediated[2] contexts.

Studies 1 and 2 presented in this and the previous chapter have shown the importance of role differences in the effect of technology upon communication. However, roles were experimentally assigned. The logical next step would to be

[2] See glossary in appendix V for a definition of this term.

look at the effect of communication technology on groups with and without existing role differences in a more natural environment - the work place, for example. One way of doing this would be to look at the effect of organisationally assigned role differences, that is, status differences, in technology-mediated established work groups to explore how the communication process in groups with and without status differences is influenced by multimedia communications technology.

In order to extend the research in laboratory studies 1 and 2, a different methodological approach will be adopted in study 3, a field study approach. This will allow us to see how groups in the 'real world' are affected by communications technology and whether this reflects its impact on groups in the laboratory. By 'triangulating' (using multiple methods) we will be in a stronger position to understand the effect of multimedia communications technology on group interaction.

Naturally occurring groups differ from *ad hoc* lab groups in a variety of ways; the group members have a shared history, greater investment in the group and they carry out real communication tasks with real consequences. It will therefore be interesting to see whether role differences of a different nature –organisational status differences - in established work groups have a similar impact to that already found in this thesis on how much speakers contribute to discussions, i.e., will status differences negatively affect the equality with which speakers participate in multimediated meetings?

5 Chapter 5. Study 3. Impact of status differences and multimedia audio communication technology on business meetings

5.1 *Introduction*

The research reported so far has investigated the ways in which multimedia communications technology impacts group interaction in controlled laboratory settings. Study 1 looked at the effects of unequally distributed technology on mixed-role groups comparing audio and video conferences with face-to-face communication. Study 2 went on to explore the impact of shared video conferencing technology on small groups whose members had similar roles. In this final study, a different methodological approach has been adopted: it examines the effect of multimedia audio communication on groups in a naturalistic setting, the work place.

The organisational psychology and management literature (e.g. Nellessen, 1999) documents that organisations increasingly rely on small decision-making and problem-solving groups to run their businesses. Traditionally these groups have been led by a senior member or manager yet there is now concern as to the effectiveness of this traditional hierarchical group structure for decision making and innovation since status inequalities have various implications for communication effectiveness (Carletta, Garrod and Fraser-Krauss, 1998; West, Garrod and Carletta, 1998).

The effect of status on group communication

In the laboratory Bales (1950) and Berger *et al.* (1977) found that high status individuals exert more control over discussions even when not an expert on the topic under consideration. Possible reasons for lower status individuals contributing less are that they are more apprehensive of having their ideas evaluated negatively (Silver *et al.*, 1994) and that they accord greater weight to the views and opinions of high status group members (Berger, Cohen and Zelditch, 1972; Humphreys and Berger, 1981; Silver, Cohen and Crutchfield, 1994).

Further evidence has been found in the field that the presence of status differences in face-to-face group meetings reduces equality of participation and influence: Carletta, Garrod and Fraser-Krauss (1998) examined twenty-one meetings of six problem-solving manufacturing groups in small- to medium-sized enterprises and discovered that traditional group managers dominate and control discussions.

This inequality of participation has consequences for information sharing which in turn has implications for effective problem solving. More equal participation increases the likelihood that unique information gets contributed to discussions, (Straus, 1996) and effective sharing of information results in groups reaching a better understanding of a problem and to better solutions (e.g. Stasser and Titus 1985; Stasser and Stewart, 1992). Therefore, as status can inhibit information sharing in groups (Straus, 1996) status-differentiated groups could result in less effective problem solving, decision making and innovation (Carletta, Garrod and Fraser-Krauss, 1998; Carletta, McEwan and Anderson, 1998). For these reasons, techniques have been developed to counteract the negative effects of status on communication such as employing professional meeting facilitators (West, Garrod and Carletta, 1998), brainstorming (de Bono, 1971) and the Stepladder technique (Rogelberg, Barnes-Farrell and Lowe, 1992) which aim to increase equality of participation and prevent premature adoption of one solution.

The effect of text conferencing on status constraints in groups

It has been suggested that the use of asynchronous text-based computer-mediated communication (CMC) technology, such as email and discussion lists, in the workplace help to overcome the social and psychological boundaries, such as status constraints, which can hamper free communication between levels of an organisation (Kiesler and Sproull, 1992) since the interpersonal cues that indicate status such as gaze, posture, title, seating position, clothing etc. (Argyle, 1988) are, with the exception of title, absent. On the other hand, some authors point out that the impact of this type of electronic communication is shaped by the social and organisational contexts in which it is used (e.g. Mantovani, 1994).

In *synchronous* communication contexts without a visual channel, in text-based and audio conferences for example, it is reasonable to suppose that status effects may also be attenuated. It has been argued by some researchers that disinhibition due to a lack of social context cues and social feedback results in greater equality of participation and influence in text-based CMC (e.g. Kiesler and Sproull, 1992), an argument which could also be applied to audio conferencing, which although not as impoverished a medium as CMC, provides fewer social cues than face-to-face communication.

There are two types of experimental study into the effects of synchronous text-based communication technologies (henceforth referred to by the abbreviation CMC) on mixed-status group communication: ones which examine how CMC affects the formation of status hierarchies and ones which look at how it affects existing status hierarchies.

The former type of laboratory studies, reviewed in greater detail in chapter 4, has shown that communicating via synchronous text messages can lead to more equality of participation and influence in groups, that is, it prevents the emergence of a leader, at least in small groups of students performing problem-solving tasks (Siegel *et al.*, 1986; Benbasat and Lim, 1993; Straus, 1996). However, Lea and Spears (1991) found that participation in CMC was less equal under certain conditions, in particular when members of small student discussion groups were socially isolated or 'deindividuated' during communication and social boundaries defining individual, as opposed to group identity were made salient.

In terms of the consequences of synchronous text-conferencing for the outcome of peer group communication, decisions have been found to be more extreme or polarised (i.e., they are more risky than the decisions of individual group members) for a variety of types of groups (students, managers, university administrators) under various conditions in the laboratory (e.g. anonymous and non-anonymous communication) (McGuire, Kiesler and Siegel, 1987; Hiltz, Turoff and Johnson, 1989; Lea and Spears, 1991), as already described in the previous chapter.

In research directly studying status differences in groups communicating face-to-face and via text-based CMC, the findings are often contradictory. Some studies report that it is the existence of status differences, others that it is the communication context, and still others that it is both combined, which most affect(s) communication.

Research which found that communication medium and existence of status differences had a combined effect on interaction includes an experimental study by Dubrovsky, Kiesler and Sethna (1991) which showed that CMC reduced status effects on the communication process in decision-making groups consisting of one postgraduate and three undergraduate business students. The proportion of remarks made by the high-status member and his/her first advocacy, i.e., the proportion of times he/she was the first person to advocate a proposal, were significantly reduced in CMC suggesting that the 'equalisation phenomena' can operate in mixed- as well as same-status groups. Benbasat and Lim (1993) carried out a meta analysis of experimental studies which revealed an effect of medium and status on outcome and subjective evaluations of group communication in text conferences: status-differentiated groups performed worse and had lower group satisfaction than status-undifferentiated groups for a variety of tasks.

The following lab experiments comparing face-to-face and text conferencing found status to have the greater impact on interaction. Silver, Cohen and Crutchfield (1994), for instance, found status to be more influential than communication medium for groups of students performing an idea generation task: in both CMC and face-to-face communication, status-differentiated groups generated significantly less ideas and tended to censor ideas, but context had little effect. In this study, status differences were created on a task-relevant status attribute. Similarly, newly-formed groups of business students with high-status postgraduate and low-status undergraduate members had *unequally* distributed participation for two decision tasks, with high status members contributing more comments in both face-to-face and computer-mediated communication contexts (Weisband, Schneider and Connolly, 1995).

A lab-based experiment by Barkhi, Jacob, Pipino and Pirkul (1998) found a variety of effects of context, status, and a combined effect of the two. They assigned leaders to twenty-six existing student project groups for a task in which not everyone has the same information and objectives (a 'mixed-motive' task). In addition, the leader had the authority to select among competing solutions or override a consensus solution of group members. They compared four conditions: text-based CMC and face-to-face communication, with and without a leader. On subjective measures, Barkhi and colleagues found a main effect of communication context and of status: there was higher participant satisfaction face-to-face than in CMC, and more feelings of frustration with the process in status-differentiated than status-undifferentiated groups. Subjective and objective performance measures showed an advantage of face-to-face communication over CMC. For the sole objective measure of communication process - percentage of untruthful reporting by group members - status and context were found to interact such that when there was no leader, CMC group members were more truthful than face-to-face group members, but when there was a leader, face-to-face group members were more truthful than those in CMC. The authors interpret this as showing that some aspect of CMC causes members to distrust their leaders more, consequently they provide her/him with information that is less accurate. However, the authors still conclude that '*the presence or absence of a formal leader did not appear to have substantive effects*' (Barkhi, Jacob, Pipino and Pirkul, 1998, pp. 205).

In another laboratory study by Barkhi, Jacob and Pirkul (1999), twelve four-person groups of students with designated leaders carried out a mixed-motive task via synchronous text messages or face-to-face communication. In this study they did not compare groups with and without leaders. Leader frustration with the process was no different in CMC and face-to-face communication but there was significantly greater group member frustration in CMC than face-to-face. Face-to-face groups outperformed CMC groups although there was no significant difference in time taken to reach a solution. Thus there appear to be advantages of face-to-face communication for performance and lower participant frustration, but the authors warn that the results from mixed-motive tasks are not generalisable to other types of task.

Summary of effects of text-based CMC and status

In the empirical research into status differences and text-based CMC described above, the wide variety of methods, tasks and types of status difference (e.g. existing versus manipulated) investigated are probably responsible for the contradictory findings. However, it is possible to identify an overall pattern of findings. Status differences between group members have an effect on communication processes which in turn can have negative implications for communication outcome, whether interaction is face-to-face or via a text-based electronic medium. It is generally only when process measures of communication, such as participation rate and accuracy of information reporting, have been analysed that the combined effects of status and medium have become apparent: CMC led to more equal contributions from group members (Dubrovsky *et al.*, 1991) and group participants reported information less accurately to their leader in CMC (Barkhi *et al.*, 1998). In addition, more studies have found the equalisation phenomenon of synchronous text communication to hold true for groups *without* existing status differences, i.e., the technology suppresses emergence of dominance (Siegel *et al.*, 1986; Straus, 1996), than those which have found the technology to equalise the effect of existing status differences (Dubrovsky *et al.*, 1991). However, a meta analysis of thirty-one studies also showed combined effects of status and CMC on subjective data (Benbasat and Lim, 1993).

One laboratory study which looked at the effect of a different communication channel, the audio channel, is that of Harmon, Schneer and Hoffman (1995). They explored the impact of audio conferencing on the perceptions of influence and power, and on the decision quality of status-differentiated and status-undifferentiated groups for two problem-solving tasks, one intellective and one highly value-laden. Harmon *et al.* discovered that in established four-person student project teams, participants' subjective ratings of status differentiation and leader influence were stable and almost identical for both face-to-face and audio conferences for both tasks, contrary to their expectation that status hierarchy would be less stable in audio conferences. They had also hypothesised that audio would weaken support for decisions and improve decision quality but found face-to-face and audio conferencing groups to be similar on these measures. Therefore the authors maintain that established groups will probably adapt to the demands of the medium to solve problems successfully.

Multimedia communications technology and status

Increasingly, organisations are utilising multimedia communications technologies, such as video and audio conferencing, in addition to text-based communication technologies to carry out their collaborative work. 'Multimedia' here is taken to mean technology which incorporates more than one medium for communication - this may include any combination of audio, video and data channels - thus excluding text-based communication technologies such as electronic mail from the definition. The impact of multimedia communication technology on status processes in group communication has not yet been explored in great detail.

Text-conferencing technology differs from multimedia technology in several important ways: communication is via typing meaning that contribution rates are lower due to the greater effort required to participate than in spoken communication; bandwidth is lower as cues from tone of voice, pauses, background noises and so forth are unavailable; in CMC participants can contribute simultaneously to the discussion whereas spoken communication is sequential; and CMC contributions can be anonymous.

Types of research carried out into the impact of *multimedia* technologies, such as audio and video conferencing, in the field have used various different methodologies with varying aims, for example, Tang and colleagues (Isaacs and Tang, 1993; Tang and Isaacs, 1993; Tang, Isaacs and Rua, 1994) took an ethno-methodological approach using qualitative analyses of video-taped interactions to inform the design process (these field studies are reviewed more thoroughly at the beginning of chapter 3), while others have analysed system use, usage patterns and user evaluations to assess, for example, the suitability of the audio channel for a shared media space (e.g. Ackerman, Hindus, Mainwaring and Starr, 1997). Yet another approach is a quantitative analysis of the communication process such as that carried out by O'Conaill, Whittaker and Wilbur (1993) to investigate the suitability of VMC systems for collaborative work in the field. Little is known however about how multimedia communication technology affects status-differentiated groups.

O'Conaill, Whittaker and Wilbur (1993) did look at equality of turn and word distribution in meetings with status differences in real life meetings across two VMC systems and face-to-face, with five meetings carried out in each medium. (This study is reviewed in more detail in chapter 3). They computed the percentage of words and turns contributed by the two most and the two least frequent speakers in each communication medium, they then compared across conditions and found no significance differences in the extent or lack of dominance. There was inequality in all conditions with 58% or more turns and 70% or more words being taken by the two most dominant individuals. However, they did not state the relationship between status and dominance.

Summary of the effect of technology-mediation on mixed-status groups

The research summarised above consists predominantly of lab studies of text-based electronic communication. While the lab provides a controlled environment in which to analyse communication technologies, ecological validity is a problem: the groups investigated are usually newly-formed with neither shared history nor substantial investment in the group and the tasks are artificial. In addition, there is no simple way of replicating status hierarchies in the lab. Although some experimental studies have tried to exploit existing status differences, there is always the chance that status effects are moderated by the lack of real-world consequences.

A further criticism is that the types of text-based electronic media used in organisations tend to be asynchronous, while the majority of the studies cited above have investigated group communication and problem solving via *synchronous* text-conferencing applications which tend not used in these ways in the field (Postmes *et al.*, 1998). In addition, there is a paucity of research into the effects of *multimedia* as opposed to text-based communication technology on status-differentiated groups, especially those working in the field.

Multimediation and status

Nonetheless, it is possible that the findings of lab research into synchronous text conferences can give clues as to what might occur in multimediated group discussions. From the existing research one might hypothesise that multimedia communications technology will either equalise or have little effect on status inequalities, and that groups will be able to communicate as effectively in either medium. However, the methods used in the empirical research described vary and have often relied upon subjective measures of leadership, equality and satisfaction with communication, as opposed to objective measures.

In contrast, the empirical research studies 1 and 2 described in chapters 3 and 4 employ detailed and objective communication analyses to investigate the *patterns* of interaction. Such analyses can uncover subtle effects of the technology of which users may be unconscious, something which subjective data, from questionnaires for example, may not do. The results indicate that the multimedia communications technology in fact exaggerated role differences in small groups: in three-person groups where one person has a different role, participation became less equal in technology-mediated contexts, with co-located same-role participants dominating the discussion in order to achieve the same level of task performance as in face-to-face communication. Four-person groups with no role-differentiation had remarkably similar patterns of communication in face-to-face and multimediated conditions. It appears that the crucial difference is the *interaction* of the technology with the heterogeneity of participant roles. These roles could be considered analogous to the status differences investigated in studies of text conferencing.

Study rationale

The best test of status might be to examine the effects of organisationally assigned status differences in workplace group communication, much of which occurs during business meetings. In organisations as compared to the laboratory, meeting participants have a greater investment in the group (which is generally an established group); the group's effectiveness has implications for the wider organisation to which it belongs and to which it has to answer; and senior group members or leaders are usually responsible for the group's performance, hence will have a higher stake in the group's success than group leaders in the lab. Furthermore, workplace group leaders usually have a substantial amount of power and authority: they can override the consensus recommendation of group members; can select among different recommendations; promote group members; change rewards; and terminate membership of the group (Barkhi *et al.*, 1998), behaviours which do not exist or have a much lesser impact in the lab.

If we wish to investigate the impact of communications technology on status-differentiated groups in the field, it is necessary to examine the use of technology which is currently utilised in organisations. Text-based conferencing, unlike multimedia technology, is not widely used for business meetings. Therefore, this research examines the effects of multimedia conferencing technology and organisational status levels on the communication patterns in workplace groups. Mixed- and same-status audio conferencing groups, and mixed-status groups communicating face-to-face are compared. An attempt to gather examples of status-undifferentiated face-to-face meetings and video conferences was unsuccessful.

Study Hypotheses

Since this field study employs communication analyses which differ from previous investigations of status differences and technology, but similar to those carried out in lab studies 1 and 2, the hypotheses draw on the findings of the lab studies of multimedia communication technology. It is expected that multimediation will have a similar effect on communication patterns when organisational status differences rather than experimentally manipulated role differences are investigated. The research hypotheses are:

- mixed-status group participants are expected to contribute less equally to meetings than peers
- high-status group members are expected to be the ones who dominate interactions
- technology-mediation is expected to exaggerate status inequalities.

Studies in the field are valuable as they have real-world validity but they cannot have the same level of controlled conditions as in the laboratory which can make drawing conclusions more problematic. Establishing success of communication outcome is also difficult and was not possible in this study.

5.2 Method

Data

At the research lab of a large telecommunications company in the UK, appeals for volunteers to take part in a study of communications technology comparing audio conferencing with face-to-face meetings were circulated via an internal email system and leaflets handed out in the staff restaurant. This approach proved successful for gathering data, especially considering the time constraints and the difficulties of gaining access to business meetings; factors such as these tend to necessitate small sample sizes in field studies. Seventeen collaborative business meetings using three different media were audio recorded and analysed - six face-to-face meetings, two telephone audio conferences and nine audiographic PC conferences using BT's Conference Call Presence™ application. No examples of video-mediated meetings were gathered due to the infrequency with which these took place.

Technological set up

Audio conferences used an open channel audio link via the telephone network. Conference Call Presence™ includes file transfer, shared whiteboard and application sharing capabilities. Other tools and capabilities available in Presence™ are not described here as the analyses have focused on the communication process rather than data sharing, however, further details are available on the web site at: http://presence.conferencing.bt.com/presence/ index.html

Meeting profiles

Participants in audio conferences were, for the most part, genuinely physically distributed either between offices, buildings, towns or countries. Participants mainly used their own PC to take part in audio conferences but there were one or two instances in the larger audio conferences of two participants sharing a PC site.

The meetings, which have between three to eight participants, consist of team progress reviews, co-ordinating the writing of a research proposal, and preparing a presentation, and last from half-an-hour to three-and-a-half hours (mode length is three hours, mean length is two hours). In total over thirty-five hours of data were collected. The meeting profiles are summarised Figure 5-1.

The majority of the meetings took place between people who were not members of the same 'team' in the sense that they do not work together with the other meeting participants outside of the meeting. Usually meeting participants functioned as members of separate teams carrying out related work.

Background information specific to each meeting or series of meetings is given here in order to set the social context in which the meetings took place. The amount of information available varies between meetings.

Audio peer 1

This series of four meetings between three geographically dispersed senior managers all took place within a four week period as the deadline approached for their slide presentation to senior management regarding IT strategy. Prior to the recording of the first meeting analysed here, these three individuals had been holding audio conferences once or twice a week for four months.

Audio peer 2

Three colleagues in different parts of the same building held an impromptu audio conference to make changes to a technical project report they had been working on together.

Audio peer 3

The mixed nationality participants in this series of two meetings were working together to write a research proposal for a pan-European project. The first meeting had taken place face-to-face (not recorded) two weeks prior to the first audio conference. The second audio conference occurred another two weeks later. All meetings were to co-ordinate the writing of this proposal which materialised over the time span of the meetings; drafts of the proposal were commented on during the meetings.

Audio peer 4

This was also a mixed nationality telephone conference to co-ordinate a research project proposal. There had been three previous meetings in the preceding two months.

Audio status 1

These two audio conferences are instances of monthly management team meetings between seven individuals, four of whom were from same department. They occurred three months apart with the intervening monthly meetings not having been captured. The meetings followed an on-line agenda mainly concerned with tracking work progress. Future meetings were planned at current meetings. There was some sharing of conference sites between attendees.

Audio status 2

Seven out of nine members of the team took part in this monthly management team meeting which focused on the budget and organisational programmes. Two pairs of attendees shared conference sites due to shortage of equipment installed with the conference software.

Audio status 3 and Face-to-face 2

This team, which was geographically distributed around England, usually met face-to-face once per month for a meeting to update one another on work progress and decide upon future work. One example of their face-to-face meetings (face-to-face 2) which took place approximately one month after the audio conference was also recorded. They were using Conference Call Presence™ for the first time for this type of meeting, although some participants had used the technology before for other meeting purposes. They followed an agenda.

Audio status 4

This was a monthly team review meeting of employees working on separate but related research projects. They discuss finance and procurement plans among other work-related topics and plan the date of their next meeting.

Face-to-face 1

This was a one-off face-to-face meeting called to present current work projects to a new manager in order to inform him and to persuade him to continue the team's funding.

Face-to-face 2

See audio status 3.

Face-to-face 3

This meeting was one example of a monthly review meeting of individuals who are reporting on the progress of their various projects to their manager. Their projects were related but mostly independent of one another.

Face-to-face 4

This is an example of a monthly meeting of a geographically dispersed team following a set agenda. The participants had the same set of clients but different responsibilities which supported each other. There had been some re-organisation within their department and they wanted to discuss how this would affect the group. They take turns at hosting the meetings and travelling.

Face-to-face 5

This monthly research project meeting was intended to reach better understanding between team members with two very different areas expertise both relevant to the project. They discussed field research and ideas for the implementation of a database to aid information sharing.

Face-to-face 6

This fortnightly project review meeting occurred at the end of the year in order to check progress of various documented action points.

Status structure within the organisation

In order to understand the organisational context in which these groups operate, the philosophy on management structure within the organisation was ascertained from interviews with employees. A shallower management structure was adopted by this company in the early 1990s, with a move away from terms such as 'manager' to job titles that are intended to minimise the perception of status differences. Offices have recently become open plan with minimum differentiation between employees of different status levels in terms of desks and seating position and dress has become more casual. These steps have generally been taken by organisations because of an awareness of the negative impact on productivity and innovation of obvious status differences.

The meetings consist of mixed- and same-status groups. Mixed-status groups are ones in which a team leader was responsible for decision making. All face-to-face meetings involved mixed-status groups. An appeal for face-to-face meetings between peers was unsuccessful; these tended to happen informally over coffee or at people's desks rather than during formal meetings, therefore meeting participants may have felt these were not relevant or suitable for the study. The two telephone conferences both had three participants of equal status. The telephone conferences were 'multimedia' in the sense that documents were consulted by participants on PCs simultaneously to the conference call. Five of the audiographic conferences were amongst peers and four of these form a series of meetings between the same three participants, the data from these meetings were therefore averaged for inclusion in the analyses. The remaining four audiographic conferences were mixed-status.

There were between three and five organisational status levels represented by the attendees in face-to-face meetings and between three and four status levels in mixed-status audio conferences. The majority of both types of meeting had three different levels of organisational status. In all meetings with a status hierarchy, the highest status member, the 'manager' or 'team leader', ranked only one organisational status level above the member with the second highest status.

Figure 5-1 Meeting profiles

meeting name	meeting purpose	length of meeting	number of participants	number of status levels	total contributions (words)	number of meetings in series
face-to-face 1	overview of research for new team leader	1 hr 10 mins	4	3	11,448	1
face-to-face 2*	team review meeting	3 ½ hrs	5	3	44,255	1
face-to-face 3	team review meeting	2 hrs	8	5	18,945	1
face-to-face 4	team review meeting	3 hrs	6	3	32,027	1
face-to-face 5	project meeting	2 hrs 20 mins	8 (9)**	4 (5)**	26,753	1
face-to-face 6	team review meeting	1 ½ hrs	8	4	13,612	1
audio status 1	team review meeting	1 hr 20 mins	7	3	12,752	1
audio status 2	team review meeting	1 ½ hrs	7	3	14,922	1
audio status 3*	team review meeting	2 ½ hrs	6	3	21,273	1
audio status 4	team review meeting	2 hrs	8	4	18,275	1
audio peer 1	slide presentation preparation	4 x 3 hrs	3	1	79,064	4
audio peer 2	document preparation	½ hr	3	1	4012	1
audio peer 3 (phone conference)	writing research proposal	1 hr	3	1	9582	1
audio peer 4 (phone conference)	writing research proposal	1 hr	3	1	10,115	1

*These two meetings involved the same team of individuals (in face-to-face meeting 2, one member was absent).

** In face-to-face meeting 5, which had nine participants, one participant did not speak at all during the meeting. This person was a non-native English speaker and, being a student, had the lowest status in the group. It was ascertained through conversation with other meeting participants that this person never contributed to such meetings as his comprehension of English was so poor that he had difficulty following the discussion. Because of these exceptional circumstances, this person was excluded from the analyses which are now based on eight rather than nine participants and four rather than five status levels.

Henceforth, the two types of audio conference - telephone and PC - will not be referred to separately as the analyses did not focus on this differentiation, but on that of technology-mediation versus face-to-face communication and mixed- versus same-status groups.

Communication analyses

All face-to-face meetings were audio recorded onto two channels of a Sony Walkman using PZM desk microphones. Audio conferences were recorded using a telephone recorder operated by the researcher at her own site while she listened in to the meeting. The face-to-face meetings were also video-taped using a single camcorder to film as many participants as possible to aid in speaker identification.

All meetings were orthographically transcribed by an audio typist and were checked thoroughly and coded for interruptions by the researcher. In face-to-face meetings, speaker identification was not problematic due to the ability to refer to video recordings of the meetings. In the larger audio conferences, feedback contributions (all one word turns) were the only problematic area with at most two percent of all turns left unidentified. Overlapping speech was transcribed without great difficulty due to the high quality of recordings. Back channel contributions, such as 'mhm' and 'uhuh' were included in the transcripts.

Detailed communication analyses were carried out in a similar way as for the laboratory research: the individual contribution rates in terms of words spoken, turns taken and interruptions made were calculated, and the patterns of interaction were examined including the order of speaker exchanges, sequences of exchanges (pairwise conversations) between pairs of participants, and the number of such conversations initiated by different individuals. (For a detailed description of these analyses refer to chapters 3 and 4). Such analyses can reveal meeting formality and equality of participation and influence between contributors, as will be described in detail in the following sections.

Additional measures were required in this study in order to make direct comparisons between meetings of different lengths and group sizes, therefore 'equality of participation' scores (based on numbers of words contributed) and 'freedom of interaction' scores (based on the predictability of the order of speaking turns) were also calculated. These analyses will also be explained in the next sections.

Equality of participation

In a discussion, some individuals speak more than others; one determinant of how much a person says is her or his organisational status - the higher her or his status, the more she or he says (e.g. Bales, 1950; Carletta, Garrod and Fraser-Krauss, 1998). The benefits of individuals contributing similar amounts to meetings, such as parity of influence over the proceedings and better quality decisions, have already been discussed in the introduction to this chapter. In this analysis, and in other studies (e.g. Stephan and Mishler, 1952; Stasser, 1988; Weisband *et al.*, 1995; Straus, 1997; Carletta, Garrod and Fraser-Krauss, 1998), equality of participation refers to how equally people contributed to the discussion in terms of the number of words uttered by each participator.

The specific technique employed here for comparing meetings (described below) was developed by Carletta, Garrod and Fraser-Krauss (1998) to deal with comparisons between business meetings which have status hierarchies and different numbers of participants. It is similar to indices of equality of participation used by other researchers (e.g. Stephan and Mishler, 1952; Weisband *et al.*, 1995; Straus, 1997) which, for various reasons, were not considered to be suitable for this field study. Straus (1997) and Weisband *et al.* (1995), for example, compared groups of equal sizes in the lab whereas group size in this study varies from three to eight. The method of Stephan and Mishler (1952) is not deemed appropriate for groups in which there are procedural constraints on participation (Stasser, 1988), such as organisational status differences, which are present in meetings analysed here.

The following analyses compare six face-to-face meetings where the participants had status differences, four audio conferences where there were status differences and seven[1] audio conferences in which the participants were 'peers'. Due to small sample sizes, the data from the two types of audio conference (telephone conferences and audiographic PC conferencing) have been collapsed for analysis. Also due to the small N, non-parametric statistics have been used.

The research hypotheses are

- the amount contributed to discussions will vary most between participants in status-differentiated meetings
- technology-mediation will exaggerate this effect.

In other words, audio conference participants who are peers will contribute the most equally to discussions whereas those who are of mixed status will contribute least equally.

5.3 Statistical analyses

For each meeting, the number of words spoken by each person and the average number of words spoken were calculated. Then a score was computed for each meeting based on the distance between the actual number of words spoken by each participant and the number expected had they all participated equally[2]. The resulting score is between 0 and 1 - it is 0 if all participants say the same amount and 1 when one person does all the talking (Carletta, Garrod and Fraser-Krauss, 1998), thus indicating how evenly talk is distributed between meeting participants. If one or more individuals dominate in a meeting, this will be reflected in the score.

---

[1] Four of these meetings form a series between the same participants therefore the average of these meetings has been used in the following analyses giving an N of 4 status-undifferentiated audio conferences.

[2] The formula for equality of participation is taken from Carletta *et al.* (1998) who describe the calculations in the following way: 'let E represent $(\Sigma_{p\in P} W_p)/|P|$, the total number of words spoken by participants in a meeting divided by the number of participants. In groups with completely equal participation, each participant says E words. Observe that $\Sigma_{p\in P} ((W_p-E)^2/E$ reflects average distance from equal participation because it is 0 if all participants speak equally and $E\,|P|(|P|-1)$ at its maximum, where one person says all words in the meeting. Therefore, we used the formula $1-(\Sigma_{p\in P} ((W_p-E)^2/E))/E|P|(|P|-1)$ to scale the scores between 0 and 1, with better equality of participation represented by scores at the higher end of the scale.' (Carletta *et al.*, 1998, pp. 556).

The meetings were ranked from one to fourteen (the number of meetings in the comparison), the meeting with the lowest equality score was given a rank of one, the next lowest score a rank of two, and so on, with the highest scoring meeting being assigned a rank of fourteen. The mean ranks were calculated for the three types of meeting and these were compared using a Kruskal-Wallis ANOVA (see Table 5.1 for the mean ranks).

Table 5.1 Equality of participation mean ranks and scores

	Mean rank	**Mean score (SD)**
audio conferences between peers	10	0.953 (0.040)
status-differentiated face-to-face meetings	7.8	0.927 (0.032)
status-differentiated audio conferences	4.5	0.872 (0.051)

The difference between how evenly participants contributed to the three sorts of meeting was found to approach statistical significance (KW=5.76, N=14, **p** <.1. Critical value at **p**<.05 is 5.99). The mean ranks in Table 5.1 reveal a trend towards participants of equal status contributing the most similar amount of words to meetings while participants in status-differentiated audio conferences contribute the least equally to meetings. Nonetheless, participants in all meeting types contribute relatively equally to discussions; as the mean scores in Table 5.1 show the scores are all fairly close to the maximum score of 1 which indicates complete parity between contributors (0 indicates a monologue).

It appears that technology-mediation somehow magnifies the effect of status on how much participants contribute to the discussion. It is assumed that the highest status members skew the pattern of interaction by dominating the talk in the status-differentiated meetings, although this will be tested in later analyses.

Other measures of equality of participation

Not only can dialogues be analysed in terms of how many words are contributed but they can also be broken down into how the words are distributed in turns throughout the discussion. Group discussions tend to consist of a series of turns or conversations between pairs of individuals with some pairs of speakers dominating the talk, that is, the order in which people contribute to a conversation is generally quite predictable. If some pairs of speakers rarely or never address each other it is thought that mutual understanding between them will be low, hence less predictable sequences, in which group members are more likely to speak to any other participant, are said to be more informative. Such sequences are also said to have higher entropy (Carletta, Garrod and Fraser-Krauss, 1998). Information theory utilises the concept of entropy (Cherry, 1966) and it has been applied to many types of analysis, including that of participation in brainstorming groups (Ruback, Dabbs and Hopper, 1984).

Since adjacent speaking turns tend to be relevant to each other, it is possible to examine how often each pair of meeting participants address each other by calculating how many times they speak after one another. These data are used to calculate how unpredictable or unconstrained the interaction is[3]. The resulting scores are between 0 and 1; 0 indicates the interaction is at its most predictable, i.e., whenever some speaker has just spoken, the same person always speaks next,

[3] The formula for calculating freedom of interaction is taken from Carletta, Garrod and Fraser-Krauss (1998). The freer the interaction in a meeting, the less predictable it is who will speak next given who spoke last. We can use the relative frequencies of each of the possible pairs of adjacent speakers to calculate this predictability. They state that: 'If $S_{a,b}$ was the number of times that speaker **b** spoke immediately after speaker **a**, and T_b was the total number of times **b** spoke after anyone in the meeting, then the entropy H of the meeting is given by: $H=-\Sigma_{Sa,b}(S_{a,b/}\ T_b)\log_2(S_{a,b}\ /T_b)$. H is 0 whenever some speaker has just spoken, the same person always speaks next, and is at its theoretical maximum if the interaction is at its most free - that is, if whenever some speaker has just spoken, everyone else has an equal chance of speaking next. This maximum varies with the size of the meeting and is equal to $-n \log_2(1/(n-1)^2)$, where n is the number of participants in the meeting. Therefore, it was possible to score a meeting for freedom of interaction by subtracting H from the maximum possible for a meeting of that size and dividing by that maximum. This yielded a score between 0 and 1 where 0 is the most free interaction and 1 the most predictable. We then subtracted this score from 1 so that it reflected freedom and not predictability of interaction.' (Carletta *et al.*, 1998, pp. 556). NB This means that 0 now represents the most predictable and 1 the most free interaction.

and 1 represents interaction at its most free, that is, whenever some speaker has just spoken, everyone else has an equal chance of speaking next. This measure is referred to as the 'freedom of interaction' of a meeting, or the unpredictability of a data sequence (Carletta, Garrod and Fraser-Krauss, 1998).

In status-differentiated groups it is expected that high-status members will be over-represented in the two-person conversations in a discussion, thus the interaction in such meetings will be less free or more constrained than in meetings where the participants have similar organisational status. It is predicted that technology-mediation will magnify the impact of status, such that interaction will be become even more constrained due to the absence of non-verbal cues which facilitate co-ordination of speaker exchange in face-to-face meetings.

Freedom of interaction

For each meeting, how often all the different pairs of speakers addressed each other was calculated and these data were used to score the meetings for how freely all the speakers interacted, as already described. The statistical comparison was carried out in a similar way as for the scores of equality of participation: all the scores are ranked from one to fourteen, the lowest score being assigned a rank of one and the highest score a rank of fourteen. The mean ranks for the three types of meeting were calculated and compared by means of a Kruskal-Wallis ANOVA. The amount of freedom, or the unpredictability, in the order of speaker contributions was found to differ significantly between the three groups ($KW=6.16$, $N=14$, $\mathbf{p}<.05$), yet multiple comparisons failed to reveal significant differences between the meetings.

Table 5.2 Freedom of interaction mean ranks and scores

	Mean rank	Mean score (SD)
audio conferences between peers	9	0.393 (0.047)
status-differentiated face-to-face meetings	8.8	0.386 (0.084)
status-differentiated audio conferences	4	0.290 (0.045)

However, the mean ranks and scores given in Table 5.2 show that when status differences are present in audio conferences, the interaction is more constrained than when peers are communicating. Furthermore, mediating status-differentiated meetings with technology appears to cause interactions to be more constrained than when communication is face-to-face. The patterns of speaker exchanges in audio conferences between peers and in face-to-face meetings appear very similar, which could indicate that audio conferencing technology does not make turn-taking much more predictable than does status in face-to-face meetings, although differences in the average group size in the two types of meeting could be responsible for this result. It can be seen from the mean scores that the interaction is moderately constrained in all meetings, scores cluster around the end of the scale which indicates the most predictable pattern of contributions to a meeting.

These results are generally supportive of the predictions. Technology-mediation combined with the presence of a status hierarchy increases the predictability in how often the different pairs of participants address each other; conversations tend to be dominated by the same pairs of group members. Perhaps the absence of visual cues which aid speaker transition makes it more difficult for other participators to break into the discussion. The more constrained the interactions, the more difficult information sharing among discussants may be which can have negative implications for reaching mutual understanding.

In the above analyses, the comparison of how equally speakers contribute words to the discussion in the different meeting contexts approaches statistical significance, as do the multiple comparisons of how constrained the interaction is. As already indicated, the sample sizes in this field study, as in most field studies, are fairly small. Siegel and Castellan (1988) state that '*failure to reject H_o* ***does not imply*** *that H_o may be accepted and that there are no differences between groups. When the sample sizes are small, only relatively large differences are detected by our statistical procedures which lead to rejection of H_o. .... If H_o is not rejected, then there in fact may be no differences between the groups - or the sample sizes may be so small and/or the variability in the sample so large and/or the true difference so small that true differences can not be detected. Before* ***accepting*** *H_o in such cases the researcher should seek corroborating evidence or obtain additional data.*' (pp. 210). Hence small sample size provides a reasonable explanation as to why some comparisons did not reach statistical significance.

Summary of equality and freedom of interaction results

The results appear to support the experimental hypotheses that the technology would exaggerate the inequality in the amount of words uttered by speakers of different status levels and that the pattern of speaker interaction would be most constrained in status-differentiated audio conferences. They provide equivocal support for the hypothesis that mixed-status group participants would contribute less equally and freely to meetings than peers since, despite this pattern of results having been found, group size is a confounding factor. Not only is the participation more unequal in status-differentiated audio conferences in terms of words contributed but the turn-taking sequences are more predictable or 'less free' than in face-to-face meetings. The possible implications of this will be discussed later on in this chapter.

Status and communication technology appear to have a somewhat greater impact on how often all the different pairs of speakers address each other (the freedom of interaction) than on the equality in the amount they say. Audio conferencing technology makes discussions between individuals of varying organisational status, on average, almost 25% more constrained than those who interact face-to-face (when comparing the mean 'freedom of interaction' scores of status-differentiated audio conferences and status-differentiated face-to-face meetings shown in Table 5.2). Whereas technology-mediation leads to participation which is 6% less evenly distributed amongst mixed-status participants than in face-to-face meetings (when comparing mean 'equality of participation' scores shown in Table 5.1). In addition, there is a greater effect of status on the pattern of turn-taking than on the amount contributed by participants. The contributions in audio conferences are 8.5% less evenly distributed when speakers are of mixed-status rather than same-status, whereas the interaction is 26% more constrained between mixed- than between same-status participants (when comparing the mean scores of status-differentiated audio conferences and audio conferences between peers).

In sum, multimedia technology (as exemplified by audio conferencing with shared applications) can support moderately free speaker interaction and highly equal participation rates between people of equal organisational status, at least when group size is small (mean N=3). However, the impact of a status hierarchy - more constrained speaker interactions and less parity in speaker participation rates - is exaggerated when combined with technology-mediation.

Further analyses of equality of participation

The above analysis of equality of participation between participants in audio conferences and face-to-face meetings provides general support for the hypothesis that audio conferencing technology combined with status negatively affects the equality with which people contribute to meetings. In order to seek corroborating evidence for this trend, another way of measuring equality was developed. This involves examining the number of contributions made by each participant. The person who contributes most and the person who contributes least to the meeting are identified, then the amount said by the former participant is divided by the amount said by the latter to give a ratio of difference. When the contributions are fairly evenly spread or 'equal' between discussants, the difference between these two individuals will be smaller than when the contributions are less evenly spread or less equal. The different types of meeting of various lengths and group sizes can be compared using these ratios. Not only can the difference be calculated for number of words uttered but for number of speaking turns, pairwise conversations engaged in and initiated, and the number of words uttered in these conversations.

The inspiration for these analyses comes from two sources: Carletta, Garrod and Fraser-Krauss's (1998) paper which looks at managerial dominance in real-world business meetings by comparing the amount of various types of contributions made by the manager with that of other participants; and Straus's (1997) distribution of participation measure which compared how many words were spoken by the most and least dominant participants in face-to-face and text-based CMC groups.

It is predicted that the following analyses will confirm that

- there is greater variation in the amount participants contribute to status-differentiated meetings
- multimedia technology will make this status effect even more pronounced.

Distribution among meeting participants of words spoken

For each meeting, the number of words spoken by the person who said the most was divided by the number of words uttered by the person who said least to give a ratio of difference. The meetings were ranked, the meeting with the smallest ratio was given the rank of one, the next smallest a rank of two, and so forth with the biggest ratio being given a rank of fourteen. The mean ranks were calculated for the three meeting types and were compared using a Kruskal-Wallis ANOVA. A significant difference in how equally people contributed to the three meeting types was found (KW=10.41, N=14, **p**<.01).

Table 5.3 Number of words spoken: mean ranks and mean ratios of difference between highest and lowest contributors

	Mean rank	Mean ratio (SD)
audio conferences between peers	3	2.1 (0.8)
status-differentiated face-to-face meetings	8	17.2 (26.3)
status-differentiated audio conferences	11.25	226.5 (368.4)

Multiple comparisons reveal that audio conferences with status differences show statistically significantly greater variation in the amount contributed than audio conferences between peers ($|11.25-3|=8.25$, critical value=6.3, **p**<.05, one-tailed). Multiple comparisons with face-to-face meetings did not reach statistical significance. As shown in Table 5.3, the most dominant individual in status-differentiated audio conferences said, on average, over two hundred times more words than the least dominant individual. The extent of this dominance is about ten times greater than that found in face-to-face meetings and about a hundred times greater than in audio conferences between peers. This analysis confirms that participation is least equally distributed, in terms of words spoken, in mixed-status group meetings and that multimedia communication technology tends to lead to even greater status inequality. The most equal distribution of participation is in same-status meetings.

Distribution among participants of speaking turns

The next analysis focuses on the number of speaking turns contributed to meetings by participants. Although there are differences between meeting types in the how evenly speakers contribute words to the discussion, the way in which talk is distributed in speaking turns throughout the discussion could be similar, that is, the distribution of turns taken by speakers could vary little across meeting types. It is expected that the distribution of speaker turns will be similarly affected by status and technology-mediation as number of words, that is, the presence of a status hierarchy will cause greater variation between speakers in the amount of turns they contribute and communication technology will exaggerate this effect.

The greatest number of turns taken by a participant was divided by the least number of turns taken by a participant for each meeting. The resultant ratios were then used to rank meetings from one to fourteen from the smallest to the largest ratio. The mean ranks were compared using a Kruskal-Wallis ANOVA. The meeting types also differ significantly on this measure of equality ($KW=13.3$, $N=14$, $p<.01$).

Table 5.4 Number of speaking turns: mean ranks and mean ratios of difference between highest and lowest contributors

	Mean rank	**Mean ratio (SD)**
audio conferences between peers	4	1.6 (0.29)
status-differentiated face-to-face meetings	7.7	8.6 (10.7)
status-differentiated audio conferences	11.75	82.5 (125.6)

Multiple comparisons reveal that audio conferences with status differences have a significantly greater disparity between number of speaking turns taken by contributors than audio conferences between peers ($|11.75-4|=7.75$, critical value=6.3, $p<.05$, one-tailed). The comparisons with face-to-face meetings did not reach statistical significance. The mean ratios in Table 5.4 show that in status-differentiated audio conferences, the most dominant participant takes, on average, around eighty times more turns than the least dominant participant. This dominance is almost ten times higher than that of the highest contributor in face-to-face meetings, and over fifty times higher than in audio conferences where participants have equal status. The most equal distribution of turns is in same-status meetings. Again, technology-mediation tends to increase the status imbalance in how much speakers contribute.

Hence, the above analyses of the distribution of words and turns amongst group members confirm the trend revealed by the equality of participation scores, and confirm the experimental hypothesis that use of audio conferencing technology results in even less equality in how much speakers of varying organisational status contribute to meetings.

Influence and control over discussion

A further type of analysis based on an examination of speaking turns focuses on the order and pattern of speaker contributions. Carletta, Garrod and Fraser-Krauss (1998) argue that since adjacent contributions in group discussions are related by their relevance to each other, it is possible to identify sequences of three or more exchanges which form a conversation between pairs of participants - a 'pairwise conversation' - by counting the number of times each participant speaks before or after each other participant. They and other researchers (such as Parker, 1988; and Stasser and Taylor, 1991) maintain that group discussion is typically made up of a series of these pairwise conversations. This type of analysis was also used in studies 1 and 2.

A group member can dominate proceedings through, for instance, greater involvement in floor exchanges or pairwise conversations. This is because patterns of floor exchange (turn-taking) are quite predictable in the following way: the current speaker 'hands the floor' to the next speaker, who is disproportionately likely to be someone who has contributed recently (Steinzor, 1955; Dabbs and Ruback, 1987; Parker, 1988), and contributions are expected to be relevant to the preceding ones. Therefore, whoever predominates in pairwise conversations should have some degree of control over the proceedings (Carletta, Garrod and Fraser-Krauss, 1998). Furthermore, the person who initiates most pairwise interactions is likely to have most influence over the meeting content and information flow: the initiator sets the context for subsequent exchanges, usually by introducing a new topic, asking a question or making a suggestion. This is then responded to with a relevant contribution from the second speaker, which is reacted to by the first speaker, and so on (Bales, 1951; Schegloff, 1968; Carlson, 1983; Carletta, Garrod and Fraser-Krauss, 1998).

The following analyses examine how evenly participants take part in and initiate pairwise conversations in face-to-face meetings and status-differentiated audio conferences. The more parity between contributors, the more equal their control over the discussion should be. It is hypothesised that if higher status group members are dominating interactions as has been found previously (e.g. Bales, 1950), there will be a greater difference between the amount of influence participants have over the discussion in status-differentiated meetings. An even greater difference is predicted in technology-mediated status-differentiated meetings due to the absence of non-verbal cues making it more difficult for lower status group members to break into the conversations.

Influence and control over discussion: dominance in pairwise conversations

For each meeting, the number of pairwise conversations taken part in by each speaker was calculated and the highest and lowest contributors were identified. The difference between the number of conversations these two individuals took part in was calculated in the same way as for the preceding analyses (the highest number is divided by the lowest number to give a ratio). As before, all meetings were ranked from lowest to highest ratio and the mean ranks of the three meeting types were compared using a Kruskal-Wallis ANOVA. The meeting contexts were found to differ significantly in how equally speakers took part in conversations ($KW=11.6$, $N=14$, $\mathbf{p}<.01$).

Table 5.5 Pairwise conversations engaged in: mean ranks and mean ratios of difference between highest and lowest contributors

	Mean rank	Mean ratio (SD)
audio conferences between peers	3	1.3 (0.11)
status-differentiated face-to-face meetings	7.7	14.7 (24.8)
status-differentiated audio conferences	11.75	45.1 (39.9)

Multiple comparisons reveal that mixed-status contributors in audio conferences have significantly less equal influence over the flow of the discussion than same-status audio conferencing participants ($|11.75-3|=8.75$, critical value=6.3, $p<.05$, one-tailed). Multiple comparisons with face-to-face meetings did not reach statistical significance. The mean ratios in Table 5.5 show that in status-differentiated audio conferences the most dominant individual takes part in, on average, forty-five times more pairwise conversations than the least dominant individual. This dominance is around three times greater than in face-to-face meetings and around thirty-five times higher than in same-status audio conferences. These analyses suggest that the amount of influence and control which contributors have over the flow of information in meetings is least egalitarian when there are status differences amongst participants who are using communications technology to interact, thus confirming the prediction.

Distribution among participants of words uttered in pairwise conversations

The above analysis shows that participants in status-differentiated audio conferences have the most variable amounts of influence over meetings when comparing their involvement in pairwise conversations. However, the amount said during these conversations may not be unequally distributed. The existence of status differences is expected to result in influence being unequally shared between individuals (in terms of the amount said in conversations) to a greater extent than in same-status meetings, and technology-mediation is expected to exaggerate this impact of status.

To discover whether this is the case or not, the number of words said by each person during pairwise conversations was calculated and the most and least dominant individuals in each meeting were compared. The difference between the highest and lowest contributors was calculated as before, and the meetings were ranked from smallest to largest ratio. The mean ranks were compared using a Kruskal-Wallis ANOVA and the three types of meeting were found to differ significantly (KW=12.7, N=14, **p**<.01).

Table 5.6 Words uttered in pairwise conversations: mean rank and mean ratio of difference between highest and lowest contributor

	Mean rank	Mean ratio (SD)
audio conferences between peers	2.75	2.2 (0.95)
status-differentiated face-to-face meetings	7.7	19.5 (26.2)
status-differentiated audio conferences	12	289.1 (372.8)[4]

Multiple comparisons reveal that in audio conferences participators with status differences have significantly more disparity in influence than peers in audio conferences (|12-2.75|=9.25, critical value=6.3, **p**<.05, one-tailed). As can be seen from Table 5.6, the most dominant individuals in status-differentiated audio conferences say, on average, two-hundred-and-ninety times more words during pairwise conversations than the least dominant individuals. Their dominance is almost fifteen times greater than in face-to-face meetings and around one hundred-and-thirty times greater than in technology-mediated peer meetings. Thus, these analyses show that the disparity in amount of influence and control between

[4] This calculation excludes data from audio status meeting 3 in which the lowest contributor took part in zero pairwise conversations.

participants is greatest in status-differentiated audio conferences and lowest in audio conferences between peers, both in terms of the amount participants say during pairwise conversations and the number of such conversations in which they engage. The difference in mean group size must however be borne in mind when interpreting these findings.

Influence over flow of information in meetings: initiation of pairwise conversations

The preceding comparisons suggest that there is a difference between meeting types in how evenly meeting attendees influence proceedings in terms of the amount of pairwise conversations in which they take part. It is also possible to identify who initiates a sequence of three or more exchanges with another group member. This can provide a finer measure of equality of influence and control over information exchange since the conversation initiator tends to set the topic under discussion. It is hypothesised that status will also lead to greater inequalities in the amount of control meeting participators have over the initiation of conversations and that audio conferencing technology will lead to even more status inequality.

The number of times each participant initiated a pairwise conversations was counted and for each meeting the distance between the most and least dominant initiators was calculated as a ratio. These ratios were used to rank meetings from lowest to highest ratio in the same way as before. The mean ranks of the three meeting types were compared using a Kruskal-Wallis ANOVA and a significant difference in how equally participants initiated conversations was found ($KW=11.3$, $N=14$, $\mathbf{p}<.01$).

Table 5.7 Number of pairwise conversations initiated: mean rank and mean ratio of difference between highest and lowest contributors

	Mean rank	Mean ratio (SD)
audio conferences between peers	3.25	1.9 (0.76)
status-differentiated face-to-face meetings	7.3	11.3 (12.4)
status-differentiated audio conferences	12	33.9 (5.5)[5]

Multiple comparisons reveal that mixed-status participants in audio conferences differ significantly more in their influence over conversations than same-status technology-mediated participants ($|12-3.25|=8.75$, critical value=6.3, $p<.05$, one-tailed). The multiple comparisons involving face-to-face meetings do not reach statistical significance. The highest contributor in status-differentiated audio conferences initiates on average around thirty-four times more than the lowest contributor. This variation is three times higher than in face-to-face meetings and around eighteen times higher than in audio peer meetings (see Table 5.7). Thus this analysis also shows less equality in control and influence over discussion proceedings between status-differentiated speakers and technology-mediation makes this effect even more pronounced.

The results of the above three indices of equality of control and influence in meetings (pairwise conversations engaged in and initiated, and number of words spoken during such conversations) converge to show that there is indeed a tendency for audio conferencing technology to exaggerate the impact of status negatively affecting the parity between speakers in their control over the direction and flow of the discussion.

[5] This calculation excludes data from audio status meeting 2 in which one person initiated no pairwise conversations.

Summary of equality of participation and influence analyses

The preceding analyses have compared the communication process of status-differentiated speakers in face-to-face meetings and audio conferences and speakers of homogenous status in audio conferences. A variety of indicators were employed to explore the equality between meeting participants in the amount they contribute to and influence the flow of the interaction. It was hypothesised that

- mixed-status participants would take part in and influence the discussion less equally than same-status participants
- the patterns of interaction of status-differentiated participants would be less free compared to those of peers
- the technology would increase the above-described impact of status hierarchies on communication

The analyses converge to reveal a coherent pattern of results. Meetings were first compared by means of scores incorporating data from all meeting participants: an equality of participation score, derived from the parity in number of words speakers contributed, indicates that the difference between meetings in how equally speakers participate approaches statistical significance (**p**<.1). The other score shows that how freely participants interacted, or the freedom with which all the different pairs of speakers addressed one another, differs significantly between contexts (**p**<.05). The direction of differences was as expected, participants in audio conferences interacted most freely and equally in meetings with their peers. Unfortunately, it is not clear whether the smaller group size in these meetings or the lack of status differences is responsible for these results. In audio conferences where a manager or team leader was present, one individual tended to dominate the discussion.

The extent to which one individual dominated the discussion and the effect of status and technology-mediation on this was explored by calculating the difference in the number of contributions made by the most and least dominant participators in each meeting. Technology-mediation of mixed-status groups made the domination by one individual even more pronounced than in face-to-face meetings in terms of the number of words spoken, the number of speaking turns taken, and involvement in and initiation of pairwise conversations (all **p's**$<.01$). Therefore, not only does this person say the most but he or she also directs the flow of the discussion most through his or her participation in pairwise exchanges. This approach confirms that equality is lower between technology-mediated group members than between face-to-face group members of heterogeneous status. Although equality was greatest between group members of homogenous status in audio conferences, it must be borne in mind when interpreting this finding that these groups were of a smaller size than the status-differentiated groups (mean N=3 in peer meetings, mean N=7.5 in status-differentiated audio conferences and mean N=6.5 for face-to-face meetings). Thus the pattern of findings is generally supportive of some of the experimental hypotheses. However, the above analyses do not tell us *who* is dominating discussion in the meetings in which there are status levels.

Managerial dominance in meetings with organisational status differences

As outlined earlier, organisational status is one factor which affects participation rates in business meetings: the highest status member dominates (Carletta, Garrod and Fraser-Krauss, 1998). The analyses carried out thus far have shown that the presence of a status hierarchy in business meetings does indeed influence participation rates, however, they do not indicate if it is the highest status individual who dominates the discussions. For this reason, further comparisons were carried out on the status-differentiated meetings. The measures used are those employed by Carletta, Garrod and Fraser-Krauss (1998) in their field study: for each meeting, the contributions of the highest status participant are compared with those of the average participant in terms of the number of words uttered, speaking turns taken, and pairwise conversations engaged in and initiated. It is hypothesised that:

- highest status members will contribute more to the meetings than the average participant in number of words and turns
- highest status members will dominate in number of pairwise conversations engaged in and initiated, i.e., they will have more control over the meeting

- this dominance will be higher in technology-supported groups than in face-to-face communication.

The following analyses are based on comparisons of six face-to-face and four audio conferences with status hierarchies. In the first analyses, the raw data were examined to verify the identity of the highest contributor in all meetings. The number of meetings in which the manager did and did not dominate were compared by means of a Fisher exact probability tests for all four measures of equality and influence to see if the distributions of meetings in which the highest status contributor did and did not dominate differed significantly for face-to-face and audio conferences.

Number of words uttered

In all of the audio conferences in which there is a status hierarchy, the highest status member is the individual who says the most words, but in two of the six face-to-face meetings it is a junior group member who dominates (as shown in Table 5.8). In face-to-face meeting 1, a participant with the lowest status utters the most words and in face-to-face meeting 5 a participant with the second lowest status says the most. A Fisher exact probability test on this rather small data set (N=10) shows that face-to-face and audio conferences do not differ statistically significantly in how often the managers do and do not dominate in terms of number of words uttered (**p**= 0.333, 1 tailed).

Table 5.8 Number of meetings in which manager says the most words

	manager dominates	**manager does not dominate**
face-to-face meetings	4	2
audio status-differentiated meetings	4	0

Number of speaking turns taken

Similarly, in all status-differentiated audio conferences the most senior participant takes the most speaking turns, but in two of the six face-to-face meetings (as seen in Table 5.9) - face-to-face meeting 5 and face-to-face meeting 4 - a junior member dominates by taking most speaking turns. However, a Fisher exact probability test shows that face-to-face and audio conferences do not differ statistically significantly in how often the manager does and does not dominate in terms of number of turns taken ($\mathbf{p} = 0.333$, 1 tailed).

Table 5.9 Number of meetings in which manager takes the most turns

	manager dominates	**manager does not dominate**
face-to-face meetings	4	2
audio status-differentiated meetings	4	0

Influence and control over the discussion

In terms of who has the most influence and control over the meeting proceedings, a similar pattern of results is found. Upon examination of the number of pairwise conversations engaged in, the most senior member was found to be the most influential in all of the status-differentiated audio conferences, whereas in three out of six face-to-face meetings a junior group member dominated (see Table 5.10). In face-to-face meeting 4, in which there are three different levels in the status hierarchy, a participant with the middle status level dominated. In face-to-face meeting 5 with four different levels of status, it is a participant with the second lowest status level who engaged in the most conversations. A Fisher exact probability test shows that face-to-face and audio conferences do not differ statistically significantly in how often the managers do and do not dominate in terms of the number of pairwise conversations in which they engage ($\mathbf{p} = 0.83$, 1 tailed).

Table 5.10 Number of meetings in which manager engages in most pairwise conversations

	manager dominates	manager does not dominate
face-to-face meetings	3	3
audio status-differentiated meetings	4	0

Number of pairwise conversations initiated

For another measure of the influence and control meeting participants have, initiation of pairwise conversations, the findings are similar. In all status-differentiated audio conferences the senior member dominates, whereas in three of the face-to-face meetings this is not the case (see Table 5.11). In face-to-face meeting 1, the most junior member initiated most pairwise conversations, in face-to-face meeting 5 it was the second lowest status member, and in face-to-face meeting 4, it was the participant with the middle status level. A Fisher exact probability test shows face-to-face and audio conferences do not differ statistically significantly in how often the managers do and do not dominate in terms of the number of pairwise conversations they initiated (**p** = 0.83, 1 tailed).

Table 5.11 Number of meetings in which manager dominates in pairwise conversations initiated

	manager dominates	manager does not dominate
face-to-face meetings	3	3
audio status-differentiated meetings	4	0

Although the most senior member in a meeting dominates more often in audio conferences than in face-to-face meetings in terms of words uttered, turns taken, and pairwise conversations engaged in and initiated, these distributions do not differ statistically significantly between media (when N =10).

The previous analyses have shown that there is a tendency for less equality in status-differentiated audio conferences than in face-to-face meetings. These analyses reveal that in these audio conferences it is the most senior member who dominates on all four indices of equality and influence, whereas for face-to-face meetings the dominant contributor is not always the highest status member and is in fact sometimes the lowest status member. The statistical comparisons of the distributions of face-to-face and technology-mediated meetings with and without a dominant manager were not however significant, although this may be attributable to the rather small data set.

Managers' dominance in status-differentiated audio conferences and face-to-face meetings

From the above data, it seems that the managers dominate in the majority of meetings. Furthermore, the analyses carried out thus far have shown that status-differentiated speakers in audio conferences tend to participate less equally than in face-to-face meetings. Therefore, manager dominance is expected to be significantly higher in audio conferences than in face-to-face meetings.

In the following analyses, the amount contributed by the average participant is calculated by summing the contributions of all participants (excluding those of the highest status member) and dividing by the number of those participants. Then the amount said by the manager is divided by that of the average participant to give a ratio of difference which can be used to compare the two types of meeting which are of different lengths and sizes. Next, the meetings are ranked by ratio, the lowest ratio is ranked one, the second lowest is ranked two, and so forth with the highest ratio having a rank of ten (since ten is the number of meetings in the sample). For both types of meeting, the ranks are summed and compared by means of a Wilcoxon-Mann-Whitney test. These calculations were carried out to investigate manager dominance in words uttered, turns taken, and pairwise conversations engaged in and initiated.

Managers' dominance in words spoken

The dominance of the manager with regards to the number of words he (all were men) contributes is nearly significantly higher in audio conferences with status differences than in face-to-face meetings as revealed by a Wilcoxon-Mann-Whitney test (W_x=30, *m*=4, *n*=6, **p**=.0571). As can be seen in Table 5.12, there is a tendency for managers to say, on average, four times more than the average participant. This 'dominance effect' is almost twice as large as that found in face-to-face meetings. This confirms that managers' dominance tends to be exaggerated when communication is technology-mediated.

Table 5.12 Words spoken: managers' dominance over average participant

	Median rank	**Mean ratio of difference (SD)**
face-to-face status-differentiated meetings	4	2.1 (1.1)
audio status-differentiated meetings	8	4.0 (1.1)

Managers' dominance in speaking turns taken

The manager is also expected to dominate more in audio conferences than face-to-face meetings in terms of the distribution of his participation, i.e., the number of turns taken. A Wilcoxon-Mann-Whitney test reveals that managers' dominance in audio conferences is nearly significantly higher than in face-to-face meetings in terms of the number of speaking turns taken (W_x=30, *m*=4, *n*=6, **p**=.0571). Table 5.13 shows that the highest status participant takes, on average, almost three-and-a-half times more turns than the average participant. This dominance is one-and-a-half times greater than his dominance in face-to-face meetings.

The above analyses confirm that the highest status member tends to be more dominant in technology-mediated meetings than in face-to-face meetings in terms of words and speaking turns contributed. They also show that the less even participation of speakers in status-differentiated audio conferences is indeed due to the dominance of the highest status group member.

Table 5.13 Turns taken: managers' dominance over average participant

	Median rank	Mean ratio of difference (SD)
face-to-face status-differentiated meetings	3.5	2.1 (1.2)
audio status-differentiated meetings	7.5	3.4 (0.4)

Managers' influence and control over discussions

It might be predicted that whoever predominates in pairwise conversations will have more control over the discussion. Another measure of influence is the proportion of pairwise conversations initiated by a participant, and this was also calculated. Preceding analyses in this field study have revealed that there is more inequality of influence in status-differentiated audio conferences than in status-differentiated face-to-face meetings. In most meetings it is the manager who is dominating. It is expected, therefore, that managers will have more influence and control in audio conferences than face-to-face meetings, in terms of the amount of pairwise conversations they engage in and initiate. These comparisons can show the relative inequalities in the amount of influence over the discussion process that participants of different status have.

Managers' dominance in pairwise conversations

Similar to the method described earlier, the average number of pairwise conversations engaged in by participants is calculated, then the amount engaged in by the manager is divided by that of the average participant to give a ratio. The ratios are used to rank the meetings from one to ten (lowest to highest). The ranks are summed separately for each type of meeting and compared using a Wilcoxon-Mann-Whitney test which reveals that the managers' dominance in audio conferences is nearly significantly greater than in face-to-face meetings (W_x=30, m=4, n=6, p=.0571). As shown in Table 5.14, the highest status participant in audio conferences engages in, on average, over three times more pairwise conversations then the average participant. This dominance is one-and-a-half times greater than in face-to-face meetings. As expected, managers tend to have greater control and influence over the discussion in technology-mediated than in face-to-face meetings.

Table 5.14 Pairwise conversations engaged in: managers' dominance over average participant

	Median rank	**Mean ratio of difference (SD)**
face-to-face status-differentiated meetings	3.5	2.1 (1.2)
audio status-differentiated meetings	7.5	3.2 (0.33)

Managers' dominance in pairwise conversations initiated

The same comparison was carried out for the amount of pairwise conversations initiated. A Wilcoxon-Mann-Whitney test reveals that managers initiate nearly significantly more pairwise conversations than the average group participant compared to face-to-face meetings (W_x=29.5, m=4, n=6, p=.0714). In Table 5.15, it can be seen that the highest status participant in audio conferences initiates, on average, nearly five times more pairwise conversations than the average participant. This managerial dominance is more than one-and-a-half times greater than in face-to-face meetings. This confirms that the highest status group member tends to control and influence discussions to a greater extent in technology-mediated workplace communication than in face-to-face communication.

Table 5.15 Pairwise conversations initiated: managers' dominance over average participant

	Median rank	Mean ratio of difference (SD)
face-to-face status-differentiated meetings	3.5	2.8 (2.1)
audio status-differentiated meetings	7.5	4.9 (1.8)

Summary of managerial dominance

The above analyses were intended to explore the extent of managerial dominance in meetings in terms of how much they contribute to and how much they influence the flow of the discussion. Firstly, it was predicted that managers or 'team leaders' would contribute most to meetings. This was found to be true for the majority of meetings although this was not the case for all of the face-to-face meetings, some of which were dominated by lower status individuals. It was also predicted that status-differentiated audio conferences would have greater managerial dominance than face-to-face meetings since equality of participation tended to be lower in these meetings than in face-to-face meetings. The data reveal an overall tendency for the highest status group member to dominate to a greater extent in technology-mediated compared to face-to-face discussions in terms of number of words, turns, and pairwise conversations engaged in and initiated, thus supporting the experimental hypotheses.

Interruptions

Another possible index of the influence and seniority of team leaders is the way in which they take turns of speaking, one indicator of which is interruptions. Senior participants in a meeting may rarely be interrupted by other more junior speakers who wish to show respect and politeness. High status individuals may also be sufficiently confident to interrupt their subordinates. In the following analysis of the frequency of interruptions, these hypotheses will be tested:

- managers will interrupt more than other speakers
- managers will be interrupted less than other speakers
- these effects will be exaggerated in audio conferences.

Interruptions by managers and other participants

The number of interruptions made by the average speaker was calculated then the number of interruptions made by the manager was divided by that of the average participator to give a ratio for each meeting. The meetings were ranked from one to ten by size of ratio and the ranks were summed separately for face-to-face meetings and status-differentiated audio conferences. A Wilcoxon-Mann-Whitney test revealed that in audio conferences managers do not interrupt statistically significantly more than the average group participant compared to face-to-face meetings (W_x=26, *m*=4, *n*=6, **p**=.2381). As Table 5.16 shows, the highest status group member does make, on average, over two-and-a-half times more interruptions compared to the average participant in both technology-mediated and face-to-face discussions. However, there is no statistically significant difference between face-to-face and audio conferences contrary to expectations that this status effect would be exaggerated by the communication technology.

Table 5.16 Number of interruptions: managers' dominance over average participant

	Median rank	**mean ratio of difference (SD)**
face-to-face status-differentiated meetings	4.5	2.6 (2.1)
audio status-differentiated meetings	7.5	2.8 (1.1)

Interruption rate of managers and the average participant

The percentage of own turns interrupted was calculated for the most senior member and for the average participant in each status-differentiated meeting. It was expected that the highest status group member would be interrupted at a lower rate than the average participant and that the manager would be interrupted at an even lower rate in audio conferences than in face-to-face meetings.

For each meeting, the manager's interruption rate was divided by that of the average participant and the resultant ratios were used to rank the meetings, as before. A Wilcoxon-Mann-Whitney test (W_x=20, m=4, n=6, **p**<.3810) did not reach statistical significance, indicating that there is very little difference between face-to-face and mediated meetings in the rate at which managers are interrupted compared to the average participant. The mean ratios in Table 5.17 show that managers' turns were in fact interrupted slightly less than average in face-to-face meetings and only slightly more than average in audio conferences. Therefore the experimental hypothesis that managers in technology-mediated meetings would be interrupted even less than other participants than in face-to-face meetings is rejected.

Table 5.17 Rate interrupted: managers' dominance over average participant

	Median rank	**mean ratio of difference (SD)**
face-to-face status-differentiated meetings	6.5	0.96 (0.4)
audio status-differentiated meetings	4	1.1 (0.5)

It was hypothesised that managers would interrupt more, and would be interrupted less, than the average participant and that this would be exaggerated in audio conferences compared to face-to-face meetings. The data are inconclusive with respect to how frequently managers interrupt and are interrupted.

Summary of managerial dominance

The preceding analyses compared status-differentiated meetings via face-to-face communication and audio conferencing technology for the extent of dominance by the highest status participant. Predictions were as follows:

- highest status members will dominate meetings in terms of the number of contributions they make
- highest status members will contribute more to the meetings than the average participant in number of words and turns and will dominate in number of pairwise conversations engaged in and initiated
- this dominance will be higher in technology-supported groups than in face-to-face groups
- managers will interrupt more than the average participant and this will be exaggerated in audio conferences
- managers will be interrupted less than the average participant and this will be exaggerated in audio conferences

The analyses tend to confirm that it is indeed the highest status individual who is the key person dominating discussions. In both contexts they say, on average, a higher ratio of words and turns, and engage in and initiate more pairwise conversations than the average participant. As regards the evidence that multimedia technology tends to magnify these differences, comparisons with face-to-face communication approach statistical significance for numbers of words and turns contributed, and pairwise conversations engaged in (**p's** = 0.0571) and initiated (**p** = 0.0714). The small sample size (N=10) could be the reason for the marginal significance of some comparisons. In general, the pattern shows that the highest status member in a meeting dominates the proceedings in the amount they contribute to and the extent of their influence over the discussion to a greater extent in technology-mediated than in face-to-face meetings.

Formality of mediated communication

The final analysis was carried out to try to replicate a fairly robust finding from other studies that in technology-mediated communication that there are fewer interruptions compared to face-to-face communication (e.g. O'Conaill *et al.*, 1993; Sellen, 1995). This is explained as being due to the greater formality of communication channels with restricted visual cues. Therefore, it was expected that there would be a significantly higher rate of interruptions in face-to-face meetings than in audio conferences.

Interruption rate in different types of meetings

In order to compare meetings of different lengths, the rate of interruptions was calculated as the percent of turns which contain interruptions. As the interesting comparison on this measure is between face-to-face and technology-mediated meetings, all the audio conferences (N=8) were combined into one category for comparison with face-to-face meetings (N=6). All meetings were ranked from lowest to highest interruption rates and the two meeting types were compared using a Wilcoxon-Mann-Whitney test. The difference between the summed ranks was almost statistically significantly higher for face-to-face meetings than for audio conferences (W_x=58, *m*=6, *n*=8, **p**=.0539).

Table 5.18 Interruption rate in different types of meetings (% turns interrupted)

	Median rank	Mean rate (SD)
audio conferences	4.5	17.8% (14.1)
face-to-face meetings	9.5	31.5% (5.0)

More interruptions were indeed found in face-to-face meetings than in audio conferences in which there were differing status levels; the comparison approached statistical significance. The face-to-face meetings contained a 75% greater proportion of interrupted turns than audio conferences (see Table 5.18). The high mean rank for audio conferences, shown in Table 5.18 was attributable to two peer meetings in which two of the three participants were non-native speakers of English - the high interruption rate in these meetings would seem to suggest difficulty in co-ordinating speaker exchange. Hence, there is general support for previous findings that face-to-face communication is less formal than mediated communication, as shown by proportion of interruptions.

5.4 Discussion

Multimedia communications technology is currently being utilised for group communication in organisations, yet a review of the literature has revealed a lack of field studies into its effects. In particular, little is known about how it impacts status-differentiated groups. This field study was designed to address these issues. It examined the patterns of communication and influence in seventeen business meetings comparing two different communication media - face-to-face communication and audio conferences - and the effects of organisational status differences. Three types of meeting were compared - status-differentiated face-to-face and audio conferences and status-undifferentiated audio conferences. An attempt to record examples of status-undifferentiated face-to-face meetings to complete the comparison was unsuccessful. Although field research cannot be as tightly controlled as laboratory experiments it has the advantage of high ecological validity meaning results may be more widely applicable.

From existing experimental research it was possible to predict two contrasting patterns of results. From the findings of text-based CMC lab research one might have predicted that multimedia communications technology would either equalise or have a minimal effect on status inequalities and that groups would be able to communicate as effectively in either medium. On the other hand, findings from lab studies of multimedia audio and video technology presented in this thesis suggested that technology would exaggerate inequalities in groups with heterogeneous roles or status. This prediction was the one which was adopted for the following reasons: the pattern of interaction analysis is similar to that employed in this field study, and both the lab and field studies use synchronous multimedia communications technology (although of different kinds). In this naturalistic study, it was hypothesised that

- participation and influence would be less equal between speakers who are status-differentiated compared to those who are peers
- high-status group members would dominate interactions
- speakers of different organisational status would interact less freely than those of similar status
- audio conferencing technology would exaggerate status inequalities.

The starting point for the meeting analyses was an established method of communication analysis which includes calculation of the individual contribution rates in terms of words spoken, turns taken and interruptions made (as used by O'Conaill *et al.*, 1993; Sellen, 1995; and Anderson *et al.*, 1997, among others). This enables the patterns of interaction to be examined, including the order of speaker exchanges, sequences of exchanges between pairs of participants (pairwise conversations), and the number of such exchanges initiated by different individuals (as carried out by Carletta, Garrod and Fraser-Krauss, 1998). This technique can be very informative, as has been shown already in lab studies 1 and 2, when the communication of groups as opposed to dyads is under investigation. Such analyses can reveal, for instance, equality of participation and influence between speakers, and meeting formality.

In addition, other existing innovative methods were employed, equality of participation scores (based on numbers of words contributed) and freedom of interaction scores (based on the predictability of the order of speaking turns) which allow direct comparisons to be made between meetings of different lengths and group sizes (Carletta, Garrod and Fraser-Krauss, 1998). These methods show how evenly distributed contributions are between participants and how freely they exchange turns with one another.

It was necessary, however, to devise new techniques to analyse the field data, which are by their very nature non-standard, in order to support the other analyses. Equality of participation and influence amongst meeting attendees were ascertained by comparing how evenly distributed between speakers different types of contributions were, specifically, the difference between the number of contributions by the highest and lowest participators was calculated for each meeting. The dominance of high-status group members was revealed by comparing managers' contributions with those of the average participant.

The data analysis approach adopted has proven to be very informative and the results of the variety of analyses carried out converge to indicate that there is general support for the experimental hypotheses that high-status group members would dominate interactions and audio conferencing technology would exaggerate status inequalities. Participation and influence are unequally shared between participants of mixed-status groups; the highest status member contributes most to the discussion and also appears to have the greatest control over the flow of the discussion. Technology-mediation further exaggerates this inequality and tends to increase the dominance of the highest status individual. There were also differences in how often all the different pairs of speakers addressed one another (the predictability of speaker order): presence of status differences resulted in speakers exchanging turns less freely in technology-mediated meetings. Freer interaction is seen as desirable as it has been associated with participants reaching mutual understanding more easily, and hence being more co-ordinated in their goals (Clark and Wilkes-Gibbs, 1986; Clark and Schaefer, 1989; Clark and Brennan, 1991), and it is also said to be more informative (Carletta, Garrod and Fraser-Krauss, 1998). Less free interaction in status-differentiated audio conferences could therefore be problematic for group understanding and consensus.

Unfortunately, comparisons with the audio conferences between peers are confounded by systematic differences in group size between these meetings and face-to-face meetings and mixed-status audio conferences. It has been found, for example, that smaller groups interact more freely and equally than larger groups (e.g. Bales, 1955; Carletta, Garrod & Fraser-Krauss, 1998). This confound was unavoidable due to the nature of field data over which the researcher has less control but which can allow greater generalisability of results than laboratory studies. Therefore, although it was found that peer groups interacted more freely and equally than the other types of group examined, it is unclear whether the presence or absence of status differences amongst meeting participants or group size is responsible for this finding.

The final analysis carried out confirmed a frequently found effect of technology-mediation on communication: audio conferences tend to have a lower proportion of interruptions than face-to-face revealing that the style of multimediated communication is indeed more formal.

To summarise, although the techniques employed are complex and novel and, characteristically of field studies, the sample size small, this field study has revealed statistically significant effects of two influential factors - status and technology - on equality of participation and influence, and freedom of interaction. In accordance with the experimental hypotheses, organisational status influences the patterns of interaction in both face-to-face meetings and audio conferences such that the highest status participant contributes more and has greater influence and control over the meeting than the average participant. However, technology-mediation appears to exaggerate the dominance of the highest status member found in face-to-face meetings. These results confirm the findings of Carletta, Garrod and Fraser-Krauss's (1998) field study which found that high-status group members in face-to-face business meetings have more influence than the average participant and are more dominant. Even in organisations which are trying to minimise status differences within the organisation, such as the one involved in this field study, the constraints of status hierarchies are still apparent in group communication.

This study's finding that rich multimedia communications technology can exaggerate the effect of status is in contrast to the impact of text-based communication technology which has been found by various authors to have little or no effect on status-differentiated group communication (Benbasat and Lim's 1993 meta analysis; Silver *et al.*, 1994; Weisband *et al.*, 1995; Barkhi *et al.*, 1998, 1999), or to reduce the dominance of the high-status group member (Dubrovsky *et al.*, 1991). It also contradicts the conclusions of Harmon *et al.*'s

(1995) lab study of audio communication which state that there were no differences between status hierarchy and leader influence in audio conferencing and face-to-face status-differentiated groups of students for subjective measures of equality and influence. There are two possible reasons for the differences between this study's results and those of Harmon *et al.*: 1, Harmon *et al.*'s data were derived from subjective indices of status and influence which may not have been sensitive enough to show status differences which were revealed in this field study through detailed analysis of communication patterns; 2, the status differences Harmon *et al.* investigated may not have been as sensitive to communication mode since they were not organisationally assigned but had developed during the course of student project work. Furthermore, groups' existing status hierarchies were ignored: assigned leaders had not always been the 'leader' in the past.

The findings of this field study are given further weight by the fact that they converge with those of the controlled laboratory studies described in chapters 3 and 4 which found that inequality between group members in role-differentiated communication was exaggerated in multimedia video and audio communication in terms of how much they said, and that mode of communication did not affect the overall participation rates of groups of peers. Thus, the effect of role differences in the lab appears to have a similar effect to status differences in the field, although this is not to say that role and status are analogous.

There are both positive and negative implications of the findings of this field study for communication effectiveness. There are situations in which unequal participation may be beneficial. Vroom and Yetton (1973) maintain that if knowledge or good ideas are unevenly distributed between group members, time to make a decision is limited, or acceptance of a decision by group members is not critical, then equality of participation may be inefficient. A more dominant individual serving as a leader can also help the group focus attention and facilitate group consensus (Hiltz *et al.*, 1986). Furthermore, Farris (1973) found that the most innovative teams were not those which were most democratic but those in which the leader exerted a moderate amount of control.

Possible negative implications of the findings presented here are as follow. In a discussion there is competition for the floor yet turn-taking tends to proceed in a predictable fashion- the next speaker is usually handed the floor (non verbally in face-to-face communication) by the current speaker, and the next speaker is much more likely to be someone who has recently spoken (Dabbs and Ruback, 1987; Parker, 1988; Steinzor, 1955). What is said next is also constrained since contributions are expected to be relevant to the preceding ones. We know that the highest status members tend to be the ones dominating in terms of turns taken and initiation of pairwise conversations - as such they have a disproportionate amount of control over who speaks next and over the relevance of subsequent contributions. This can make it more difficult for lower status members to contribute information, hence status could inhibit information sharing in groups. Not sharing information is problematic for certain types of group, such as problem-solving and innovative groups, which rely on open and unconstrained information sharing (Carletta, Garrod and Fraser-Krauss, 1998), therefore, the performance of these types of group could be poorer in status-differentiated audio conferences than in face-to-face meetings, and poorer in meetings with defined status hierarchies than in peer meetings. With regards to the business meetings investigated here, as is often the case with field data, performance measures were unobtainable; to the extent that the majority of meetings were team review meetings in which members report on their progress, unequal participation may not have been a great barrier to effective communication.

Implications for the design of multimedia communication technology for groups

The tendency of high-status group members to dominate discussions in meetings, and of communications technology to exaggerate this effect is therefore a challenge to the design of communications technology to support groups. Possible solutions could be to introduce some form of Group Decision Support System (GDSS) to the technology (which could also be used in face-to-face meetings). These are '*a set of techniques, software and technology designed to focus and enhance communication, deliberations and decision making of groups*' (Nunamaker Jr., 1997, pp. 357). Some of the benefits of such a system, identified by El-Shinnawy and Vinze (1997), are a higher number of alternative solutions to problems are considered, and it encourages more equality in participation and in group decision making (Weisband *et al.*, 1995). GDSSs can allow anonymous contributions to be made enabling all members to have a say or vote regardless of their status in the group, thus could be used to establish consensus or opinions when making important decisions. A GDSS could also be combined with other techniques intended for the purpose of reducing status effects in face-to-face interactions, such as brainstorming (de Bono, 1971), or the Stepladder technique (e.g. Rogelberg *et al.*, 1992). To date, however, GDSS systems have been largely text-based, and the ways in which they could support freer communication and interaction in multimedia-supported groups have not yet been explored.

Another possible solution could be to enlist the assistance of a professional meeting facilitator in order to overcome established patterns of communication determined by status. These are already used by some companies to improve the productivity of face-to-face meetings and have been recommended by Carletta, McEwan and Anderson (1998) for technology-mediated meetings. They acknowledge that this may be a costly option but suggest that the facilitator's role could be a temporary one, training group members to overcome the constraints of status on free and equal participation.

Alternatively, or in addition, people could be trained in order to raise their awareness of the effect of status on group communication and to provide them with techniques for overcoming the constraints. Users of multimedia communications technology should be warned of its tendency to exaggerate status inequalities. Mediated groups could perhaps make use of some of the above-mentioned techniques to counteract status constraints when communicating face-to-face, if these are appropriate to the meeting purpose (for example, in innovative and problem-solving meetings when unequal participation could be expected to have negative consequences for group productivity / effectiveness). There is also the possibility of workplace groups developing their own less intrusive methods for overcoming status constraints which could be as simple as agreeing on acceptable ways of breaking into a conversation or curtailing overlong contributions.

It is important to combine research in the field with controlled lab experiments and detailed communication analysis to gain an understanding of the subtleties of mediated multiparty interaction. This will facilitate innovative solutions to its constraints and help us to better support it with new communications technologies.

This field study examining the effects of organisational status and multimedia communication technology on communication patterns in business meetings contributes new and interesting findings to the literature. Not only does it confirm previous findings regarding status constraints on face-to-face meetings, but it reveals a new and surprising finding that multimedia communications technology can in fact exacerbate status constraints. This is in contrast to the results of various CMC studies which have found no combined effect of text-based communication technology and status on communication, or have found technology to equalise status inequalities.

Further research is required in this area to discover the effects of multimedia technology on other types of business meetings such as problem-solving meetings, and to discover how other types of multimedia technology such as video conferencing technology affect status constraints. Furthermore, it would be useful to identify and investigate other barriers to equal participation in addition to organisational status which may also be influenced by technology-mediation. Finally, designers and researchers should investigate whether the techniques suggested for adapting technology and communication can positively influence the impact of status on communication.

6 Chapter 6. Thesis conclusions

The aim of this thesis was to assess the impact of two types of multimedia communications technology, audio and video conferencing, upon the collaboration of small groups. The multimedia contexts differ in one important way, the video context provides a visual channel of communication, thus more closely resembles co-present face-to-face communication.

The literature reviewed in chapter 2 and in the introductions to chapters 3 and 4 showed that there are few studies of multimediated group communication which have involved in-depth analyses of communication process; the majority of such research has focused on dyadic interaction in the lab. The few studies which do exist have tended to be limited in the focus of their analysis, exploring a restricted range of indicators of the communication process and outcome. Another issue that has not received much attention in the literature is the effect of sharing multimedia technology on group interaction, in particular how it affects the patterns of speaker participation and communication effectiveness. The final area in which a lack of research was identified is the impact of multi-channel technology on role and status constraints between members of a group.

6.1 Key results from three studies

Study 1 investigated the impact of sharing high quality video and audio conferencing technology on the task outcome and communication process of three-person groups in a service encounter simulation. The communications technology was unequally distributed with two 'clients' sharing one site in order to communicate with a remote 'travel agent'. The results show that groups performed equally well in the technology and face-to-face conditions with very similar amounts of verbal effort and levels of speaker co-ordination. However, a detailed analysis of the patterns of interaction, which differentiated between technology-mediated and co-present conversations in the audio and video conditions, revealed that co-present, same-role participants interacted significantly more (in turns and words exchanged) in the video context and had a tendency to converse more in audio conferences compared to face-to-face communication. Surprisingly, remote conversations were remarkably stable across communicative conditions. There was an impact of communication medium on how equally speakers contributed to discussions with one of the individuals (playing the role of a client) saying more than the other participants in the technology conditions but not when face-to-face. The patterns of interaction in audio and video conferences were similar - video, at least a small high quality video link, is more like audio than face-to-face communication. For all of these analyses the two conditions which differed most were the video and face-to-face conditions.

A thorough examination of the content and structure of conversations in these two conditions (face-to-face and VMC) using Conversational Games Analysis confirmed that when the third group member was remote, co-present, same-role participants sharing communications technology interacted significantly more to complete the task. It also revealed that significantly more collaborative work in terms of conversational Moves was required in the video condition, and confirmed that partly video-mediated communication did affect the content of the communication leading to more information exchange and giving of instructions on the part of the same-site participants. The structural analysis showed that the co-located group members collaborated with one another significantly more in the video than in the face-to-face context, while the amount of collaboration between remote group members was largely unaffected by context.

The overall finding is that the communications technology impacted the distribution of talk even in a group as small as three people, with the two same-role, co-located discussants becoming more dominant in terms of the mean number of words and turns exchanged, Moves initiated and conversational Games they were jointly involved in, or, to put it another way, in the amount of interactive work they engaged in even though they were co-present. However, sharing a site was confounded with role differences: the same-site speakers played similar roles in the simulation and were familiar with each other, while the remote member had a different role and was unfamiliar. For this reason, study 2 sought to clarify this issue by exploring the effect of shared communications technology on groups whose members had homogenous roles.

In **study 2** peer groups communicating via shared video conferencing technology (with two participants at each of two sites) compared to a round-the-table face-to-face context performed more poorly in a persuasion and decision-making task when required to justify their group's choice. This was despite remarkable similarity in the communication processes of participants in the two communication media: overall, the amount of verbal interaction, the co-ordination of speaker switching, the formality of conversations and the speakers' persuasive behaviour did not differ between the face-to-face and video contexts. Neither did sharing technology affect how equally speakers contributed to the discussion overall compared to face-to-face communication. In addition, the truly video-mediated communication was very similar to the same-site interaction for all of the above measures with one exception, there was an impact upon how actively group members were involved in cross-site video-mediated conversations - one individual at each shared site was verbally dominant in these interactions. Thus, as in study 1, the patterns of participation were affected by partial video-mediation, even when group members had similar roles in the discussion.

Nevertheless, this unequal participation in video-mediated interactions does not appear to explain the poorer VMC performance which was as a result of a larger group of poorly performing individuals than in the face-to-face context. Hence, only some participants were adversely affected in the technology condition and these were not the individuals who were less involved in cross-site talk. An analysis of their communication process revealed that they contributed more, not less, to the overall discussion than the best performers in VMC and said similar amounts to the best performers in the face-to-face condition. This group of users who were negatively impacted in the video context attributed the problems they were having to the technology. However, the analyses show that it was not the technology per se which caused the problem, but more likely their perceptions of communicative difficulties which affected their behaviour and performance; they appear to have talked more and concentrated less on the discussion with the result that their understanding and justifications of their group's decision were poorer.

Comparison of studies 1 and 2

Lab experiments 1 and 2 both investigated the impact of sharing multimedia technology on small group collaboration and communication, the main difference being that in lab 1 there were role and familiarity differences between group members which were absent in the second study. There are similarities and dissimilarities between the findings of the two studies which illuminate the impacts of role and familiarity and communications technology on the communication process.

In both laboratory studies, the sharing of conference sites compared to face-to-face communication had little impact on the overall group communication processes in terms of the amount said and the co-ordination of turn-taking. It was only when the true technology-mediated communication was examined that the effect of technology and participator role on the patterns of interaction became evident. In lab study 1, speakers participated unequally in the technology-mediated sessions but contributed relatively equal amounts to face-to-face conversations. In study 2, the absence of role and familiarity differences between group participants largely equalised the overall contribution rates in the technology context, that is, there was similar (in)equality in the amount speakers said during video and face-to-face discussions. However, removal of role differences did not completely equalise the patterns of participation: in study 2, as in study 1, there was unequal participation in video-mediated conversations with one person at each shared conference site dominating cross-site talk. Thus, sharing of conference sites when participants were peers affected only participation in the video-mediated exchanges but did not affect the overall equality in the amount speakers said. In contrast, in study 1 the combination of sharing technology and role differences between interactors led to greater disparity in their contribution rates, impacting both participation in the discussion as a whole and in mediated conversations. The explanation for the overall inequality in technology-mediated discussions of study 1 is thought to be that perceived difficulties in observing visual cues created a feeling of psychological distance which allowed the ‘clients’ to converse at greater length in order to decide on their holiday destinations without feeling inhibited by the presence of a travel agent. The reason for one person at shared conference sites acting as the main channel of communication for cross-site interaction is less clear cut but may be related to an attempt by speakers to make communication more efficient, avoiding replication of conversations. This skewed participation could have a negative impact on the sharing of information and hence on decision-making in groups (Carletta, McEwan and Anderson, 1998).

The possible effect on communication patterns of asymmetry of access to on-screen data between participants in study 1 has already been discussed in chapter 4. It was concluded that its impact on the communication process variables examined was negligible.

Another variable which differed between study 1 and study 2 was group size: these studies looked at three- and four-person groups respectively. Group size has been found to have an impact on contribution rates such that there is lower equality of contributions between speakers in larger groups (e.g. Bales, 1955; Carletta, Garrod and Fraser-Krauss, 1998). The results found in this thesis show similar parity between speaker contribution rates in four-person and three-person face-to-face groups, while three-party (in study 1), but not four-party (in study 2), mediated groups showed differences between speakers in how equally they participated in conversations. Thus, group size does not appear to have had the expected impact on how equally group members contributed to conversations. Moreover, in these two experiments most other comparisons of the communication process of technology-mediated and face-to-face groups did not differ between three- and four-person groups.

One further difference between the two studies is how the technology affected the pattern of asking questions. In both lab studies, there were no differences in the amount of questions asked overall in face-to-face and video contexts, however, the truly video-mediated behaviour was impacted differently. In the first lab study in this thesis, same-site participants asked one another more questions when the third group member was at a remote site compared to when she/he was in the same room. In addition, the difference in the average number of questions the same-role speakers (co-present in both visual conditions) asked each other compared to different role speakers (remote in VMC) was higher in the video context. In contrast, in the second study a greater proportion of questions were addressed to group members across the video link than to same-site members and this difference approached statistical significance. Hence, it appears that in study 1 the equal roles and familiarity of same-site individuals may have contributed to this greater interactivity between them since the pattern was reversed when speaker roles were homogenous.

One result which differed between studies is attributable to the presence of a noticeably delayed audio signal in the first study; this led to poorer speaker co-ordination (more speaker interruptions) in the technology-mediated exchanges compared to equivalent face-to-face interactions. In study 2, in which there was no delay, there was no such effect. Nonetheless, in lab study 1, there was no impact of the delay on the overall co-ordination of group communication or on another indicator of co-ordination - length of speaking turns - in the audio and video conditions. This seems to indicate that the delay's effect upon co-ordination of turn-taking was limited.

In summary, the communication process is similarly affected by multimedia technology for two different sizes of group (three- and four-party) performing two different tasks (problem-solving and persuasion) with a few exceptions: firstly, multimediation of groups led to more variation in contribution rates of mixed-role members (in study 1) than members of similar roles (in study 2); secondly, the interrogative behaviour of speakers was impacted differently by role manipulations and technology; the third difference is not attributable to the interaction of role and technology but to the presence of a delayed audio signal in the first study. This led to difficulty in speaker co-ordination in video-mediated conversations; in study 2 in which there was no audio delay no such difficulty was encountered.

Although in general the communication processes in both experiments were relatively unaffected by sharing conferencing technology, the outcomes were affected differently by communicative medium. In experiment 2, there was poorer performance in the video condition than in the face-to-face communication condition, whereas in experiment 1 there was no disadvantage of communicating via audio or video conferencing compared to face-to-face interaction. There are various possible explanations: in study 2 there was one more person with whom to exchange information, the demands of the task were different, there was an enforced time limit and a shorter discussion time. Perhaps the most likely explanation is that the combination of one extra participant with the time pressure revealed a disadvantage of this novel medium which was not apparent when participants were not subject to a strictly enforced time limit. (In study 1, groups were given at least half-an-hour to complete the task whereas in study 2 the ten-minute time limit was strictly imposed). Perhaps with a more extended discussion time, or more experience of the medium, VMC would not have shown a disadvantage for some users for communication success in the persuasion task.

A different methodological approach was adopted in **study 3.** Users of multimedia audio conferencing technology were observed engaged in business meetings in their work environment and their interaction compared to face-to-face meetings; the impact of the technology on status-differentiated and status-undifferentiated groups was explored. This extended the investigation of role differences and communications technology in the empirical studies 1 and 2 by focusing on real-world role differences between group participants - organisational status differences - in established work groups.

The research revealed that organisational status influenced the patterns of interaction in both face-to-face meetings and audio conferences such that technology-mediation appeared to exaggerate the impact of status; participants contributed less equally, had less equal influence over the meeting and speakers interacted less freely than in face-to-face meetings. In particular the dominance of the highest status member was increased. Similarly, the first controlled laboratory study found that inequality of participation in role-differentiated ad hoc groups of students was greater in multimedia video and audio than in face-to-face communication, with one dominant individual. In this way, both role and status in controlled and naturalistic environments respectively have been found to interact with multimedia communications technology to affect contribution rates such that group members say less similar amounts when role or status differences are present in a multimediated communication context.

'Breaking into' conversations

Many of the comparisons between groups interacting via different communication media in this thesis, (especially in studies 1 and 2), did not reveal differences in the communication process at the level of dialogue surface structure. It is possible that there were differences of a different or more subtle type reflecting, for instance, the difficulties in trying to gain the floor or take a turn in the conversation. It has been proposed by West *et al.* (1998), for instance, that restricted access (such as might be found in a technology-mediated communication context) to group members' non-verbal cues that can aid turn exchange could make breaking into a conversation more difficult. There are various possible indicators of such difficulties, one of which could be the number of false starts or abandoned attempts to take the floor. Another indicator could be the mean length (in speaking turns or words) of pairwise conversations; these may be longer when there are difficulties for a new speaker in breaking into the discussion, such as might occur in visually impoverished communication contexts like the video and audio conditions in this thesis' research (for example, in the video conditions of studies 1 and 2 presented in this thesis, eye-contact was not possible and the view of gestures was more limited than in face-to-face communication). Furthermore, the asymmetry of access to on-screen data between participants in study 1 could have made it more difficult for the remotely located travel agent to break into conversations between the clients about that data. Such analyses were outwith the scope of this thesis due to time constraints but could prove fruitful areas of investigation for follow-up research into mediated group interaction.

6.2 Relation of findings to theories of mediated communication

How do the results of the three studies reported in this thesis relate to the various theories of mediated communication described in chapter 2? Short *et al.*'s (1976) social presence theory states that technology-mediated communication will have lower social presence then face-to-face communication, however, in study 1 there were no differences in the perceived levels of social presence in audio, video and face-to-face contexts for a problem solving task. In contrast, in study 2 there was higher awareness of presence in across-the-table face-to-face than in video-mediated conversations, thus this experiment provides some support for this approach. Short and colleagues only explicitly state how levels of presence impact communication style, not communication outcome; low social presence is supposed to lead to communication which is less personal, more antagonistic and tightly-focused (these impacts were not investigated in this thesis), but will only have a negative impact in more social tasks, such as negotiation rather than in problem-solving tasks. Therefore it is difficult to interpret the significance of the study 2's performance advantage in face-to-face communication within the framework of this theory.

A theory which focuses on the function of non-verbal cues, the cuelessness theory of Rutter *et al.* (1981; Rutter, 1987), claims that fewer cues will lead to a more stilted style and a more task-centred and impersonal communication content. Indices of communication style that are explored in this thesis are turn length and interruptions which can indicate formality or a stilted style. Contrary to this theory's predictions, there was no difference between face-to-face and video-mediated communication on these measures in lab 2, while in lab 1 more interruptions in video-mediated exchanges were caused by an audio delay. In study 3, mediated conversations did tend to have fewer interruptions showing a more formal or stilted style as Rutter *et al.* would have expected. Thus there is limited support for cuelessness theory provided by the research in this thesis.

According to Kiesler and colleagues (Kiesler *et al.*, 1984; Kiesler, 1986; McGuire *et al.*, 1987; Siegel *et al.*, 1986; Sproull and Kiesler, 1986), a lack of social context cues should lead to more equal participation rates in video and audio conditions. Yet this was not found in any of the three studies, for example in the field study, audio conferencing exaggerated the inequality found in status-differentiated face-to-face meetings.

Neither is grounding theory (Clark and Brennan, 1990) supported by the findings of study 1 which explored mutual understanding in VMC and face-to-face discussions; no differences were found in the use of utterances involved in establishing mutual understanding, contradicting Clark's assertion that grounding should have been more difficult in VMC.

Media Richness Theory (MRT) (Hollingshead, McGrath and O'Connor, 1993) talks about good and poor 'fits' of media and task depending on the information richness provided by the medium and that required by the task. The task in study 1 could be considered to fall under the category of a 'judgement task'. For such a task, face-to-face is supposed to be too rich a medium while video and audio are said to be a good fit. However, it is not clear what aspects of communication process reflect good and poor fits. Communication outcome is supposed to be affected negatively when the medium provides more information richness than the task requires since this distracts from efficient performance, yet there were no performance differences between the audio, video and face-to-face contexts in the first study of group problem-solving.

The persuasion task in study 2 comes under the heading of 'negotiating conflicts of interest' for which video is considered too constrained a medium while face-to-face communication is said to be a good fit. In this case, a communication medium which is too constrained should lead to inferior task performance. VMC did indeed adversely affect performance (at least for some users) but not persuasion, although it is uncertain what predictions the theory would make about the effect on persuasion of communication medium. Hence there is some support for MRT in study 2 but none in study 1.

It is evident that none of the above theories satisfactorily account for all of the findings of the research presented in this thesis. This suggests the inadequacy of existing explanations of how technology-mediation affects the outcome and process of group communication.

6.3 Contributions to the literature on group multi-mediated communication

The series of studies of group collaboration and communication presented in this thesis has focused on three main areas: firstly, the effects on group interaction of different types of multimedia communications technology - audio and video conferencing compared to face-to-face communication; secondly, the impact of sharing such technologies; and lastly, the effect of status and role on multimediated and face-to-face groups. This research has added to the literature in various ways: it has shown the value of combining different methodological approaches and analytical methods; it provides insight into how such technology can exaggerate the constraints of role and status; it confirms that sharing conference sites can create inequality of participation in group discussion; and it reveals a surprising effect of technology-mediation on persuasion.

6.4 Methodological issues

Different types of task and groups have been investigated ranging from newly-formed groups of students participating in simulations of real world tasks in the lab in studies 1 and 2, to real work groups taking part in collaborative business meetings via audio conferencing in study 3. Laboratory simulations allow for tight control of experimental conditions which permit, for example, the efficiency of different communicative modes to be judged. The results of such studies can be nonetheless difficult to generalise to real-life communication, hence the value of combining experiments with research in field settings where the tasks and groups are 'real-world'. By combining these different methodological approaches it has been shown, for instance, that multimedia technology interacts with role and status in its effect on participation equality of group members in both the laboratory and the field for both ad hoc student groups and established business teams.

Laboratory study 1, which explored the impact of sharing audio and video communications technology on small group problem-solving discussions, has made original and interesting contributions to the literature. It has emphasised the value of a multi-faceted analytical approach to give a holistic view of the process and outcome of group interaction and to validate new methods of analysis. For instance, Conversational Games Analysis has been applied to multiparty dialogue for the first time and has been extended to investigate patterns of speaker interaction, that is, who took part in the interactions. The latter analysis has confirmed that two different methods of exploring patterns of interaction, one based on an analysis of turn-taking and the other on the function and content of utterances (CGA), converge in their findings. This analysis of who participated in Conversational Games or units of conversation proved reliable and valuable; it supports claims based on investigations of turn-taking patterns by the likes of Parker (1988), Stasser and Taylor (1991) and Carletta, Garrod and Fraser-Krauss (1998) that conversation is made up of series of exchanges between pairs of participants, and that the same pairs tend to dominate discussions. It has also confirmed that in groups, people tend to communicate mostly in pairs rather than in true group interaction, or in other words, the minority of interaction is true group conversation, thus the study has validated the content-free approach.

Sharing technology

In terms of the impact on interaction of sharing conference sites, study 1 revealed that small groups sharing multimedia communications technology can collaborate as effectively as face-to-face groups for a problem-solving task. Both lab studies reveal that, in general, the group communication process compared to face-to-face communication is relatively unaffected by the sharing of conference sites between two people. Sharing technology does however impact equality of participation in cross-site interaction. Although performance was poorer in the second study, this does not appear to be attributable to this inequality.

Status constraints and multimedia technology

The field study examining the effects of organisational status and multimedia communication technology on communication patterns in business meetings surprisingly has revealed a previously unknown effect: multimedia communications technology can exacerbate status constraints. In contrast, text-based communications technology has been found to either equalise status inequalities (Dubrovsky *et al.*, 1991) or to have no effect on them (e.g. Weisband, Schneider and Connolly, 1995). Studies 1 and 2 support these findings in a controlled environment. The convergence of lab and the field results lends support to the validity of the findings.

VMC and persuasion

In contrast to the belief that a less rich communication medium such as VMC will be less suitable for the demands of tasks involving persuasion (e.g. Short, Williams and Christie, 1976), study 2 has shown that persuasion can be just as effective in video-mediated and face-to-face contexts.

Analytical methods

In addition, the research in this thesis demonstrates the value of detailed dialogue analysis combined with subjective data and measures of communication success, for example sharing technology was revealed to have an impact only through in-depth analysis of interaction patterns; subjective data suggested the reason for poorer performance in study 2; and in the second study, the use of a measure of communication success revealed that despite the very similar communication processes in video and face-to-face contexts, communication was more effective when face-to-face.

6.5 *Applications of research*

The findings reported in this thesis suggest possibilities for future adaptations of multimedia technologies intended to support group communication, and for training users how to use them effectively. Multimedia communications technologies appear to exaggerate the effects of organisational status differences on communication processes in meetings, they also decrease the equality with which different-role speakers contribute to discussions in the laboratory. Various ways of improving this situation have been suggested such as adapting the technology along the lines of a Group Decision Support System (GDSS). Other researchers have already suggested ways of reducing status impacts in face-to-face groups which could also be applied to mediated groups, such as brainstorming (de Bono, 1971) and the Stepladder technique (e.g. Rogelberg *et al.*, 1992), although these methods are rather intrusive as they drastically alter the communication process. The ways in which such adaptations could be applied to mediated group communication merits investigation. Other approaches involve raising user awareness of the difficulties of multimediated group interaction or using, at least temporarily, the services of an outside party such as a professional meeting facilitator to manage the interaction, as suggested by Carletta *et al.* (1998) for technology-mediated meetings, who could also train users how to manage their own meetings more effectively. It could be fruitful to investigate the extent of the intervention and training required to help groups overcome the constraints on their communication.

The results of the first and second studies indicate that the use of shared multimedia communications technology does not seem to have a great impact on small group collaboration and communication. Study 1 indicates the shared use of technology in the service industry, perhaps in the form of a video conferencing booth, is promising as it has little impact on group communication in general and does not adversely affect customer satisfaction. Study 2 confirms that the sharing of a video sites between pairs of group members does not negatively impact the majority of the communication process. It would be interesting to explore how the sharing of multimedia technology between more than two people influences group interaction. However, although sharing of technology is not damaging overall to the group processes it does seems to disadvantage some individuals in terms of the amount they contribute to cross-site conversations, i.e., it reduces how freely all group members interact in both peer and role-differentiated groups. This could have negative implications for information sharing, therefore in situations in which unconstrained interaction is desirable, in innovative meetings for instance, perhaps the sharing of conference sites should be avoided.

6.6 Future directions for research

In this thesis, the effect of role and status have been shown to be exaggerated by multimediation, are there other types of constraints on free and equal participation in discussions that are affected by technological-mediation? Another worthwhile area of research would be to explore techniques and adaptations to multimedia communications technology that could improve its negative impact on patterns of group interaction. The field research presented here could also be extended to investigate how video conferencing affects the communication of groups with and without status differences - does access to visual cues improve the inequality of participation and lower the dominance of high status individuals or have the opposite effect? How does multimediation impact the process and outcome of other types of business meeting such as those with problem-solving and innovation as their major component?

One issue which merits further investigation is how users adapt over time to multimedia contexts, for example, what effect does this have on how equally group members participate? Will the poorly performing individuals in the VMC context of study 2 improve their performance and perceptions of their communication with extended use of the technology? What technological adaptations might help to improve their performance, e.g. a larger video image? Are these individuals utilising their non-verbal behaviour differently and less effectively in mediated contexts? While the lab studies here have examined subjective perceptions of non-verbal cues, these could be investigated using objective measures, for instance, the use of gaze could be explored perhaps by using eye tracking technology.

In summary, this thesis has shown that both multimedia video and audio communications technology have similar impacts on the patterns of speaker contributions in different types and sizes of groups, and that the extent of this is influenced by the presence or absence of role differences between group members.

Examining the ways in which groups are affected by status and multimedia communications technologies has provided some interesting insights into the subtle effects of technology and status on the equality of speaker contributions which may impact the success of communication. This demonstrates the value of such a detailed level of analysis in combination with subjective measures which can help to explicate the reasons behind the patterns of interaction in different communicative contexts. Furthermore, the importance and usefulness of combining different methodologies (laboratory and naturalistic) have been highlighted.

References

Abele, A. (1986). Functions of gaze in social interaction: communication monitoring. Journal of Nonverbal Behavior, 10 (2): 83-101.

Acker, S. R. and Levitt, S. R. (1987). Designing Videoconference Facilities for Improved Eye Contact. Journal of Broadcasting and Electronic Media. 31 (2): 181-191.

Ackerman, M.S., Hindus, D., Mainwaring, S.D and Starr, B. (1997). Hanging on a 'wire: a field study of an audio-only media space, ACM Transactions on Computer-Human Interaction, 4 (1): 39-66.

Adler, R. B., Rosenfeld, L. B., and Towne, N. (1995), 6th edition. Interplay- The Process Of Interpersonal Communication, Fort Worth: Harcourt Brace College Publishers.

Ahlers, K. H., Kramer, A., Breen, D. E., Chevalier, P-Y, Crampton, C., Rose, E., Tuceryan, M. Whitaker, R. T. and Greer, D. (1995). Distributed Augmented Reality for Collaborative Design Applications. Eurographics '95, 14 (3): C-3 - C-14.

Anderson, A. H., Mullin, J., Katsavras, E., Brundell, P., McEwan, R., Grattan, E. and O'Malley, C. (1999). Multimediating multiparty interactions, (pp313-320) Human computer Interaction Interact IFIP TC.13 International Conference on Human-Computer Interaction, 30th August - 3rd September, Edinburgh, UK, Amsterdam: IOS Press.

Anderson, A. H., Mullin, J., Newlands, A., Doherty-Sneddon, G. and Fleming, A-M. (1994). Video-Mediated Communication in CSCW: Effects on Communication and Collaboration. In Workshop on Video-Mediated Communication: Testing, Evaluation, and Design Implications -position papers. (pp. 1-4). Proceedings of CSCW '94 Chapel Hill, North Carolina, 22 October 1994, ACM.

Anderson, A. H., Newlands, A., Mullin, J., Fleming A-M., Doherty-Sneddon, G. and Van der Velden, J. (1996). The impact of VideoMediated Communication on Simulated Service Encounters. Interacting with Computers, 8 (2): 193-206.

Anderson, A., O'Malley, C., Doherty-Sneddon, G., Langton, S., Newlands, A., Mullin, J., Fleming, A. and Van der Velden, J. (1997). The impact of VMC on collaborative problem-solving: an analysis of task performance communicative process and user satisfaction. In Finn, K., Sellen, A. and Wilbur, S. (eds.). Video-Mediated Communication. (pp. 133-156). Mahwah, New Jersey: LEA.

Angiolillo, J. S., Blanchard, H. E., Israelski, E. W. and Mane, A. (1997). Technology Constraints Of Video-Mediated Communication. In Finn, K., Sellen, A. and Wilbur, S. (eds.). Video-Mediated Communication. (pp. 51-74). Mahwah, New Jersey: LEA.

Argyle, M. (1988). Bodily communication. 2nd edition. Routledge.

Argyle, M. and Cook, M. (1976). Gaze and Mutual Gaze. London: Cambridge University Press.

Bales, R. F. (1950). Interaction Process Analysis: A Method For The Study Of Small Groups. Cambridge, Mass.: Addison-Wesley Press Inc.

Bales, R. F. (1955). How people interact in conferences. Scientific American, March: 3-7.

Bales R. F. and Borgatta, E. F. Size of group as a factor in the interaction profile. In A. P. Hare, E. F. Borgatta and R. F. Bales (eds.) (1955). Small Groups: Studies In Social Interaction. New York: Alfred A. Knopf.

Bales R. F., Strodtbeck, F. L., Mills, T. M. and Roseborough, M. E. (1951). Channels of communication in small groups. American Sociological Review, 16: 461-468.

Barber, P. J. and Laws, J. V. (1994). Image Quality and Video Communication. In Damper, R; Hall, W. and Richards, J. (Eds.). Proceedings of IEEE International Symposium on Multimedia Technologies and their Future Applications (pp163-178). London: Pentech Press.

Barkhi, R., Jacob, V. S., Pipino, L., Pirkul, H. (1998). A study of the effect of communication channel and authority on group decision processes and outcomes. Decision Support Systems, 23 (3): 205-226.

Barkhi, R., Jacob, V. S., Pirkul, H. (1999). An experimental analysis of face to face versus computer mediated communication channels. Group Decision And Negotiation, 8 (4): 325-347.

Beattie, G. W. (1978). Sequential temporal patterns of speech and gaze in dialogue. Semiotica, 23: 29-52.

Beattie, G. W. (1979). Planning units in spontaneous speech: some evidence from hesitation in speech and speaker gaze direction in conversation. Linguistics, 17: 61-78.

Beattie, G. W. (1980). The role of language production processes in the organisation of behaviour in face-to-face interaction. In B. Butterworth (Ed.) Language Production. (pp. 69-107). Academic Press.

Beattie, G. W. (1981). A further investigation of the cognitive interference hypothesis of gaze patterns during conversation. British Journal of Social Psychology, 20: 243-248.

Benbasat, I. and Lim, L. H. (1993). The effects of group, task, context, and technology variables on the usefulness of group support systems - a metaanalysis of experimental studies. Small Group Research, 24 (4): 430-462.

Berger, J., Cohen, B. P., and Zelditch, M., Jr. (1972). Status characteristics and social interaction. American Sociological Review, 37 (3): 241-255.

Berger, J.M., Fisek, M.H. Norman, R.Z. and Zelditch, M., Jr. (1977). Status Characteristics And Social Interaction: An Expectation-States Approach. New York: Elsevier.

Birdwhistell, R.L. (1952). Kinesics and Context, University of Philadelphia Press, Philadelphia.

Blau, P. M. and Scott, W. R. (1962). Formal Organizations. San Francisco: Chandler.

Borgatta, E. F. and Bales, R. F. (1953a). Interaction of individuals in reconstituted groups, Sociometry, 16: 302-320.

Borgatta, E. F. and Bales, R. F. (1953b). The consistency of subject behavior and the reliability of scoring in interaction process analysis, American Sociological Review, 18: 566-569.

Bovard, E.W., Jr. (1951). Group structure and perception, Journal of Abnormal And Social Psychology, 46: 398-405.

Boyle, E. A., Anderson, A. M., and Newlands, A. (1994). The effects of visibility on dialogue and performance in a co-operative problem-solving task. Language and speech, 37 (1): 1-20.

Bruce, V. (1996). The role of the face in communication: implications for videophone design. Interacting with Computers, 8: 166-176.

Burke, P. J. (1974). Participation and leadership in small groups. American Sociological Review, 39: 832-843.

Carletta, J., Anderson, A. H. and McEwan, R. (forthcoming). The effects of multimedia communication technology on non-colocated teams: a case study. Ergonomics.

Carletta, J., Garrod, S., and Fraser-Krauss, H. (1998). Placement of authority and communication patterns in workplace groups: the consequences for innovation, Small Group Research, 29 (5): 531-559.

Carletta, J., Isard, A., Isard, S., Kowtko, J., Doherty-Sneddon, G., and Anderson, A. (1995). The coding of dialogue structure in a corpus. In J. A. Andernach, S. P. van de Burgt and G. F. van der Hoeven (Eds), Proceedings of the Twente Workshop on Language Technology: Corpus-based approaches to dialogue modelling, (pp. 25-34), June.

Carletta, J., McEwan, R. and Anderson, A. (1998). Communication in virtual supply chain teams, In G. Jacucci, G.J. Olling, K. Preiss and M.J. Wozny (Eds.) Globalization of Manufacturing In The Digital Communications Era Of The 21st Century: Innovation, Agility, And The Virtual Enterprise (pp. 55-67). Boston: Kluwer Academic Publishers.

Carlson, L. Dialogue Games: An Approach to Discourse Analysis. Dordrecht: D. Reidel, 1983.

Chapanis, A., Ochsman, R. B., Parrish, R. N. And Weeks, G. D. (1972). Studies In Interactive Communication: I The Effects Of Four Communication Modes On The Behaviour Of Teams During Co-operative Problem-Solving. Human Factors, 14 (6): 487-509.

Cherry, C. (1966). On Human Communication: A Review, A Survey, And A Criticism (2nd ed.). Cambridge: MIT Press.

Clark, H. H. (1994). Discourse in production. In M. A. Gernsbacher (ed.) Handbook of Psycholinguistics, (pp985-1021). Academic press.

Clark, H. H. and Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, J. Levine and S. D. Teasely (eds.), Perspectives On Socially Shared Cognition, (pp. 127-149). Washington DC: American Psychological Association.

Clark, H. H. and Marshall C. R. (1981). Definite reference and mutual knowledge. In Aravind K. Joshi, Bonnie L. Webber, and Ivan A. Sag, editors, Elements of Discourse Understanding. (pp. 10-63). Cambridge University Press.

Clark, H. H. and Schaefer, E. (1989). Contributing to discourse. Cognitive Science, 13: 259-294.

Clark, H. H. and Wilkes-Gibb, D. (1986). Referring as a collaborative process. Cognition, 22: 1-39.

Cohen, K. M. (1982). Speaker Interaction: Video Teleconferences Versus Face-To-Face Meetings. In Proceedings Teleconferencing And Electronic Communications, (pp. 189-199). Madison: University of Wisconsin Press.

Dabbs, J. M. and Ruback, R. B. (1987). Dimensions of Group Process: Amount and Structure of Vocal Interaction. Advances in Experimental Social Psychology, 20: 123-169.

Daft, R. L. and Lengel, R. H. (1986). Organizational Information Requirements, Media Richness And Structural Design. Management Science, 32 (5): 554-571.

Daft, R. L., Lengel, R. H. And Trevino, L. K. (1987). Message Equivocality, Media Selection, And Manager Performance: Implications For Information Systems, MIS Quarterly, 11: 355-368.

Daly-Jones, O., Monk, A. and Watts, L. (1998). Some advantages of video conferencing over high-quality audio conferencing: fluency and awareness of attentional focus, International Journal of Human-Computer Studies, 49: 21-58.

De Bono, E. Lateral Thinking for Management, New York: McGraw Hill, 1971.

Doherty-Sneddon, G. Anderson, A., O'Malley, C., Langton, S., Garrod, S. and Bruce, V. (1997). Face-to-face and video-mediated communication: a comparison of dialogue structure and task performance. Journal of Experimental Psychology Applied, 3 (2): 105-125.

Dubrovsky, V. J., Kiesler, S. and Sethna, B. N. (1991). The equalization phenomenon. Human Computer Interaction, 6: 119-146.

Duncan, S., Jr. (1972). Some signals and rules for taking speaking turns in conversations. Journal of Personality and Social Psychology, 23 (2): 283-292.

Dykstra-Erickson, E. A., Rudman, C., Hertz, R., Mithal, K., Schmidt, J. and Marshall, C. (1995). Supporting adaptation to multimedia desktop conferencing. Proceedings of the 15th international symposium on human factors in Telecommunications (pp. 31-38).

Edmondson, W. (1981). Spoken Discourse: A Model For Analysis. London and New York: Longman.

Ellsworth, P. C. and Carlsmith, J. M. (1968). Effects of eye contact and verbal content on affective response to a dyadic interaction, Journal of Personality And Social Psyhology, 10: 15-20.

Ellyson, S. L., Dovidio, J. F., Corson, R. L. and Vinisur, D. L. (1980). Visual dominance behavior in female dyads: siuation and personailty factors, Social Psychology Quarterly, 43: 328-335.

El-Shinnawy, M. and Vinze, A. S. (1997). Technology, culture and persuasiveness: a study of choice-shifts in group settings, International Journal of Human Computer Studies, 47: 473-496.

Exline, R. V., Ellyson, S. L. and Long, B. (1975). Visual behavior as am aspect of power role relationships, In P. Pliner, L. Kramers and T. Alloway (Eds.) Advances in the Study Of Communication And Affect, vol. 2 (pp21-52). New York: Plenum.

Farris, G. F. (1973). The Technical Supervisor: Beyond the Peter Principle, Technical Review 75.

Feldstein, S. and Welkowitz, J. (1978). A chronography of conversation: in defense of an objective approach. In A.W. Siegman and S. Feldstein (Eds.), Nonverbal Behavior And Communication, Hillsdale, NJ: Erlbaum.

Festinger, L. (1950). Informal social communication, Psychological Review, 57: 271-282.

Finn, K. E. (1997). Introduction: an overview of video-mediated communication literature. In K. E. Finn, A. J. Sellen and Wilbur, S. B. (eds.) Video-Mediated Communication, (pp. 3-20). LEA Mahwah, New Jersey.

Fish, R. S., Kraut, R. E., Root, R. W. and Rice, R. E. (1993). Video as a Technology for Informal Communication. Communications of the ACM, 36: 49-61.

Furnace, J., Hamilton, N. M., Helms, P. and Duguid, K. (1996). Medical teaching at a peripheral site by videoconferencing. Medical Education, 30: 215-220.

Fussell, S. R. and Benimoff, I. (1995). Social and Cognitive Processes in Interpersonal Communication: Implications for Advanced Telecommunications Technologies. Human Factors, 37: 228-250.

Gale, S. (1990). Human aspects of interactive multimedia communication. Interacting with Computers. 2 (2): 175-189.

Gale, S. (1991). Adding audio and video to an office environment. In J. M. Bowers and S.D. Benford Studies in computer-supported co-operative work - theory practice and design, (pp. 49-62). Elsevier Science Publishers B.V.: North Holland.

Gergen, K. J., Greenberg, M. S. and Willis, R. H. (eds.) (1980). Social Exchange: Advances In Theory And Research. New York; London: Plenum Press.

Gibbins, K. (1969). Communication aspects of women's clothing and their relation to fashionability, British Journal of Social and Clinical Psychology, 8: 301-312.

Goodman, L. A. and Kruskal, W. H. (1963). Measures of association for cross classifications III: approximate sampling theory, Journal of American Statistical Association, 58: 310-364.

Gowan, J. A., Jr. and Downs, J. M. (1994). Video conferencing human-machine interface: A field study. Information and Management, 27: 341-356.

Green C. A. and Williges R. C. (1995). Evaluation Of Alternative Media Used With A Group Ware Editor In A Simulated Telecommunications Environment. Human Factors, 37 (2): 283-289.

Hare, A. P. (1962). Handbook Of Small Group Research. New York: The free press.

Hare, A. P., Borgatta, E. F. and Bales R. F. (eds.) (1955). Small Groups: Studies In Social Interaction. New York: Alfred A. Knopf.

Harmon, J. (1998). Electronic meetings and intense group conflict: effects of a policy-modeling performance support system and an audio communication support system on satisfaction and agreement, Group Decision And Negotiation, 7: 131-155.

Harmon, J., Schneer, J.A. and Hoffman, L.R. (1995). Electronic meetings and established decision groups: audioconferencing effects on performance and structural stability, Organizational Behavior And Human Decision Processes, 61 (2): 138-147.

Heath, C. and Luff, P. (1991). Disembodied Conduct: Communication Through Video In A Multi-Media Office Environment. (pp. 99-104). In Human Factors In Computing Systems, CHI '91 Conference Proceedings, ACM Press.

Heath, C. and Luff, P. (1992). Media Space and Communicative Asymmetries: Preliminary Observations of Video-Mediated Interaction. Human-Computer Interaction, 7: 315-346.

Hiltz, S. R., Johnson, K. and Turoff, M. (1987). Experiments in group decision making - communication process and outcome in face-to-face versus computerized conferences, Human Communication Research, 13 (2): 225-252.

Hiltz, S. R., Turoff, M. and Johnson, K. (1989). Experiments in group decision making, 3: disinhibition, deindividuation, and group process in peen name and real name computer conferences, Decision Support Systems, 5: 217-232.

Hoecker, D. G., Brown, E. F., Wish, M. And Geller, V. J. (1978). A Behavioural Comparison Of Communication Using Voice-Switched And 'Continuous Presence' Videoconferencing Arrangements . NTC '78, Proceedings Of National Telecommunications Conference, (Pp. 34.2.1-34.2.3).

Hoffman L. R. (1978). The group problem-solving process. In L. Berkowitz (ed.), Group processes, (pp. 101-113). Academic press, Inc.

Hoffman L. R. and Clark, M.M. (1976). Participation and influence in problem solving groups. Paper presented at the Eastern Psychological Association Meetings, New York, April.

Hoffman L. R. and Maier, N. R. F. (1967). Valence in the adoption of solutions by problem-solving groups, II: quality and acceptance as goals of leaders and members, Journal of Personality and Social Psychology, 6: 175-182.

Hollingshead, A. B., McGrath, J. E. and O'Connor, K. M. (1993). Group task performance and communication technology, Small group research, 24 (3): 307-333.

Humphreys, P. and Berger, J. (1981). Theoretical consequences of the status charcterisitcs formulation, American Journal of Sociology, 86: 953-983.

Isaacs, E. and Tang, J. C. (1993). What Video Can And Can't Do For Collaboration: A Case Study. In ACM Multimedia '93 Proceedings, (pp. 199-206). Anaheim, California. ACM.

Isaacs, E. A. and Tang, J. C. (1994). Do Video-Mediated Communication Systems Support Real Conversations? In Workshop on Video-Mediated Communication: Testing, Evaluation, and Design Implications - Position Papers. (pp. 5-10). Proceedings of CSCW '94 Chapel Hill, North Carolina, 22 October 1994, ACM.

Ishizaki, M. and Kato, T. (1998). Exploring the Characteristics of Multi-Party Dialogue, Proceedings of the 36th Annual Meeting of the Association for Computational Linguistics and the 17th International Conference on Computational Linguistics, (pp. 583-589). Universite de Montreal, Quebec, Canada, August 14.

James, J. (1951). A preliminary study of the size determinant in small human group interaction, American Sociological Review, 16: 474-477.

James, J. (1953). The distribution of free-forming small group size, American Sociological Review, 18: 569-570.

Jefferson, G. A. (1973). A case of precision timing in ordinary conversation: overlapped tag-positioned address terms in closing sequences. Semiotica, 9: 47-49.

Kalma, A. (1992). Gazing in triads: a powerful signal in floor apportionment, British Journal of social psychology, 31: 21-39.

Kelly, J. R. and McGrath, J. E. (1985). Effects of time limits and task types on task performance and interaction of four-person groups. Journal of Personality and Social Psychology, 49 (2): 395-407

Kiesler, S. (1986). The hidden messages in computer networks, Harvard Business Review, January-February: 46-58

Kiesler, S. and Sproull, L. (1992). Group decision making and communication technology, Organizational Behaviour and Human Decision Processes, 52: 96-123.

Kiesler, S., Zubrow, D., Moses, A-M. and Geller, V. (1984). Affect in Computer-Mediated Communication: An Experiment in Synchronous Terminal-to-Terminal Discussion. Human-Computer Interaction, 1: 77-104.

Kinney, S. and Dennis, A. (1994). Reevaluating media richness: cues, feedback, and task, (pp21-30). Proceedings of the twenty-seventh annual Hawaii International conference on system sciences, IEEE.

Kleck, R. and Nuessle, W. (1968). Congruence between the indicative and communicative functions of eye-contact in interpersonal relations, British Journal of social and clinical psychology, 7: 241-246.

Kleinke, C. L. (1986). Gaze and eye contact - a research review. Psychological bulletin, 100 (1): 78-100.

Knapp, M. L. and Hall, J.A. (1992). Nonverbal communication in human interaction, 3rd ed. Ft. Worth, Texas: Harcourt Brace.

Kobayashi, M. and Ishii, H. (1993). Clearboard: A Novel Shared Drawing Medium that Supports Gaze Awareness in Remote Collaboration. EICE Trans. Commun., E76-B (6): 609-617.

Kowtko, J., Isard, S. And Doherty-Sneddon, G. (1991). Conversational Games In Dialogue. A. Lascarides (Ed.) HCRC Technical Report RP-26 Publications, University Of Edinburgh.

Kraut, R. E.; Rice, R. E.; Cool, C. and Fish, R. S. (1994). Life and Death of New Technology: Task, Utility and Social Influences on the Use of a Communication Medium. CSCW '94 October 1994. (pp. 13-21). Chapel Hill, NC, USA. ACM.

Kristoffersen, S. and Rodden, T. (1996). Working By Walking Around - Requirements Of Flexible Interaction Management In Video-Supported Collaborative Work. Proceedings Of HCI 1996, (Pp. 315-329).

Kydd, C. T. and Ferry, D. L. (1994). Managerial use of video conferencing. Information and Management, 27: 369-375.

Lea, M. and Spears, R. (1991). Computer-mediated communication, de-individuation and group decision-making, International Journal Of Man-Machine Studies, 34: 283-301.

Leavitt, J. J. H. (1951). Some effects of certain communication patterns on performance. Journal of Abnormal And Social Psychology, 46: 38-50.

Lott, D. F. and Sommer, R. (1967). Seating arrangements and status, Journal of Personality And Social Psychology, 7: 90-95.

Mantovani, G. (1994). Is computer-mediated communication intrinsically apt to enhance democracy in organisations? Human Relations, 47 (1): 45-62.

Masoodian, M., Apperley, M. And Frederickson, L. (1995). Video Support For Shared Work-Space Interaction: An Empirical Study. Interacting With Computers, 7 (3): 237-253,

McDowall, J. J. (1978). Interactional synchrony: a reappraisal. Journal of Personality and Social Psychology, 36 (9): 963-975.

McGrath, J. E. (1993). The JEMCO Workshop- description of a longitudinal study, Small Group Research, 24 (3): 285-306.

McGrath, J. E. and Kravitz, D. A. 1982. Group Research. Annual Review of Psychology, 33: 195-230.

McGuire, T. W., Kiesler, S and Siegel, J. (1987). Group and computer-mediated discussion effects in risk decision making, Journal of Personality And Social Psychology, 52 (5): 917-930.

McKenna, E. F. (1987). Psychology In Business: Theory And Applications. LEA.

McKinlay, A.; Procter, R.; Masting, O.; Woodburn, R.and Arnott, J. (1994). Studies of turn-taking in computer-mediated communication. Interacting with Computers, 6 (2): 151-171.

McLaughlin, M. L. (1984). Conversation: How Talk Is Organized. SAGE publications, Inc.

Mehrabian, A. and Williams, M. (1969). Nonverbal concomitants of perceived and intended persuasiveness, Journal Of Personality And Social Psychology, 13: 37-58.

Meltzer, L., Morris, W. N. and Hayes, D. P. (1971). Interruption outcomes and vocal amplitude: explorations in social psychophysics, Journal of Personality And Social Psychology, 18: 392-402.

Monk, A. F., McCarthy, J., Watts, L. and Daly-Jones, O., (1996). Measures of process, in Thomas, P.J. (ed.) CSCW Requirements And Evaluation, (pp. 125-139). Berlin: Springer-Verlag.

Monk, A. F. and Watts, L. A. (1998). Peripheral participants in mediated communication. Human Factors in Computing Systems; Proceedings of CHI '98 April 18-23, Los Angeles CA USA, (pp. 285-286) ACM.

Morley, I. E. and Stephenson, G. M. (1969). Interpersonal and inter-party exchange: a laboratory simulation of an industrial negotiation at the plant level, British Journal Of Psychology, 60 (4): 543-545.

Morley, I. E. and Stephenson, G. M. (1970). Formality in experimental negotiations: a validation study, British Journal Of Psychology, 61(3): 383-384.

Mühlbach, L., Böcker, M. and Prussog, A. (1995). Telepresence In Videotelecommunications: A Study On Stereoscopy And Individual Eye Contact. Human Factors, 37 (2): 290-305.

Nellessen, L. (1999). Management and team work: On lengthy acquisition of new forms of coping. Gruppendynamik-Zeitschrift fur Angewandte Sozialpsychologie, 30 (1): 69-82.

Ng, S. H., Brooke, M. and Dunne, M. (1995). Interruption and influence in discussion groups, Journal of Language And Social Psychology, 14: 369-381.

Nunamaker, J. F. Jr. (1997). Future research in group support systems: needs, some questions and possible directions, International Journal of Human-Computer Studies, 47: 357-385.

Ochsman R. B. And Chapanis A. (1974). The Effects Of 10 Communication Modes On The Behavior Of Teams During Co-operative Problem-Solving. International Journal Of Man-Machine Studies, 6: 579-619.

O'Conaill, B. and Whittaker, S. (1997). Characterizing, Predicting, And Measuring Video-Mediated Communication: A Conversational Approach. In Finn, K., Sellen, A. and Wilbur, S. (eds.). Video-mediated communication. (pp. 107-132). LEA, Mahwah, New Jersey.

O'Conaill, B., Whittaker, S. and Wilbur S. (1993). Conversations Over Video Conferences: An Evaluation of the Spoken Aspects of Video-Mediated Communication. Human-Computer Interaction, 8: 389-428.

Olson, G. M., Olson, J. S., Carter, M. R. and Storrosten, M. (1992). Small group design meetings: an analysis of collaboration. Human-Computer Interaction, 7: 347-374.

Olson, J. S., Olson, G. M. and Meader, D. K. (1994). What Mix of Video and Audio is useful for Remote Real-time work? In Workshop on Video-Mediated Communication: Testing, Evaluation, and Design Implications - Position Papers. (pp. 33-41). Chapel Hill, North Carolina, 22 October 1994, ACM.

Olson, J. S., Olson, G. M. and Meader, D. K. (1997). Face-to-face group work compared to remote group work with and without video. in Finn, K., Sellen, A. and Wilbur, S. (eds.). Video-Mediated Communication. (pp. 157-172). LEA, Mahwah, New Jersey.

O'Malley, C. and Langton, S. (1994a). Making the Case for face-to-face Interaction: Empirical Studies of VMC. In S. Emmott And D. Travis (Eds.) POTS to PANS symposium, Hintlesham Hall, Suffolk.

O'Malley, C. and Langton, S. (1994b). Video-mediated communication - strategies for research. In Workshop on Video-Mediated Communication: Testing, Evaluation, and Design Implications -position papers (pp. 43-48). Proceedings of CSCW '94 Chapel Hill, North Carolina, 22 October 1994, ACM.

O'Malley, C., Langton, S., Anderson, A., Doherty-Sneddon, G. and Bruce, V. (1996). Comparison of face-to-face and video-mediated interaction. Interacting with Computers, 8: 177-192.

Orestrom, B. (1983). Turn-taking in English conversation. Lund, Sweden: Gleerup.

Parker, K. C. H. (1988). Speaking Turns in Small Group Interaction: A Context-Sensitive Event Sequence Model. Journal of Personality and Social Psychology, 54 (6): 965-971.

Postmes, T., Spears, R. and Lea, M. (1998). Breaching or building social boundaries? SIDE-Effects of computer-mediated communication, Communication Research, 25 (6): 689-715.

Ridgeway, C. L., Berger, J. and Smith, L. (1985). Non-verbal cues and status: an expectation states approach, American Journal Of Sociology, 90 (5): 955-978.

Rogelberg, S.G., Barnes-Farrell, J.L. and Lowe, C.A. (1992). The Stepladder Technique: an alternative group structure facilitating effective group decision making, Journal of Applied Psychology, 77 (5): 730-737.

Rosa, E. and Mazur, A. (1979). Incipient status in small groups. Social Forces, 58: 18-37.

Rosenfeld, H. M. (1987). Conversational control functions of nonverbal behaviour. In A. Siegman, and S. Feldstein (eds.), Non-Verbal Behaviour And Communication (pp563-601). Hillsdale, NJ: LEA.

Ruback, R. B., Dabbs, J. M. and Hopper, C. H. (1984). The process of brainstorming: an anlaysis with individual and group vocal parameters, Journal of Personality And Social Psychology, 47 (3): 558-567.

Rudman, C. and Dykstra-Erickson, E. (1994). Adaptation over time is required for effective use of video for group work. Position paper in: Workshop on video-mediated communication: testing, evaluation and design implications, CSCW, (pp49-54). North Carolina, 22 October, 1994.

Rutter D. R. (1987). Communicating By Telephone. Oxford: Pergamon Press.

Rutter D. R., Stephenson, G. M. And Dewey, M. E. (1981). Visual Communication And The Content And Style Of Conversation. British Journal Of Social Psychology, 20: 41-52.

Sacks, H. (1992). Lectures On Conversation. Vol. 1 and 2. Blackwell publishers.

Sacks, H., Schegloff, E. A. and Jefferson, G. (1974). A simplest systematics for the organization of turn-taking for conversation. Language, 50: 696-735.

Schegloff, E. A. (1968). Sequencing in conversational openings, American Anthropologist, 70: 1075-1095.

Schegloff, E. A. and Sacks, H., (1973). Opening up closings, Semiotica, 7 (3/4): 289-327.

Schiffrin, D. (1994). Approaches to discourse. Oxford, UK and Cambridge, USA: Blackwell.

Schober, M. F. and Clark H. (1989). Understanding by addressees and overhearers. Cognitive Psychology, 21: 211-232.

Scott, D. (1996). A Pilot Study Of Nonverbal Cues In Video Telecommunication. Psychological Reports, 78: 555-561.

Sellen, A. J. (1992). Speech Patterns in Video-Mediated Conversations. Proceedings of CHI '92. (pp49 - 59). ACM.

Sellen, A. (1994). The effects of video-mediation on human interaction. In: Workshop on video-mediated communication: testing, evaluation and design implications - position papers (pp59-64). Proceedings of CSCW '94, North Carolina, 22 October, 1994.

Sellen, A. J. (1995). Remote Conversations: The Effects of Mediating Talk With Technology Human-Computer Interaction, 10: 401-444.

Shaw, M. E. (1971). Group Dynamics, The Psychology Of Small Group Behaviour. New York: McGraw-Hill.

Sheffield, J. (1995). The effect of communication medium on negotiation performance, Group Decision And Negotiation, 4 (2): 159-179.

Short, J., Williams, E. and Christie, B. (1976). The Social Psychology of Telecommunications. John Wiley and Sons.

Siegel, S. and Castellan, N. J., Jr. (1988). Non Parametric Statistics (2nd ed.), McGraw Hill Inc.

Siegel, J., Dubrovsky, V., Kiesler, S. and McGuire, T. W. (1986). Group Processes in Computer-Mediated Communication. Organizational Behaviour and Human Decision Processes, 37: 157-187.

Silver, S. D., Cohen, B. P., and Crutchfield, J. H. (1994). Status differentiation and information exchange in face-to-face and computer-mediated idea generation. Social Psychology Quarterly, 57 (2): 108-123.

Sinclair, J. H. and Coulthard, R. M. (1975). Towards An Analysis Of Discourse: The English Used By Teachers And Pupils, Oxford: Oxford University Press.

Sissons, M. (1971). The social psychology of class. In Money Wealth and Class, Milton Keynes: Open University Press.

Smith R. B., O'Shea, T., O'Malley, C., Scanlon, E. And Taylor, J. (1991). Preliminary Experiments With A Distributed, Multi-Media, Problem-Solving Environment. Pp. 31-48 In J. M. Bowers And S. D. Benford. Studies In Computer Supported Co-operative Work - Theory, Practice And Design.

Smith-Lovin, L. and Brody, C. (1989). Interruptions in group discussions: the effects of gender and group composition, American Sociological Review, 54: 424-435.

Stasser, G. (1988). Computer-simulation as a research tool - the discuss model of group decision-making, Journal of Experimental Social Psychology, 24 (5): 393-422.

Stasser, G. and Stewart, D. (1992). Discovery of hidden profiles by decision-making groups -solving a problem versus making a judgment, Journal of Personality and Social Psychology, 63 (3): 426-434.

Stasser, G. and Taylor, L. A. (1991). Speaking turns in face-to-face discussions. Journal of Personality and Social Psychology, 60 (5): 675-684.

Stasser, G. and Titus, W. (1985). Pooling of unshared information in group decision making: biased information sampling during discussion, Journal of Personality And Social Psychology, 48 (6): 1467-1478.

Steiner, I. D. (1972). Group processes and productivity, Academic press, Inc.

Steinzor, B. (1955). The spatial factor in face to face discussion groups. In A. Paul Hare, Edgar F. Borgatta, and Robert F. Bales, (editors), Small Groups: Studies In Social Interaction. (pp. 348-353). Alfred A. Knopf, New York.

Stephan, F. F. (1952). The relative rate of communication between group members of small groups, American Sociological Review, 17 (4): 482-486.

Stephan, F.F. and Mishler, E. G. (1952). The distribution of participation in small groups: An exponential approximation, American Sociological Review, 17: 598-608.

Storck J. And Sproull, L. (1995). Through A Glass Darkly - What Do People Learn In Videoconferences? Human Communication Research, 22 (2): 197-219.

Straus, S. G. (1996). Getting a clue: the effects of communication media and information distribution on participation and performance of computer-mediated and face-to-face groups, Small Group Research, 27 (1): 115-142.

Straus, S. G. (1997). technology, group process, and group outcomes: testing the connections in computer-mediated and face-to-face groups, Human-Computer Interaction, 12 (3): 227-266.

Suh, K. S. (1999). Impact of communication medium on task performance and satisfaction: an examination of media-richness theory, Information and Management, 35 (5): 295-312.

Tang, J. C. and Isaacs, E. (1993). Why do Users Like Video? - Studies of Multimedia-Supported Collaboration. Computer Supported Co-operative Work (CSCW) 1: 163-196.

Tang, J. C.; Isaacs, E. A. and Rua, M. (1994). Supporting Distributed Groups with a Montage of Lightweight Interactions. CSCW '94 Conference Proceedings (pp23 -34) October 1994 Chapel Hill, NC, USA. ACM.

Valacich, J. S., Mennecke, B. E., Wachter, R. M. and Wheeler, B. C. (1994). Extensions to media richness theory: a test of the task-media fit hypothesis, (pp. 11-20). Proceedings Of The Twenty-Seventh Annual Hawaii International Conference On System Sciences, IEEE.

Vitkovitch, M. And Barber, P. (1994). Effect Of Video Frame Rate On Subjects' Ability To Shadow One Of Two Competing Verbal Passages. Journal Of Speech And Hearing Research, 37: 1204-1210.

Vroom, V. and Yetton, P. W. (1973). Leadership and Decision-Making. Pittsburgh, PA: University of Pittsburgh Press.

Walther, J. B. (1995). Relational aspects of computer-mediated communication: experimental observations over time. Organization Science, 6 (2): 186-203.

Watts, L., Monks, A. And Daly-Jones, O. (1996). Inter-Personal Awareness And Synchronization: Assessing The Value Of Communication Technologies, International Journal Of Human-Computer Studies, 44: 849-873.

Weeks, G. D. And Chapanis, A. (1976). Co-operative Versus Conflictive Problem Solving In Three Telecommunication Modes. Perceptual And Motor Skills, 42: 879-917.

Weisband, S. P., Schneider, S. K. and Connolly, T. (1995). Computer-mediated communication and social information: status salience and status differences. Academy of Management Journal, 38 (4): 1124-1151.

West, M. A., Garrod, S., Carletta, J. Group-decision-making and effectiveness: unexplored boundaries. (1998). In C. L. Cooper and S. E. Jackson (eds.) Creating Tomorrow's Organisations: A Handbook for Future Research in Organizational Behavior (pp. 293-317). Chichester, England: John Wiley.

Whittaker, S. (1995). Rethinking Video As A Technology For Interpersonal Communications: Theory And Design Implications. International Journal Of Human-Computer Studies. 42: 501-529.

Whittaker, S. and O'Conaill, B. (1997). The Role of Vision in Face-to-face and mediated Communication. In K. E. Finn, Sellen, A. J. and Wilbur, S. B. (eds.) Video-Mediated Communication, (pp. 23-49). LEA, Malwah, New Jersey.

Williams, E. (1977). Experimental Comparisons of Face-to-Face and Mediated Communication: A Review. Psychological Bulletin, 84: 963-976.

Appendices

Appendix A. Study 1 - Participant Instructions for Travel Game - VMC condition

Please read these instructions carefully before you say you are ready to start the great US holiday competition. If you have any questions please ask the travel agent.

Competition Summary Your task is to plan a holiday for yourselves and two friends travelling in the USA. Use the video-conferencing to introduce yourselves to the travel agent and explain that you want to plan a 22 day trip for four people using your air travel pass (details below).

At the end of the session you will be asked to provide a short explanation of your chosen travel plan. Independent judges will assess these plans and the best holiday plan will win the first prize of 40 pounds.

The Screen To help you plan the trip, you have a map of the USA in front of you on the screen.

- The map can be scrolled around by clicking on the arrows in the frame around the map.
- Each red icon is a city with an airport used by Atlantic Airways where you can view a short travel video showing some of the attractions of that part of the USA.
- Only the states are named on the map

The travel agent has details of all the direct flights, and can send you the travel videos/ information about the cities. You should ask the agent if you want to see any of this information. **He/she cannot provide information on accommodation or any other form of transport.** NB There is no audio accompaniment to the video clips.

Task

Use the map, the information provided by the travel agent, and the information available about the different cities to plan a **22 day trip** around the USA using an 'Atlantic Air Travel Pass'. The rules for the Travel Pass are:

- You are allowed to make **four** stops in the USA (including where you fly to initially)
- You must Move from **East to West**
- You may only take **direct flights** between your chosen destinations

You are travelling with two friends who have different interests.:

- **Sue** who likes the great outdoors, hiking, rock climbing etc. She has not travelled much before, and is slightly nervous of big cities (but willing to give it a go for a bit, if you're interested)
- **Tom** who is a history and culture enthusiast
- **Both of you** who like.... *(Use your own preferences here but don't forget to include them in your justification)*

<u>You should take into account everyone's preferences when planning your holiday and obey the travel pass rules.</u>

The travel agent will keep and update an itinerary of your progress, and you can see your 'itinerary' on the computer screen throughout the session. <u>You may restart or change your itinerary at any point in the Game. It is your final itinerary that counts.</u>

After **30 minutes** discussion, the agent will log your final choices and the no more than **six line justification** of why this travel plan will give everyone a great US holiday in light of the different interests in the group. You should include all your destinations and reasons for these choices in your justification

Technical information

Eye-contact Don't forget that if you want to make eye-contact with the travel agent you have to look at the camera rather than at the screen picture.

In the middle of the screen are sliding volume buttons for the microphone and headphones. These will be pre-set so you should not need to touch these. If you have trouble hearing the agent tell him/her and they'll tell you what to do.

With your permission this session will be audio- and video-taped, there is a consent sheet to sign. If you wish to discontinue the experiment at any point you may do so but may forfeit your fee as a result.

Appendix B. Study 1 - Participant Instructions for Travel Game - face to face condition

Please read these instructions carefully before you say you are ready to start the great US holiday competition. If you have any questions please ask the travel agent.

<u>**Competition Summary**</u> Your task is to plan a holiday for yourselves and two friends travelling in the USA. Introduce yourselves to the travel agent and explain that you want to plan a 22 day trip for four people using your air travel pass (details below).
At the end of the session you will be asked to provide a short explanation of your chosen travel plan. Independent judges will assess these plans and the best holiday plan will win the first prize of 40 pounds.

<u>**The Screen**</u> To help you plan the trip, you have a map of the USA in front of you on the screen.

- The map can be scrolled around by clicking on the arrows in the frame around the map.
- Each red icon is a city with an airport used by Atlantic Airways where you can view a short travel video showing some of the attractions of that part of the USA.
- Only the states are named on the map

The travel agent has details of all the direct flights, and can send you the travel videos/ information about the cities. You should ask the agent if you want to see any of this information. **He/she cannot provide information on accommodation or any other form of transport.**

Task

Use the map, the information provided by the travel agent, and the information available about the different cities to plan a **22 day trip** around the USA using an 'Atlantic Air Travel Pass'. The rules for the Travel Pass are:

- You are allowed to make **four** stops in the USA (including where you fly to initially)
- You must Move from **East to West**
- You may only take **direct flights** between your chosen destinations

You are travelling with two friends who have different interests.:

- **Sue** who likes the great outdoors, hiking, rock climbing etc. She has not travelled much before, and is slightly nervous of big cities (but willing to give it a go for a bit, if you're interested)
- **Tom** who is a history and culture enthusiast
- **Both of you** who like.... *(Use your own preferences here but don't forget to include them in your justification)*

You should take into account everyone's preferences when planning your holiday and obey the travel pass rules. You should include all your destinations and reasons for these choices in your justification

The travel agent will keep and update an itinerary of your progress, and you can see your 'itinerary' on the computer screen throughout the session. You may restart or change your itinerary at any point in the Game. It is your final itinerary that counts. After **30 minutes** discussion, the agent will log your final choices and the no more than **six line justification** of why this travel plan will give everyone a great US holiday in light of the different interests in the group.

With your permission this session will be audio- and video-taped, there is a consent sheet to sign. If you wish to discontinue the experiment at any point you may do so but may forfeit your fee as a result.

Appendix C. Study 1 - Instructions for Travel Agent

1. Travel Agent Script

Try to treat this as if you really are a professional travel agent. In such a situation you would not know the clients goals/aims unless they tell you them.

Introduce yourself to the 'clients' / subjects: e.g. "My name is ....I'm your travel agent today..."

Ask them what you can do for them. They should tell you that they want to plan a trip around the States with their 'Atlantic Air Travel Pass'. If they don't then you may need to prompt them e.g. "Where do you want to go" and "Do you have an air travel pass...".
Don't help them too much, they have a description of their task and the rules of the pass.

If you get very quiet clients try not to over-compensate by doing all the talking - make THEM do some work!

Try to be equally helpful to all subjects. **Don't** make suggestions to them for their travel plan. If they get really stuck you might suggest that they take a look at a video etc.

2. Travel Agent Task

You will keep and update on screen an itinerary of the 'clients' progress, and they can see their itinerary on their computer screen throughout the session. 'Clients' may restart or change their itinerary at any point in the Game. It is their final itinerary that counts.

You have details of all the direct flights, and you can send the 'clients' the travel videos/ information about the cities. **They** should ask **you** if they want to see any of this information.

They have **30 minutes** to plan their holiday. Try and get them to keep to the **1/2 hour time limit** e.g. by hinting you have another appointment soon etc. after which time you must log their final choice on screen and the 6 line justification of why this holiday will give everyone a great US holiday.

3. Subject/client task and instructions

They have a copy of the rules for the travel pass which are:

- You are allowed to make **four** stops in the USA (including where you fly to initially)
- You must Move from **East to West**
- You may only take **direct flights** between your chosen destinations

This is the description of the task that participants have been given

Use the map, the information provided by the travel agent, and the information available about the different cities to plan a ***22 day trip*** *around the USA using an 'Atlantic Air Travel Pass' for yourselves and your two friends, Sue and Tom who have different interests.*

The clients' screen

The clients have a copy of the map of the USA which they can scroll about. This shows a *dot* for each city with an airport used by Atlantic Airways, and the states are named. There are *red icons* on the map indicating where they can view a short travel video showing some of the attractions of that part of the USA.

4. Technical information for video-conferencing condition

Eye-contact Don't forget that if you want to make eye-contact with the clients you have to look at the camera rather than at the screen picture.

Appendix D. Study 1 - Scoring scheme for judges rating holiday itinerary justifications

How to score each justification:

+1 for each valid reason for choosing a destination e.g. history and culture = 2 separate reasons, so get 1 point each.

+1 for a justification where 2 people were pleased by the choice of 4 destinations when the aspects that will please them are given and are attributed to the individual

+2 for a justification where 3 people were pleased by the choice of 4 destinations when the aspects that will please them are given and are attributed to the individual

+3 a justification where all 4 people were pleased by the choice of 4 destinations when the aspects that will please them are given and are attributed to the individual

-1 for a large city destination. Take a mark off for Los Angeles, New York and Chicago only. If they have given a reason as to why Sue will be happy with going to a big city area then no mark is deducted, but they don't get a point added either.
e.g.
Los Angeles - beaches, nightlife - but will got to countryside near LA for sue. - no point taken off.
Los Angeles - beaches, nightlife. - minus one point

-1 for each violation of flight rules
-1 for any other violation of rules (e.g. east to west only rule) -]

Participants were asked to justify their choices of 4 destinations in America in light of the different interests in the group, and to do so in only 6 lines. The two participants were meant to include their own interests and those of their imaginary companions Sue who likes the great outdoors and is slightly nervous of big cities, and tom who is a history and culture enthusiast.

Appendix E. Study 1 - Travel agent instructions for procedure for accessing flight information and video clips in face-to-face condition

<u>agent information on **flight information**</u>

1) To find out if a direct flight is available **type in the dialogue box** (NB you must first click in this box before you can type in it) the name of the 2 states e.g.

Arizona - California

(meaning 'is there a direct flight from Arizona to California?')

and press return

2) I will then type in a response from my machine which I will send to you

e.g. **Arizona - California - yes**

meaning there is a direct flight

OR **Arizona to California -NO**

meaning there is no direct flight

3) If this method fails then **check for availability of direct flights on the paper copy** listing all states and possible destinations. The states are ordered alphabetically.

e.g. if you want information on flights from San Francisco look under *California, San Francisco,* if you want information on flights from Niagara falls look under *New York, Niagara*

NB my sending this information to you via the dialogue box will automatically override (delete) anything you have written in the dialogue box at your end so **do not type out the holiday plan or itinerary until the very end**.

Appendix F. Study 1 - User Evaluation Questionnaire

Participant experience and evaluation

Subject no.: *Age:* *Sex:*

The questions in **Part 1** ask for information about your experience of using computers. **Part 2** requests details about the Travel Game in which you have just taken part. The questionnaire will take about 15 minutes to complete.
All the information you give us is confidential.

For each question that follows please indicate which answer best represents your experience by ticking alongside one option, unless directed to do otherwise.

Part 1. Previous Computer Experience.

1. How often do you use computers? Please tick the response that matches your habits most closely.

a) Every day (.....)
b) Several times a week (.....)
c) Occasionally (.....)
d) Never (.....)

2. Please tick below all the applications which you have used.

Word processing (......)
Spreadsheets (e.g. Excel) (......)
Statistical analysis (e.g. SPSS, Minitab) (......)
Desk top publishing (e.g. Adobe photoshop) (......)
Graphics (e.g. PowerPoint) (......)
Programming (......)
Other. Please specify. ....

3. Have you used a 'mouse' before today? Please circle one response.

yes / no

4. Have you used electronic-mail (e-mail) before? Please circle one response.

yes / no

5. Which of the following have you used before today? Tick all that apply to you.

a) **Video-conferencing** (.....)
b) **Audio-conferencing** (speaking and hearing through a computer) (.....)
c) **Shared workspace** (e.g. a tool on screen which all communicants can manipulate such as a tool for drawing on a white board) (.....)

Part 2. Questions about the session you have just completed

1. How easy / difficult was it to hear the travel agent?

a) Very easy	(......)
b) Easy	(......)
c) Neither easy nor difficult	(......)
d) Difficult	(......)
e) Very difficult	(......)

2. How aware were you of the presence of the travel agent?

a) Very aware	(......)
b) Fairly aware	(......)
c) Neither aware nor unaware	(......)
d) Fairly unaware	(......)
e) Very unaware	(......)

3. How difficult / easy was it to make eye contact with the travel agent?

a) Very easy	(......)
b) Easy	(......)
c) Neither easy nor difficult	(......)
d) Difficult	(......)
e) Very difficult	(......)

4. How easy / difficult was it to see the travel agent's
a) gestures?

a) Very difficult	(......)
b) Difficult	(......)
c) Neither easy nor difficult	(......)
d) Easy	(......)
e) Very easy	(......)

b) facial expressions?

a) Very difficult	(......)
b) Difficult	(......)
c) Neither easy nor difficult	(......)
d) Easy	(......)
e) Very easy	(......)

5. How difficult / easy was it to get your questions across?

a) Very difficult (......)
b) Difficult (......)
c) Neither easy nor difficult (......)
d) Easy (......)
e) Very easy (......)

6. Did you feel free to chat informally to the travel agent?

yes / no

Comments (optional):

....
....
....
....

7. How difficult / easy was it to for you to take a turn in the conversation when you wanted to?

a) Very easy (......)
b) Easy (......)
c) Neither easy nor difficult (......)
d) Difficult (......)
e) Very difficult (......)

8. At any point in the session did you feel excluded from the discussion?

a) Often (.....)
b) Sometimes (.....)
c) Never (.....)

9. How often / little did the travel agent mistakenly think you were talking to him/her when you were talking to your friend?

a) Never (.....)
b) Occasionally (.....)
c) Often (.....)

10. Was it ever difficult for you to communicate with your friend while also paying attention to the travel agent or images?

a) Frequently (.....)
b) Sometimes (.....)
c) Never (.....)

11a. Were there any differences of opinion between you and your partner while planning the itinerary? Please tick one option.

Yes (.....) **Go to question 11b**
No (.....) **Go to question 12**

11b. How difficult / easy was it to resolve these differences?

a) Very difficult (......)
b) Difficult (......)
c) Neither easy nor difficult (......)
d) Easy (......)
e) Very easy (......)

12. How easy / difficult was it to make changes in your itinerary?

a) Very easy (......)
b) Easy (......)
c) Neither easy nor difficult (......)
d) Difficult (......)
e) Very difficult (......)

13. How satisfied / dissatisfied were you with the final holiday itinerary?

a) Very satisfied (......)
b) Satisfied (......)
c) Neither satisfied nor dissatisfied (......)
d) Dissatisfied (......)
e) Very dissatisfied (......)

14. How dissatisfied / satisfied were you with the travel agent's consultation?

a) Very dissatisfied (......)
b) Dissatisfied (......)
c) Neither satisfied nor dissatisfied (......)
d) Satisfied (......)
e) Very satisfied (......)

15. During the consultation were you worried at any point that you had lost contact with the travel agent?

a) Often (.....)
b) Sometimes (.....)
c) Never (.....)

16. How would you rate the quality of the pictures of:

a) the destinations. Please circle one option.

1	2	3	4	5
very poor	poor	ok	good	very good

b) the travel agent. Please circle one option.

1	2	3	4	5
very poor	poor	ok	good	very good

17. Please rank the multimedia tools below in order of their usefulness for completing the Travel game.
Use a scale of 1 to 4 where 1 = the most useful and 4 = the least useful.

a) The picture of the travel agent's face (.....)
b) The videos / descriptions of the destinations (.....)
c) The shared itinerary window (.....)
d) The map of the USA (.....)

18. In order to run the Travel game on a slower computer the quality of one of the features must be downgraded.

RANK which of the following changes you would make 1st, 2nd, 3rd, 4th and 5th.

	Rank
a) Make the picture of the travel agent update less often? (which may make the picture more jerky)	(.....)
b) Have a smaller picture of the travel agent?	(.....)
c) Use smaller pictures of the destinations?	(.....)
d) Use lower quality images of the destinations (which may be more grainy and less distinct)?	(.....)
e) Use still images of the destinations?	(.....)

19. For each of the following pairs of communication types, which would you prefer to use for planning an itinerary similar to the one you planned today? Circle one option for each pair.

1) Video-conferencing or Face-to-face
2) Video-conferencing or Telephone
3) Face-to-face or Telephone

20. How much time would you be prepared to spend travelling to an agency to avoid a video-mediated consultation? Please tick one option.

a) Not applicable - I would prefer a video-mediated consultation (.....)
b) Less than 1/2 hour (.....)
c) 1/2 hour to 1 hour (.....)
d) 1 to 2 hours (.....)
e) More than 2 hours (.....)

21a. Having used the video-mediated technology today, is there any feature you would like to improve?

Yes (.....) **Go to question 21b**
No (.....) **Go to question 22**

21b. TICK which of the changes below you would make.

<u>Aspect</u>	<u>Tick</u>.
a) Improve sound/audio quality	(......)
b) Enlarge size of video window	(......)
c) Improve quality of video picture of agent	(......)
d) Improve quality of travel video clips	(......)
e) Suggest alternative aspect(s):	

....

22. Are there any other comments about the communication technology you have experienced today that you would like to add?

....

....

....

....

....

....

....

....

....

Appendix G. Study 2 - Palmtop PCs product brief and market information

Palmtop PC Brief

Palmpilot PCs (hand held portable personal computers) are becoming an increasingly popular alternative to the more cumbersome 'laptop' portable PCs. The new generation of Palmpilots has greater memory capacity than ever before meaning they are faster and can support more features.

Market information

Market research shows that customers are interested in convenience of use, compatibility with Windows, and communications capability (email, fax, Internet).

The products

Four designers have each designed a product. Look at the four products and choose the one that you would take to your manager as the new product for winter 1999.

Appendix H. Study 2 - Digital Cameras product brief and market information

Digital camera Brief

No need for camera film! Digital cameras do not use film but record images which can be displayed on and printed from your PC (personal computer). Images are stored either in a memory card, a standard PC floppy disk or the latest 'mini discs' - miniature CDs - for transfer to PC. Today's digital cameras give a choice of resolution formats (more pixels or 'dots' means higher quality) meaning you can choose the quality of your pictures, while display monitors let you preview or review your shots with the option of deleting or saving them.

Market information

Market research shows that customers who buy digital cameras are between the ages of 23 and 50 and tend to fall into two categories: those who are environmentally conscious and those who are image conscious.

The products

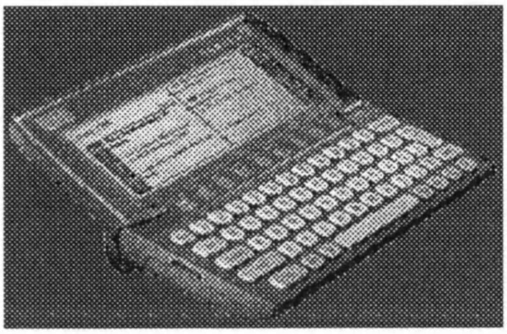
Four designers have each designed a product. Look at the four products and choose the one that you would take to your manager as the new product for winter 1999.

Appendix I. Study 2 - PC Product A information

<u>Your product design</u>

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

A



- **Memory** 10 MB
- **Size** 16 (L) x 15 (W) x 1 (D) cm (open)
- **Weight** 250 grams
- **Keyboard** QWERTY keyboard
- **Screen** 60 characters x 15 lines

Features

- modem connection for e-mail, Internet and fax link up
- Windows compatible
- word processor and spreadsheet facilities
- infra-red port for file transfer
- large touch sensitive screen

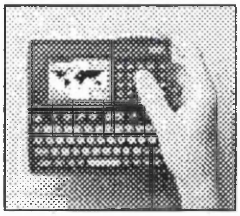
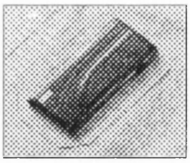
- **Production cost** 115 units

Appendix J. Study 2 - PC Product B information

Your product design

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

B

- **Memory** 8 MB
- **Size** pocket-sized when closed. 12 (L) x 13 (W) x 0.5 (D) cm when open
- **Weight** 100 grams
- **Keyboard** QWERTY keyboard
- **Screen** 20 characters x 6 lines

Features

- e-mail, Internet and fax capabilities
- Windows PC link
- built-in word processor and spreadsheet
- infra red transfer of files between machines
- backlight screen

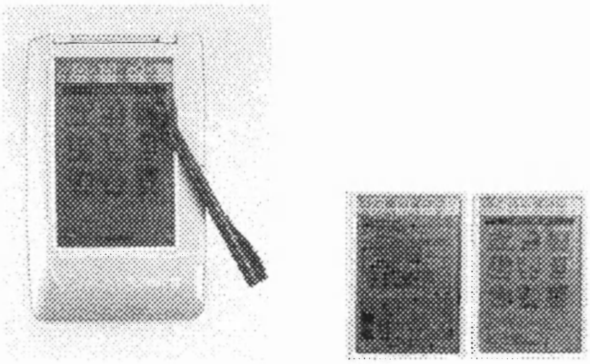
- **Production cost** 100 units

Appendix K. Study 2 - PC Product C information

<u>Your product design</u>

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

C



- **Memory** 9MB
- **Size** 13 ½ (L) x 16 (W) x 0.9 (D) cm when open
- **Weight** 161 grams including pen and battery
- **Keyboard** pen touch sensitive virtual QWERTY keyboard
- **Screen** LCD (liquid crystal display) screen. Two 30 character x 60 line displays when open

Features

- access to e-mail, Internet and fax
- Word and Excel (Windows) compatible
- spreadsheet and word processor capability
- variable display format (opens out to give wide screen)
- expandable memory

- **Production cost** 110 units

Appendix L. Study 2 - PC Product D information

<u>Your product design</u>

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

D

- **Memory** 10 MB
- **Size** 16 ½ (L) x 12 (W) x 1 (D) cm when open
- **Weight** 200 grams
- **Keyboard** QWERTY keyboard
- **Screen** 40 characters x 10 lines display

Features

- spreadsheet and word processor included
- Windows PC link
- e-mail, Internet and fax capabilities
- colour screen
- infra red file transfer capability

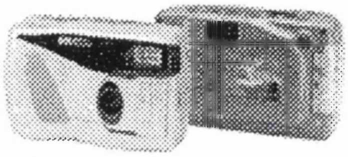
- **Production cost** 110 units

Appendix M. Study 2 - Camera Product A information

Your product design

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

A



- **Size** (H) 6 x (W) 10 ½ x (D) 3.5 cm
- **Weight** 200 grams

Features

- **recording format** removable, reusable PC memory card and card reader (for image transfer to PC)
- **photo capacity** up to 40 photos
- **resolution** high resolution (1152 x 872 pixels) or standard resolution (640 x 480 pixels)
- **display** 5cm colour monitor
- ultra compact and light weight
- energy efficient

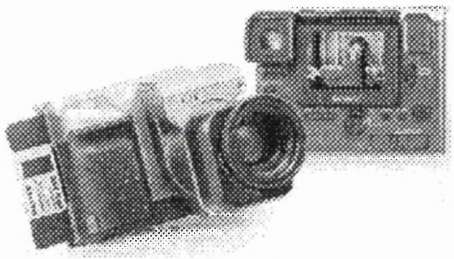
production cost 105 units

Appendix N. Study 2 - Camera Product B information

Your product design

Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

B



- **Size** (H) 10 ½ x (W) 12 x (D) 9 cm
- **Weight** 350 grams

Features

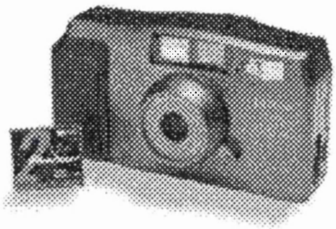
- **recording format:** 3.5" floppy disk to be inserted directly into your PC
- **photo capacity** up to 40 photos per floppy disk
- **display** 7cm colour monitor
- **resolution** high (1024 x 768 pixels) or standard resolution (640 x 480 pixels)
- case made of biodegradable plastic
- automatic zoom lens

production cost 135 units

Appendix O. Study 2 - Camera Product C information

Your product design:

C



- **Size** (H) 13 x (W) 8 x (D) 5 cm
- **Weight** 250 grams

Features

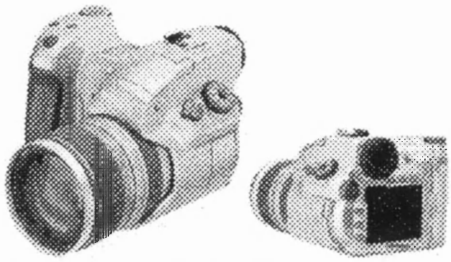
- **recording format** mini disc and disc reader
- **display** 5 ½ cm colour monitor
- **photo capacity** up to 60 images
- **resolution** high (1024 x 768 pixels), standard (640 x 480 pixels) or low resolution (320 x 240 pixels)
- case made of recyclable materials
- choice of black-and-white or colour photos

production cost 120 units

Appendix P. Study 2 - Camera Product D information

<u>Your product design</u>
Do not show this information to the other group members - it is provided for you to persuade the others to vote for your product.

D



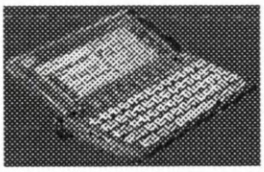
- **Size** (H) 10 x (W)11 x (D)12 cm
- **Weight** 400 grams

Features
- **recording format** removable reusable PC memory card and card reader (for image transfer to PC)
- **display** 8cm colour monitor
- **photo capacity** from 30 to 90 shots
- **resolution** choice of superfine (1344 x 1024 pixels), fine (1024 x 768 pixels) or standard resolution (640 x 480 pixels) images
- manual zoom lens
- ergonomic design (fits the contours of the hand)

production cost 150 units

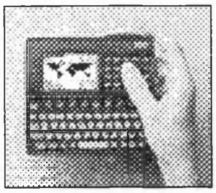
Appendix Q. Study 2 - Images of Palmpilots and summary of product information

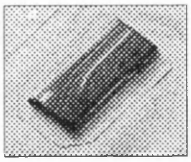
A



- **Memory** 10 MB
- **Size** 16 (L) x 15 (W) x 1 (D) cm (open)
- **Weight** 250 grams

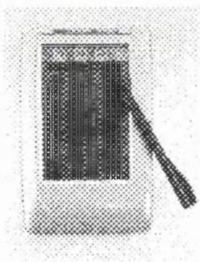
B

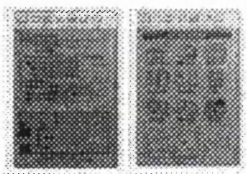




- **Memory** 8 MB
- **Size** pocket-sized when closed. 12 (L) x 13 (W) x 0.5 (D) cm when open
- **Weight** 100 grams

C





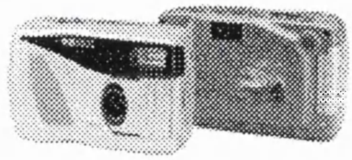
- **Memory** 9MB
- **Size** 13 ½ (L) x 16 (W) x 0.9 (D) cm when open
- **Weight** 161 grams including pen and battery

D

- **Memory** 10 MB
- **Size** 16 ½ (L) x 12 (W) x 1 (D) cm when open
- **Weight** 200 grams

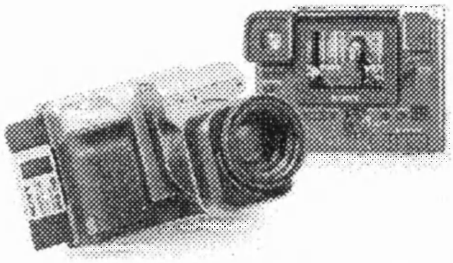
Appendix R. Study 2 - Images of cameras and summary of product information

A



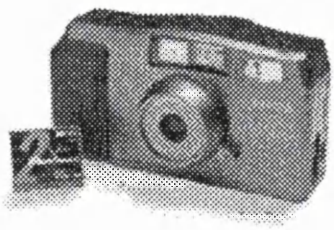
- **Size** (H) 6 x (W) 10 ½ x (D) 3.5 cm
- **Weight** 200 grams

B



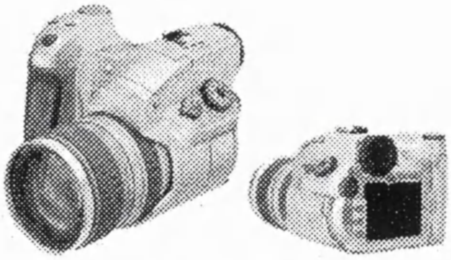
- **Size** (H) 10 ½ x (W) 12 x (D) 9 cm
- **Weight** 350 grams

C



- **Size** (H) 13 x (W) 8 x (D) 5 cm
- **Weight** 250 grams

D



- **Size** (H) 10 x (W)11 x (D)12 cm
- **Weight** 400 grams

Appendix S. Study 2 - User Evaluation Questionnaire

Section1. Questions on video communication.
Please tick one response for each question.

	very good	good	ok	poor	very poor
1. How do you rate the quality of the video image?	(...)	(...)	(...)	(...)	(...)
the product images?	(...)	(...)	(...)	(...)	(...)

	very satisfied	satisfied	neither satisifed nor dissatisfied	dissatisfied	very dissatisfied
2. How satisfied were you with the quality of the audio?	(...)	(...)	(...)	(...)	(...)
the video?	(...)	(...)	(...)	(...)	(...)

	very useful	useful	neither useful nor useless	not useful	not at all useful
3. How useful for completing the task was the video image?	(...)	(...)	(...)	(...)	(...)
were the pictures of the products?	(...)	(...)	(...)	(...)	(...)

4. Which was **more** useful: the video image? (...)

the product images? (...)

They were equally useful. (...)

	very often	often	sometimes	infrequently	very infrequently	never
5. During the video discussion, how often were you worried you had lost contact with the remote group members?	(...)	(...)	(...)	(...)	(...)	(...)

6a. Did you experience any technical difficulties during the discussion e.g. loss of audio / video signal?

yes / no

6b. If yes, please describe the difficulties:

....

....

....

7a. Would you like to make any improvements to the technology e.g. to the audio, video, graphics? **Please circle one response.**

yes / no

7b. If yes, please describe the improvements:

....

....

....

Please go on to section 2.

Section 2. Communication in face-to-face and video discussions.
Please tick one response for each question.

		much easier when face-to-face cross table	easier when face-to-face	same	more difficult when face-to-face	much more difficult when face-to-face
1. In face-to-face versus video communication, how easy was it to hear person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)
2. In face-to-face versus video communication, how easy was it to make eye contact with person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)
3. In face-to-face versus video communication, how easy was it to see the gestures of person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)
4. In face-to-face versus video communication, how easy was it to see the facial expressions of person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)
5. In face-to-face versus video communication, how easy was it to get your questions across to person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)
6a. In face-to-face versus video communication, how easy was it for you to chat informally to person	B?	(...)	(...)	(...)	(...)	(...)
	C?	(...)	(...)	(...)	(...)	(...)
	D?	(...)	(...)	(...)	(...)	(...)

6b. Please give reasons for your answers to question 6a:

....

....

....

....

....

7. In face-to-face versus video communication, how aware were you of the presence of person

	much more aware when face-to-face	more aware hen face-to-fa	same	more unaware hen face-to-fac	much more unaware when face-to-face
B?	(…)	(…)	(…)	(…)	(…)
C?	(…)	(…)	(…)	(…)	(…)
D?	(…)	(…)	(…)	(…)	(…)

8. In face-to-face versus video communication, how often did you feel excluded from the discussion?

much more often when face-to-face	more often when face-to-face	same	less often when face-to-face	much less often when face-to-face
(…)	(…)	(…)	(…)	(…)

9. In face-to-face versus video communication, how persuasive did you find the arguments of person

	much more persuasive ien face-to-face cross tal	more persuasive when face-to-face	same	less persuasive when face-to-face	much less persuasive when face-to-face
B?	(…)	(…)	(…)	(…)	(…)
C?	(…)	(…)	(…)	(…)	(…)
D?	(…)	(…)	(…)	(…)	(…)

	uch more satisfied whe face-to-face cross table	more satisfied when face-to-face	same	more dissatisfied when face-to-face	much more dissatisfied when face-to-face
10. In face-to-face versus video communication, how satisfied were you with the final product choice?	(...)	(...)	(...)	(...)	(...)
11a. In face-to-face versus video communication, how satisfied were you with the decision process by which you arrived at the final choice?	(...)	(...)	(...)	(...)	(...)

11b. Please explain your answer to **11a**: ....

....

....

	much easier hen face-to-fac	ier when face-to-f	same	more difficult when face-to-face	much more difficult when face-to-face
12. In face-to-face versus video communication, how easy was it for you to take a turn in the conversation when you wanted to?	(...)	(...)	(...)	(...)	(...)
13. In face-to-face versus video communication, how easy was it to resolve differences of opinion with					
person B?	(...)	(...)	(...)	(...)	(...)
C?	(...)	(...)	(...)	(...)	(...)
D?	(...)	(...)	(...)	(...)	(...)
14. In face-to-face versus video communication, how easy was it to assess the reactions of person B?	(...)	(...)	(...)	(...)	(...)
C?	(...)	(...)	(...)	(...)	(...)
D?	(...)	(...)	(...)	(...)	(...)
15. In face-to-face versus video communication, how easy was it to get the attention of person B?	(...)	(...)	(...)	(...)	(...)
C?	(...)	(...)	(...)	(...)	(...)
D?	(...)	(...)	(...)	(...)	(...)

Appendix T. Study 2 - Guidelines for identifying persuasion attempts

How to code persuasion attempts

- Give 1 point for each persuasion attempt.
- Just describing the features does not get a point, speaker must say why it's a good feature for a point.
- Descriptions such as 'light', 'big', 'small', 'it is good' etc. on their own are not persuasion attempts.
- I have not given marks for comparative statements unless qualified as to how that is a benefit e.g. no mark for 'lighter', 'bigger', 'smaller' unless they state why that is an advantage. The exception is comparative statements concerning price such as 'cheaper', 'cheapest' which do receive one point.

Appendix U. Study 2 - Guidelines for Judges marking justifications

Digital cameras

Groups were given market information about their customers and should satisfy these 3 core requirements in their choice of camera:

1. suitable for customers between the ages of 23 and 50
2. appeal to the environmentally conscious customer
3. appeal to the image conscious customer.

Palm pilot PCs

Groups were given market information about their customers and should satisfy these 3 core requirements in their choice of Palmpilot:

1. convenience of use - must state ‘ease of use’ / ‘easy to use’ or similar
2. compatibility with Windows
3. communications capability (email, fax, Internet).

NB Any reasons mentioned that come under the core requirements do not also get 5 points per reason.

all 3 core requirements are met	at least 76 highest scoring justification 100
2 core requirements are met	at least 51 (up to 75 depending on no. of other valid reasons)
1 core req. is met	at least 26 (up to 50 depending on no. of other valid reasons)
no core requirements are met	25 or less

Other marks are given for any other valid reasons stated for the group choice of camera or PC product.

- give 5 points per valid reason

Appendix V. Glossary of selected terms

cross-site communication (see same-site communication)

in a **technology-mediated communication** context, the communication between participants who are remotely located. NB In study 1, the nature of cross-site communication is slightly different from that of study 2 due to the differing ability to access certain on-screen data (video clips) between group members in study 1.

multimedia communications technology

communication systems that incorporate more than one medium for communication - this may include any combination of an audio, video or data link.

multimediated (communication)

communication carried out via **multimedia communications technology.**

partial technology- / video-mediation

communication when conference sites *and* conferencing equipment, including any video link, are shared between two (or more) co-present individuals in order to converse with one or more remote individuals.

partially audio- / technology- / video-mediated communication (see **shared multimedia technology** and **shared conference site)**

communication when conference sites *and* conferencing equipment, including any video link, are shared between two (or more) co-present individuals in order to converse with one or more remote individuals.

same-site communication (see also **cross-site communication)**

in a **partially technology-mediated communication context**, the communication which is between participants who are co-present and sharing conferencing equipment.

shared (sharing a) conference site (see also **partially video/audio/technology mediated** and **shared multimedia technology**)

sharing a physical location or site *and* conferencing equipment with one or more co-present individuals in order to converse with one or more remote individuals.

shared (sharing) multimedia technology (see **shared conference site** and **partially video/audio mediated)**

sharing a physical location or site *and* conferencing equipment, including any video link, with one or more co-present individuals in order to converse with one or more remote individuals.

technology-mediated (communication)

communication carried out via communications technology.

unequally distributed conference/multimedia technology

when some users in the meeting have sole access to the conference equipment including any video link, while other users in the meeting are sharing conference equipment including any video link.