Processing Unfamiliar Faces

Ahmed M. Megreya

Department of Psychology

University of Glasgow

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Abstract

It is well established that matching unfamiliar faces is highly error prone, even under seemingly optimal conditions. This thesis shows large individual differences in unfamiliar face matching. Across several visual cognition tasks, the best predictor for this variability was recognition of inverted faces, regardless of whether they were familiar or unfamiliar. In stark contrast, there was no relationship between upright familiar and unfamiliar face processing. Moreover, the ability to match faces was unrelated to the ability to reject these faces, unless they were upright familiars. Therefore, the processes involved in upright unfamiliar face processing appeared to be qualitatively similar to those underlying the recognition of inverted familiar and unfamiliar faces, but very different to those responsible for upright familiar face processing. Finally, the presence of a second face severely impaired matching a target person, particularly when they were presented close together. The implications of these findings for the forensic field are discussed.

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I would like to thank Professor A. Mike Burton for his grand support and superb supervision throughout this project. I would also like to offer my gratefulness to Markus Bindemann for proofreading and great suggestions.

Declaration

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

Ahmed Megreya

Publications

Chapters 2 (Experiment 1 only), 3, 4 and 5 of this thesis have been submitted for publication.

Chapters 2 & 3

Megreya, A. M., & Burton, A. M. (in press). Unfamiliar faces aren't faces: Evidence from a matching task. *Memory & Cognition.*

Chapters 5

Megreya, A. M., & Burton, A. M. (revised). Recognising faces seen alone or with others: When two heads are worse than one. *Applied Cognitive Psychology.*

Chapters 4

Megreya, A. M., Burton, A. M. (manuscript in preparation). Hits and false positives in face matching: a familiarity-based dissociation.

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Chapter 1

Processing Unfamiliar Faces:

A General Introduction

1.1 INTRODUCTION

A great deal is now known about the perception of familiar faces (e.g. see Bruce, 1988; Bruce & Humphreys, 1994; Bruce & Young, 1999; Young, 1998; for reviews), including theoretical frameworks that provide a good understanding of how familiar faces may be processed in the human brain (Bruce & Young, 1986; Burton, 1994, 1998; Burton & Bruce, 1993; Burton, Bruce & Hancock, 1999; Burton, Bruce & Johnston, 1990; Burton, Young, Bruce, Johnston & Ellis, 1991). In contrast, rather little is still known about the processing of unfamiliar faces (e.g. Bruce & Burton, 2002; Bruce, Hancock & Burton, 1998; Hancock, Bruce & Burton, 2000; Shapiro & Penrod, 1986 for reviews). Yet, examining the processing of unfamiliar faces is of great importance, given that eyewitness identification of potential crime suspects is highly error-prone (e.g. see Cutler & Penrod, 1995; Lindsay & Pozzulo, 1999; Narby, Cutler & Penrod, 1996; Wells, Wright & Bradfield, 1999; Westcott & Brace, 2002; Wright & Davies, 1999 for reviews). Therefore, with a sound understanding of unfamiliar face processing, we might be able to evaluate the reliability of eyewitnesses and avoid cases of wrongful imprisonment (Huff, Fattner & Sagarin, 1986; Kassin, 2005; Wells, Small, Penrod, Malpass, Fulero & Brimacombe, 1998), improve eyewitness memory (e.g. see Memon, Vrij & Bull, 2003; Wells & Olson, 2003 for reviews) and develop more successful automatic face recognition systems (e.g. Burton, Miller, Bruce, Hancock, & Henderson, 2001; Hancock, Bruce & Burton, 1998).

The study of unfamiliar face processing also has important theoretical implications. For example, unlike familiar faces for which we usually posses a wealth of semantic knowledge, such as a person's name, occupation or nationality (e.g. Burton et al., 1999), analogous knowledge for unfamiliar faces is at best circumstantial and minimal. As a consequence, unfamiliar faces are excellent representatives of complex visual patterns, by which we can examine some of the processes underlying visual perception with minimal top-down contamination (e.g. see Watt, 1992 for a review). Unfortunately, existing face recognition models have consistently failed to implement processing mechanisms for unfamiliar faces, but rather suggest that the perception of familiar and unfamiliar faces are dissociable processes (Bruce & Young, 1986; Burton et al., 1999).

This thesis examines unfamiliar face processing across four themes using a variety of matching and immediate memory tasks. The first theme concerns individual differences in the recognition of unfamiliar faces. The second theme examines the relationship between the processing of upright and inverted unfamiliar faces and its relationship with upright and inverted familiar face processing. The third theme then explores the relationship between the ability to recognise a seen face and the ability to reject an unseen face as a function of familiar and unfamiliar face processing. The final theme focuses on capacity limitations during the encoding of unfamiliar faces, by examining how the recognition of one face is affected by the presence of a second face. I begin by outlining what is currently known about differences between familiar and unfamiliar face processing, followed by a review of recognition accuracy for familiar and unfamiliar faces. I then discuss how inversion affects face recognition, with particular emphasis on differences between featural and configural facial information. This is followed by a short review of the relationship between unfamiliar face recognition and eyewitness reliability. I end this chapter by describing the general methodology of the current work.

1.2 THE DISSOCIATION BETWEEN THE PROCESSING OF FAMILIAR AND UNFAMILIAR FACES

Several studies indicate that the recognition of familiar faces is dissociable from that of unfamiliar faces. Perhaps the most convincing evidence for this dissociation comes from the neuropsychological literature. For example, Malone, Morris, Kay & Levin (1982) report two surgically recovered cases of prosopagnosia, a specific disorder of the face recognition system (McNeil & Warrington, 1993). The first case could readily recognise familiar faces, but was impaired in matching unfamiliar faces. The second case, on the other hand, failed to recognise familiar faces but preserved the ability to match unfamiliar faces. This intriguing dissociation between familiar and unfamiliar face processing is not limited to Malone et al's (1982) patients, but has also been observed for patients suffering from other neurological impairments (Benton, 1980; Tranel, Damasio & Damasio, 1988; Warrington & James, 1967; Young, Newcombe, de Hann, Small & Hay, 1993).

There is also evidence that familiar and unfamiliar face processing can be dissociated in neurological normal participants. For example, it has consistently been shown that recognition of familiar faces relies more on permanent internal facial features, such as the eyes, nose and mouth, than on external features, such as hairstyle, which can change frequently for a person. In the recognition of unfamiliar faces, on the other hand, internal and external features often provide equally useful identity cues (Bonner & Burton, 2004; Ellis, Shepherd & Davies, 1979; Young, Hay, McWeeny, Flude & Ellis, 1985). Perhaps unsurprisingly then, recognition memory for familiar faces is not sensitive to changes of viewpoint or expression between study and test phase, whereas recognition memory for unfamiliar faces is highly image-based (Bruce, 1982). To this point, Begleiter, Porjesz & Wang (1995) found that the visual memory potential (VMP) component of event-related brain potentials (ERPs) also differs significantly, albeit weakly, between the recognition of familiar and unfamiliar faces. Mohr, Landgrebe & Schweinberger (2002) also found a weak but significant effect of interhemispheric cooperation for familiar but not for unfamiliar face processing. In addition, a few brain-imaging studies report different activation patterns for familiar and unfamiliar faces, suggesting that both types of stimuli may be processed by distinct neural substrates (e.g. Leveroni, Seidenberg, Mayer, Mead, Binder & Rao, 2000; but see also Rossion, Schiltz, Robaye, Pirenne & Crommelinck, 2001).

1.3 HOW ACCURATE IS UNFAMILIAR FACE RECOGNITION?

The early face recognition literature of the 1960s and 70s proposed that people are expert at recognising unfamiliar faces. For example, recognition memory rates of more than 90% were reported regularly for unfamiliar faces (e.g. Hochberg &

Galper, 1967; Nickerson, 1965; Yin, 1969). Yet, this evidence is in apparent conflict with a remarkable fallibility of eyewitness accounts, with person identification rates commonly below 40% (e.g. see Wells, 1993 for a review). Bruce (1982) proposed a credible reason for this conflict. In face recognition memory paradigms, subjects typically learn a set of faces, and then have to make old/new decisions to the same faces and some novel (unlearned) faces at a subsequent test phase (e.g. Bruce, 1982). In the eyewitness identification paradigm, on the other hand, subjects are presented with targets on video or real-life events, and are then asked to identify the targets from a photo line-up (e.g. Memon & Bartlett, 2002). Bruce (1982) presented subjects with some unfamiliar faces during a learning phase, but used either the identical images of the learned faces, as in the recognition memory literature, or different images of the same persons at test. When identical images were used, hit rates of 90% were found. Importantly however, when the learned face identities were presented in a different image, hit rates were significantly lower at 60%. This indicates that early face recognition experiments demonstrated memory for specific *images* of faces, but not for the faces per se, and that the actual *recognition* of unfamiliar faces might be rather poor in comparison.

1.3.1 Matching Unfamiliar Faces

Recent research provides converging evidence that the recognition of unfamiliar faces is rather difficult. Bruce, Henderson, Greenwood, Hancock, Burton and Miller (1999) showed subjects arrays consisting of a target face above a line-up of 10 faces, in which a different image of the target person could or could not be included (see Figure 1.1). The subjects' task was to decide whether or not the target face was present, and if so to pick the correct match. Performance on this task was *surprisingly* poor. When the target was present, subjects picked the right person on only about 70% of trials (hits), whereas they incorrectly decided that the target was not present on roughly 20% of occasions (misses) and picked a wrong person on roughly 10% of trials (misidentifications). When the target was absent, subjects still chose a person from the line-up on roughly 30% of trials (false positives), despite knowing that half of all arrays would not contain the target. Moreover, the poor face matching performance persisted even when a target face was present in each array.

This level of performance is particularly striking, because the arrays used by Bruce et al. (1999) were designed in several dimensions to optimise subjects' performance. For instance, there was no memory load and no time constraints. Moreover, all images were taken in good lighting, from very similar full-face pose, on the same day and under the same conditions, thereby eliminating any transient differences in hairstyle, weight, age or health. In fact, the biggest difference between these face images was that they were taken with different cameras. Target stills were taken from a high quality video camera, whereas the line-up images were photographs captured with a high quality studio camera. According to Bruce et al. (1999), this causes some superficial differences in quality and the general appearance of faces that makes matching difficult. To this point, Hancock, Bruce & Burton (2000) suggest that matching unfamiliar faces does not engage processes specialising on face perception (which are used for the processing of familiar faces), but employs mechanisms that are used for the matching of simple visual patterns and that do not require any domain-specific expertise.

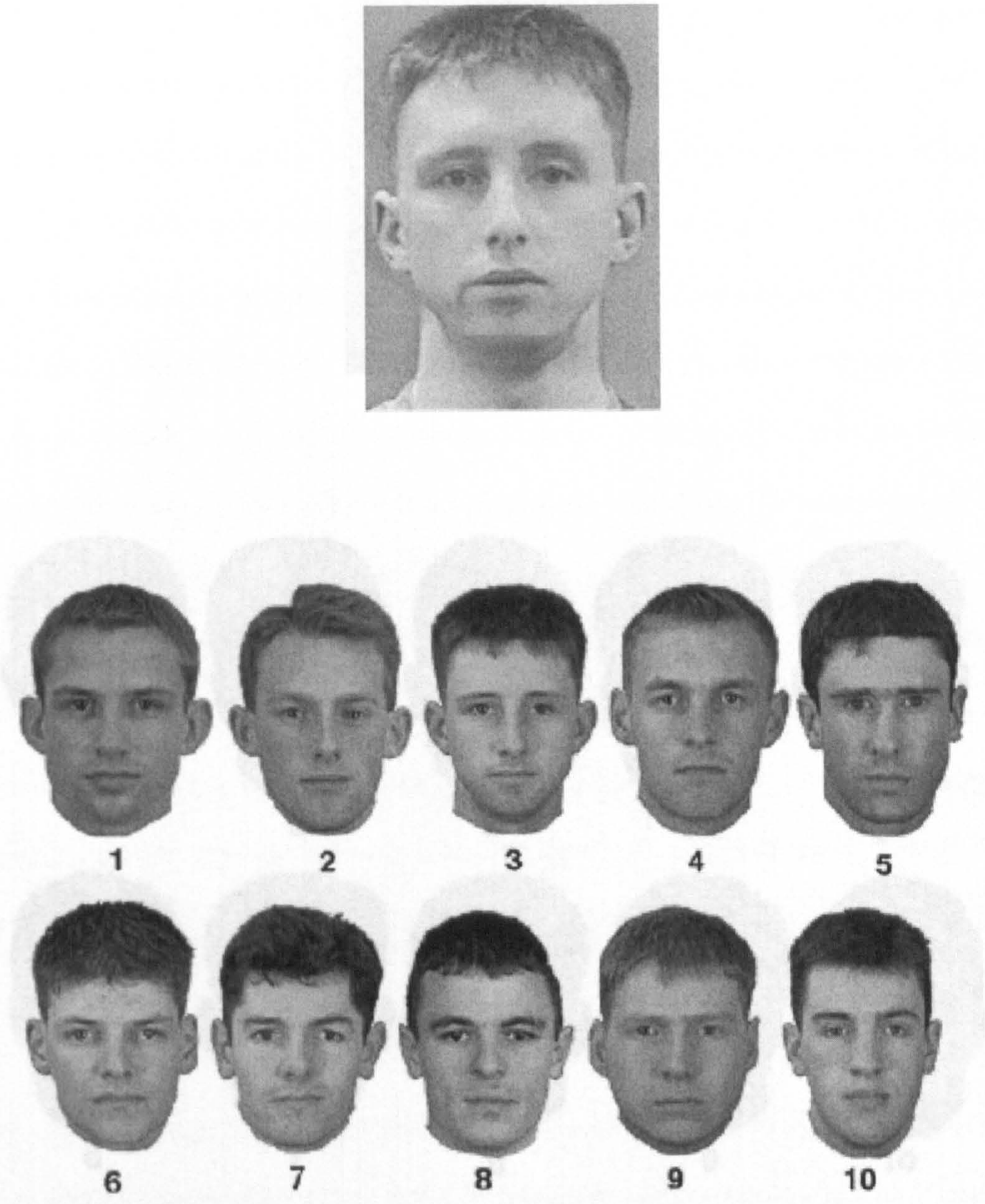


Figure 1.1a An example of target-present arrays used in Bruce et al's (1999) study. The correct match is face numbered 3.

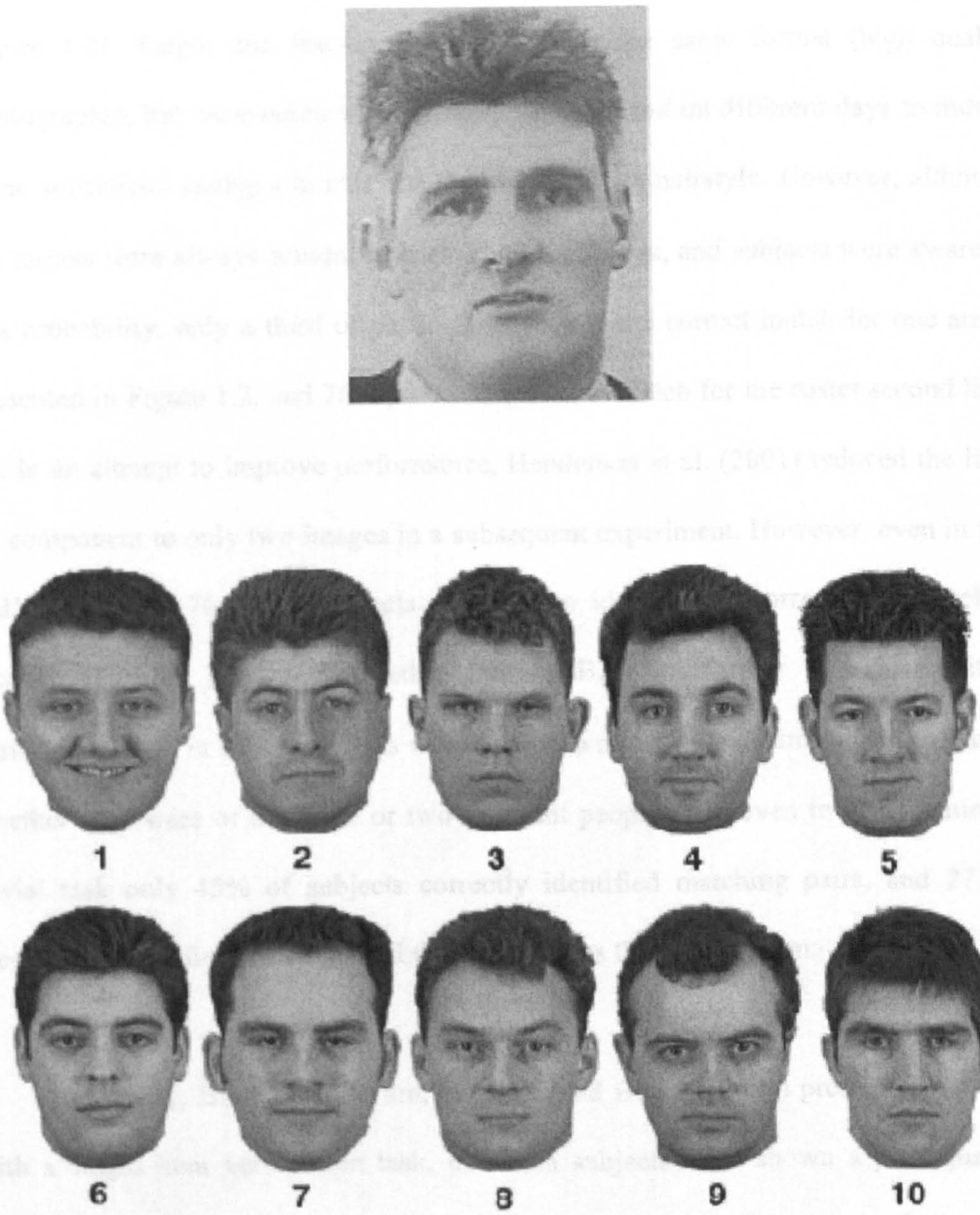


Figure 1.1b An example of target-absent arrays used in Bruce et al's (1999) study.

Henderson, Bruce and Burton (2001) confirmed Bruce et al's (1999) findings in a subsequent study. Unlike Bruce et al's (1999) stimulus arrays, Henderson et al. (2001) only used two displays, each consisting of a target and an 8-face line-up (see Figure 1.2). Target and line-up images were of the same format (high quality photographs), but were taken with different cameras *and* on different days to induce some superficial changes in external features, such as hairstyle. However, although the targets were always present in both line-up displays, and subjects were aware of this probability, only a third of participants picked the correct match for one array, presented in Figure 1.2, and 76% picked the correct match for the easier second line-up. In an attempt to improve performance, Henderson et al. (2001) reduced the line-up component to only two images in a subsequent experiment. However, even in this ABX task, only 76.2% of subjects managed to identify the correct face matches. Henderson et al. (2001) then reduced this ABX task further to a single item verification task, in which subjects were shown two images and simply had to decide whether they were of the same or two different people. Yet, even in this seemingly trivial task only 45% of subjects correctly identified matching pairs, and 27.5% incorrectly identified the target and the distractor as the same person.

Similarly, Bruce, Henderson, Newman and Burton (2001) presented subjects with a single item verification task, in which subjects were shown a poor-quality video still of a three-quarter face and a high-quality head-on photograph of a second face, and had to decide whether or not the two images were of the same person. When two images were of the same person, subjects made correct responses on only

76% of occasions. And when two different people were displayed, false positive rates of roughly 25% were found.

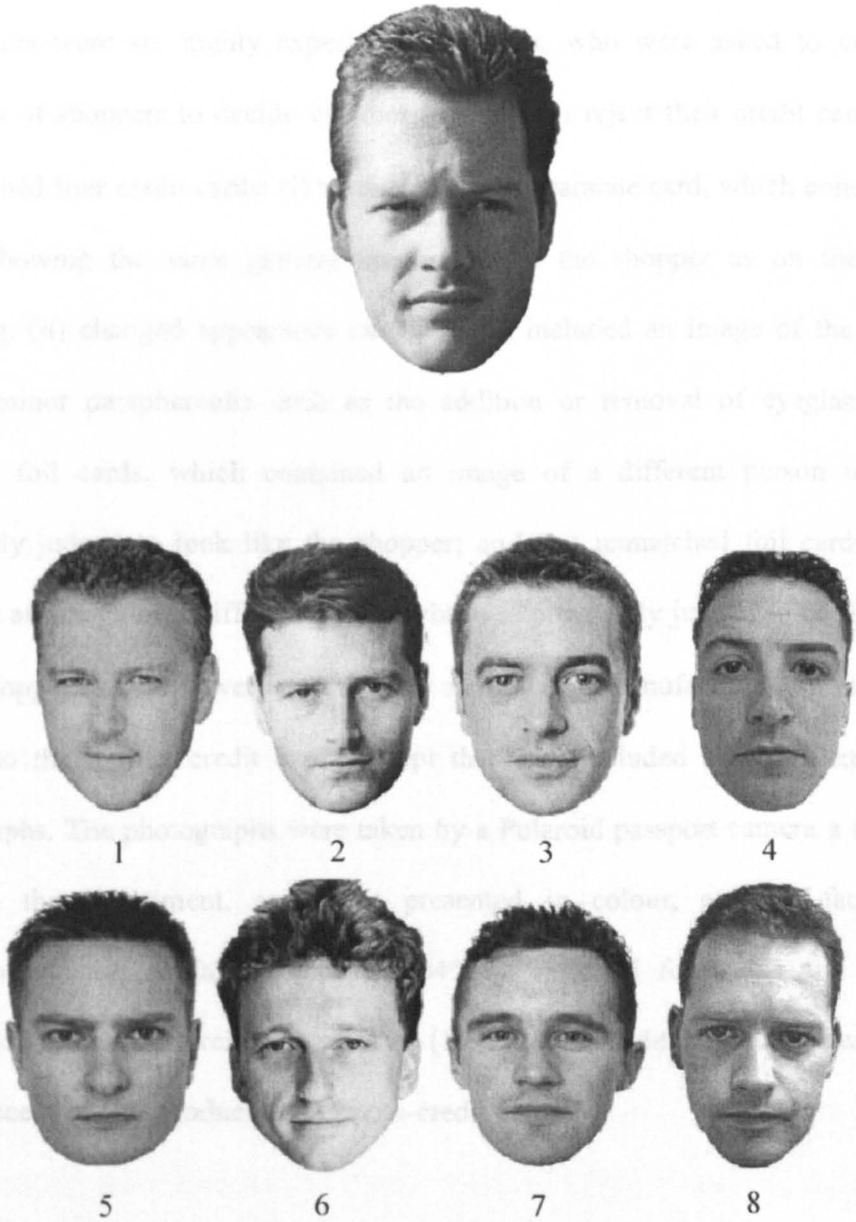


Figure 2.1 An example of target-present line-ups used in Henderson et al's (2001) study. The correct match is face numbered 8.

Outside the laboratory, the difficulty of matching unfamiliar faces has also been demonstrated by Kemp and associates in a real-life scenario. Kemp, Towell and Pike (1997) examined the accuracy of identity verification of people bearing photo-credit cards. The experiment was run in a genuine supermarket setting, and participants were six highly experienced cashiers, who were asked to verify the identities of shoppers to decide whether to accept or reject their credit cards. Each shopper had four credit cards: (i) an unchanged appearance card, which contained an image showing the same general appearance of the shopper as on the day of shopping; (ii) changed appearance cards, which included an image of the shopper with a minor paraphernalia such as the addition or removal of eyeglasses; (iii) matched foil cards, which contained an image of a different person who was previously judged to look like the shopper; and (iv) unmatched foil cards, which included an image of a different person who was previously judged to be dissimilar to the shopper. All cards were produced by a credit card manufacturer, and were very similar to the normal credit cards except that they included a small 2cm x 2cm photographs. The photographs were taken by a Polaroid passport camera a few days prior to the experiment, and were presented in colour, and full-face view. Surprisingly, cashiers falsely accepted 64% of matched foil cards and 34% of unmatched foil cards, forcing Kemp et al. (1997) to conclude that security would not be enhanced by the introduction of photo-credit cards.

Nonetheless, note that the low level of matching performance for unfamiliar faces, in the research that I have reviewed so far, does not necessarily suggest that the recognition of unfamiliar faces in real life is equally poor. Indeed, live faces provide considerable more information than photographic faces. For example, live faces are usually seen in motion, which may facilitate recognition, whereas photographic faces are static. To examine this hypothesis, Bruce et al. (1999) asked subjects to match unfamiliar faces that were either presented in static still images (as presented in Figure 1.1) or from video displays for a limited (5 seconds) or unlimited time period. In the free viewing (unlimited) condition, subjects were allowed to inspect, rewind, replay, or pause the video until they felt confident that they could accept or reject the faces. Under this condition, a hit rate of 79% was found. Notably, this recognition rate is still rather poor and suggests an alarming degree of potential error in eyewitness identification. However, it was significantly higher than hit rates for static faces and videoed faces seen under limited conditions. Indeed, hit rates for matching faces seen in static images (68%) or in video (67%) were very similar to each other. Therefore, movement alone does not appear to improve face-matching performance. This conclusion receives further support from Kemp et al.'s (1997) study, where subjects also failed to match high quality photographs to faces seen live.

In contrast to matching performance, the effect of movement on recognition memory of unfamiliar faces is rather inconclusive. Although some studies report a movement advantage (e.g. Pike, Kemp, Towell & Phillips, 1997), others have not found a benefit of movement (e.g. Christie & Bruce, 1998). In contrast, there is more reliable evidence that movement facilitates recognition of familiar faces (Knight & Johnston, 1997; Lander & Bruce, 2000; Lander, Bruce & Hill, 2001; Lander, Christie

& Bruce, 1999). These findings are summarized in a recent review by Roark, Barrett, Spence, Abdi & O'Toole (2003), who conclude that movement is helpful for recognising familiar faces, but that its benefits are less certain with unfamiliar faces. Importantly, this suggests that the low level of unfamiliar face recognition performance is not *artificial*, in the sense that it is limited to laboratory studies, but that it may extend to real-life studies. More evidence in support of this argument comes from change blindness experiments.

1.3.2 Change Blindness Of Identity

It is well established that people often fail to notice large changes to visual scenes, a phenomenon which is now known as change blindness (see Rensink, 2002; Simons, 2000; Simons & Levin, 1997; Simons & Rensink, 2005 for reviews). Simons & Ambinder (2005) suggest that change blindness may result from the difficulty in encoding, retaining and comparing visual information from one glance to the next. Intriguingly, one of the largest changes that people often fail to notice is replacement of identities. For example, 50% of observers failed to notice a change of heads in a picture of two cowboys sitting on a bench (Grimes, 1996). In another study, Levin and Simons (1997) showed subjects a video clip, in which one actor was replaced by second actor. Figure 1.3 shows some example video stills from this experiment. Here, an actor is sitting at a desk and then rises to answer the wall-phone. Unknown to the viewers, the actors are exchanged during this sequence. And importantly, although subjects were able to provide detailed descriptions of this sequence after viewing the video clip, two thirds of subjects failed to notice this change in identity. These results therefore provide some further evidence for the poor recognition of unfamiliar faces.

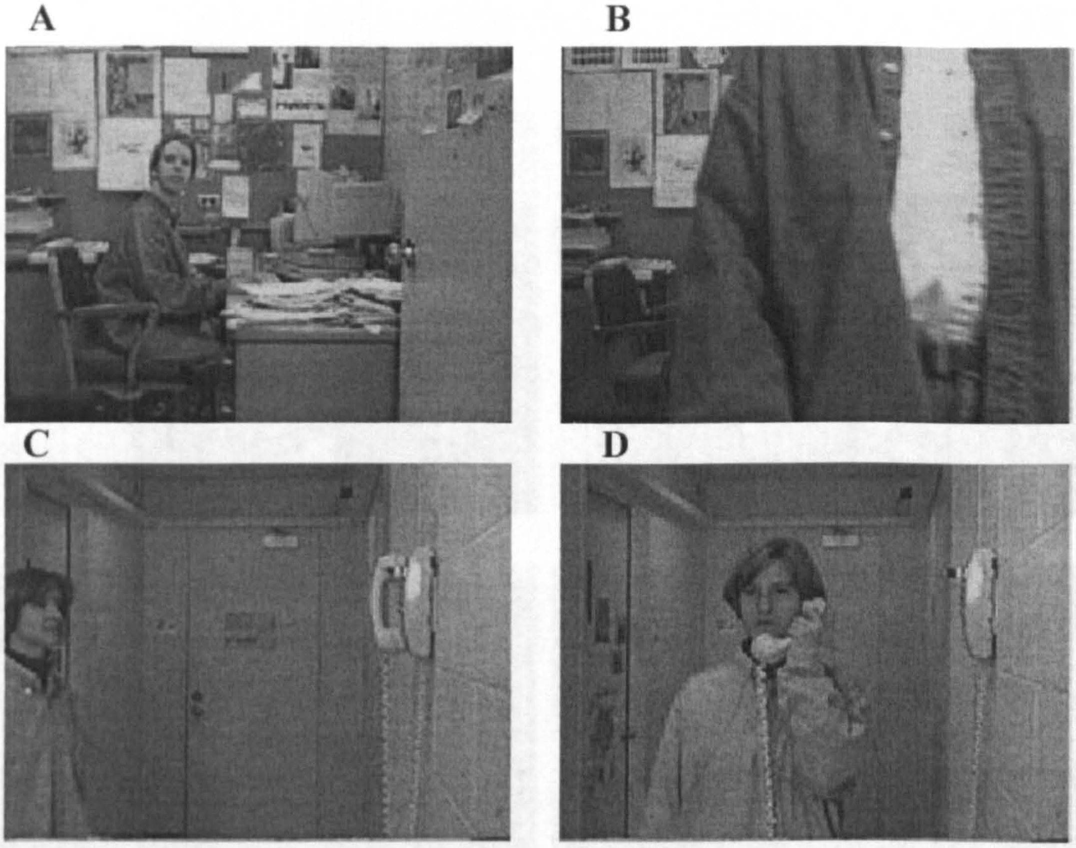


Figure 1.3 Stills from an actor change video clip used in Levin and Simons's (1997) study.

Subsequently, Simons and Levin (1998) also replicated these change blindness effects in a real-life experiment. In this, an experimenter carrying a map approached pedestrians on a university campus to ask for directions. While they were conversing, two other people carrying a large door seemingly inadvertently passed between them, and the experimenter was replaced by another person (see Figure 1.4). Surprisingly, more than 50% of pedestrians failed to notice this replacement, and continued the conversation as if nothing had happened. Moreover, when they were asked if they had noticed anything unusual, they often only reported that "*the people carrying the door were rude*" (p. 646).

Figure 1.4 The procedure of Simons and Levin's (1998) study.

Levin, Simons, Angelone and Chabris (2002) replicated change blindness of identities using yet another real-life scenario, but in which there was no distraction (e.g. giving direction) or unusual disruption (e.g. the door). This time, an experimenter approached participants and asked them if they would like to participate in a psychology experiment. The participant was given a consent form to read and sign. The experimenter then took the form and briefly disappeared behind a counter, where the replacement was made. A second person then rose and handed the participant a packet of questions and continued conversation. Although the original person and the replacement had similar clothes, they were dissimilar in their facial appearance. Yet once again, three-quarter of participants failed to notice the change in identity.

Importantly, in spite of this alarming fallibility, people usually over-estimate their ability to detect changes, and specifically changes in identity. Levin, Momen, Drivdahl and Simons (2000) termed this over-estimation "*change blindness blindness*", and described it as a meta-cognitive error. A similar position may be taken for matching unfamiliar faces. Thus, people may often think that face matching could be an easy task (Liu & Chaudhuri, 2000), but the ease or difficulty of this task is largely determined by the overall resemblance between faces (Hancock, Bruce & Burton, 2001). Moreover, experimental research, as discussed earlier, has consistently found that matching unfamiliar faces is highly error prone (Bruce et al., 1999, 2001; Henderson et al., 2001; Kemp et al., 1997).

Levin et al. (2002) also examined the relationship between recognition memory and change detection with a real-life person change. Participants who missed the identity change failed to identify both the pre- and post- change targets (37% and 32%, respectively) from a 4-person line-up. Notably, this finding does not support the rather simple *over-writing* hypothesis of change blindness (see Simons, 2000 for a review), as there was no advantage for recognising the post-change target. Participants who noticed the change, on the other hand, correctly identified both the pre- and post- change targets (81% and 73%, respectively) above chance levels. Consequently, Levin et al (2002) concluded that the inability to detect changes in identity is caused by a representation failure. Participants who missed the change, compared to those who noticed it, were more likely to insufficiently represent both targets.

Angelone, Levin and Simons (2003) hypothesized that this representation failure may be due to participants not intentionally encoding identity-related information because the real-life interaction was completely unexpected. Therefore, Angelone et al. (2003) re-examined the relationship between change blindness of identity and recognition memory for face targets, but with an intentional encoding method. Participants were presented with a silent video display, in which two female actors were switched with each other. Participants were instructed to concentrate on and to expect questions related to the video. Yet, 43.5% of participants still failed to notice the change in identity. However, when they were presented with a picture of the post-change actor and were asked to identify the pre-change actor from a 4-person line-up, then those participants who missed and those who noticed the replacement all identified the pre-change actor above chance (53.3% and 46.2%, respectively).

From these results, Angelone et al. (2003) concluded that change blindness (under this intentional encoding process) is caused by a comparison rather than a representation failure. Participants who missed the identity change did encode the pre-change target, but failed to compare between the pre- and post-change actors. This idea converges with a conclusion put forward in a recent review by Simons and Ambinder (2005) that change blindness suggests capacity limits in encoding, retaining, and comparing visual information. Indeed, outside the person recognition domain, Scott-Brown, Baker and Orbach (2000) have managed to demonstrate change blindness with a *simultaneous* visual pattern-matching task, which lead them to re-define this phenomenon as a "comparison blindness".

This position converges with the face-matching task, where the perceptual comparison between simultaneously presented faces is highly error prone. Therefore, change blindness of identities might reflect a general difficulty in encoding unfamiliar faces. Or alternatively, the face matching errors of false positives (choosing a face in target-absent array), misidentification (choosing a wrong face in target-present array), and miss (deciding that the target is absent while he is present) may represent some form of encoding blindness that is specific to change or comparison tasks.

1.4 RECOGNITION OF FAMILIAR FACES

The low level of performance for the matching of unfamiliar faces is in stark contrast to our excellent ability to recognise familiar faces. In one notable study, Burton, Wilson, Cowan and Bruce (1999) asked subjects to learn some identities from video clips captured by low quality CCTV security camera. Two thirds of subjects were students, who were either familiar or unfamiliar with the targets, and the remaining subjects were highly experienced police officers, who were also unfamiliar with the targets. At test, subjects were presented with high quality photographs, half of which showed the targets and half of which showed new persons, and were asked to indicate whether or not each face had been previously seen on video. Subjects were extremely accurate in recognising persons' faces, but *only* when the faces belonged to someone familiar. Subjects unfamiliar with the targets performed poorly, regardless of whether they were students or police officers. More recently, Liu, Seetzen, Burton and Chaudhuri (2003) replicated these results with images that were either congruent or incongruent in resolution between study and test phase. Other studies that have compared memory for familiar and unfamiliar faces with high quality images also provide similar results: recognition memory is superior for familiar than for unfamiliar faces (e.g. Klatzky & Forrest, 1984).

Memory for familiar faces is also remarkably robust over long intervals. Bahrick, Bahrick and Wittlinger (1975) conducted a real-life study to examine whether people could recognise familiar faces across long retention intervals, which ranged from 2 weeks to 57 years, using photographs of faces taken from high school yearbooks. They found that graduates could successfully recognise more than 90% of their old classmates, even after retention periods of 15 to 34 years. In fact, 48 years after graduation, subjects could still recognise 73% of their classmates' faces. Note, however, that the accuracy of memory for familiar faces over such long retention interval seems to be mediated by the *level* of familiarity. Bahrick (1984) examined the ability of college teachers to recognise students of introductory university classes, which lasted for 10 weeks and were held 3-4 times per week. Here teachers could 'only' recognise 69%, 48%, 31%, and 26% of the students after 3 months, and one, four, and eight years, respectively. Finally, and in contrast to unfamiliar identity processing, Levin and Simons (1997) failed to observe change blindness of identity when observers were familiar with the actors.

In summary, there are a number of important differences between familiar and unfamiliar face processing. Recognition of unfamiliar faces is easily disrupted by variations in viewing conditions such as viewpoint, orientation, lighting, and quality, whereas recognition of familiar faces is very robust under equivalent conditions. Moreover, people are still remarkably poor at recognising unfamiliar faces under seemingly optimal conditions (e.g. Bruce et al, 1999), whereas people are still extremely accurate at recognising familiar faces under highly demanding conditions (e.g. Burton et al., 1999). However, in spite of this dissociation, there are some circumstances where familiar and unfamiliar faces behave remarkably similar to each other, namely when these stimuli are displayed upside-down (e.g. Collishaw & Hole, 2000). The effect of inversion on familiar and unfamiliar face processing is reviewed in the next section.

1.5 THE FACE INVERSION EFFECT

Rotation of most visual patterns so that they are upside-down makes them more difficult to recognise (e.g. Rock, 1974). These inversion effects have been observed for many non-face objects such as dogs (Diamond & Carey, 1986), Greebles (Gauthier & Tarr, 1997), handwriting (Rock, 1974), dot patterns (Farah, Drain & Tanaka, 1995), and the human body (Reed, Stone, Bozova & Tanaka, 2003). However, there is a great deal of evidence that inversion *disproportionately* impairs the recognition of faces compared to other non-face objects, which are usually only seen in upright orientation (e.g. Diamond & Carey, 1986; Scapinello & Yarmey, 1970; Valentine & Bruce, 1986; Yin, 1969). For example, Yin (1969) found that when photographs of faces, houses, aeroplanes, and men in motion were presented and tested upright, recognition memory for faces was significantly better than for the non-face objects. By contrast, when these photographs were presented upside-down, faces became the most difficult stimuli to recognise. Another dramatic demonstration of face inversion is an effect called the "*Thatcher illusion*", because a picture of Margaret Thatcher's face was originally used to illustrate it (Thomson, 1980). In this illusion, inverting the eyes and mouth in an upright face makes it look grotesque, but this grotesqueness *totally* disappears when the face is inverted (see Figure 1.5).

The impairment that is caused by rotating faces upside-down is commonly known as the Face Inversion Effect (FIE). This effect has now been replicated using a range of experimental procedures (see Valentine, 1988 for review) and some authors describe it as a "signature" of face recognition (Murray, Rhodes & Schuchinsky, 2003). Consequently, the face inversion effect is of important theoretical significance for the idea of face specialisation (e.g. Yin, 1969), as it has often been interpreted as evidence that upright face processing engages a separate recognition module to other stimulus categories (e.g. see Farah, 1996; Kanwisher, 2000 for reviews).

Figure 1.5 The "Thatcher illusion".

1.5.1 Causes Of The Face Inversion Effect

Several explanations have been proposed for the face inversion effect, including: (i) a difficulty in encoding facial expressions from inverted faces (Yin, 1970); (ii) the inability to correct the misoriented features at one time (Rock, 1974); (iii) the rigidity of changing the developed face schema (Goldstein & Chance, 1980); (iv) the noise of encoding inverted faces in the multidimensional face space (Valentine, 1991); and (v) the inability to encode configural information (the spatial relationships between face regions) from inverted faces (e.g., Carey & Diamond, 1977; Diamond & Carey, 1986). This last explanation is the most plausible interpretation for the face inversion effect and has been supported by different methodologies (Bartlett & Searcy, 1993; Farah, Drain &Tanaka, 1995; Freire, Lee & Symons, 2000; Leder & Bruce, 2000; Rhodes, Brake & Atkinson, 1993; Searcy & Bartlett, 1996; Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Young, Hellawell & Hay, 1987). For example, Young et al. (1987) presented subjects with 'chimeric' face stimuli, which were constructed by combining the top halves and the bottom halves of different famous faces. The chimeric faces were either closely aligned or misaligned (see Figure 1.6). The subjects' task was to name the top halves. Young et al. (1987) found that recognition of chimeric faces was slower when aligned than when misaligned. Presumably, close alignment produced a new configuration, making it difficult to process the two different halves independently. Importantly however, this effect disappeared when the chimeric faces were presented upside down.

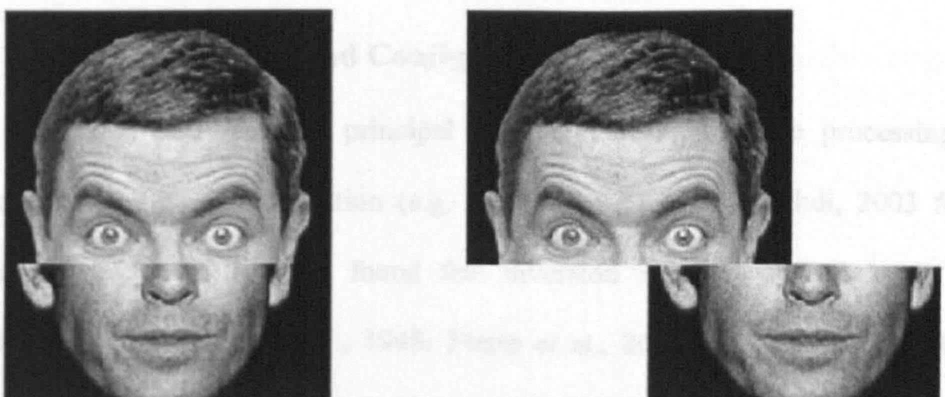


Figure 1.6 The chimeric face effect first demonstrated by Young, et al (1987). The faces in this example belong to Rowan Atkinson (top) and Pierce Brosnan (bottom), and were adapted from Jenkins (2001).

Diamond and Carey (1986) proposed that expertise is the main component of processing configural information, which is inaccessible to inverted faces. To test this idea, dog experts and novices were presented with photographs of dogs and human faces in both upright and inverted orientations, and were then given a forced-choice recognition test. Novices showed the detrimental effect of inversion for faces but not for dogs. Importantly, inversion impaired recognition of both faces and dogs in experts. Therefore, Diamond and Carey (1986) suggested that the large inversion effect could be observed for any object whenever three conditions are met: (i) there is configural information shared by a class of objects; (ii) it is possible to individuate the members of that class on the basis of configural information; and (iii) there is the expertise to exploit such configural information. Consistent with Diamond and Carey's (1986) theory, Rhodes, Brake, Taylor and Tan (1989) found larger inversion effects for the recognition of 'own-race' (high expertise) than 'other-race' (low expertise) faces.

1.5.2 Processing Featural And Configural Information

Inversion has been the principal tool for investigating the processing of featural and configural information (e.g. see Bartlett, Searcy & Abdi, 2003 for a review). It has generally been found that inversion impairs configural, but not featural processing (Farah et al., 1995; Freire et al., 2000; Leder & Bruce, 2000; Searcy & Bartlett, 1996; Tanaka & Farah, 1993). For example, Farah et al. (1995) found that inversion significantly impaired recognition when faces were learned holistically, but not when they were learned in parts. This effect does not appear memory-specific, but may reflect the encoding of faces. For example, Searcy and Bartlett (1996) found that inversion significantly reduced rated grotesqueness of configurally-changed faces, but had no effect on grotesqueness received from featurally-changed faces. In addition, inversion impaired detecting configural but not featural changes using a sequential face change detection task (Freire et al., 2000).

These results suggest that processing featural and configural information may be dissociable, and that recognition of upright faces may depend on configural information whereas recognition of inverted faces may rely on featural information (see Bartlett et al., 2003 for a review). However, these suggestions were recently subject to question. One extreme view is that configuration is *the* key component for face processing, while features are of little or no importance (Bartlett & Searcy, 1993; Friere et al 2000). At the other extreme of this debate, features are thought to be processed and represented independently (e.g. Macho & Leder, 1998; Rakover & Teucher, 1997). Cabeza and Kato (2000) propose an intermediate view, which is that features are important, alongside configural information, but that the processing of facial features and configuration differ qualitatively from each other.

It should be noted that some studies have found a detrimental effect for inversion on the processing of featural information (e.g. Barton, Deepak & Malik, 2003; Rhodes et al., 1993; Rakover & Teucher, 1997). For example, Rhodes et al. (1993) showed that inversion impaired recognition of faces, in which some features such as the eyes or mouth were swapped with different face's features, but this impairment disappeared when the features were presented in isolation, devoid of face context. Bartlett et al. (2003) interpreted this finding as that "*What is nominally a featural difference might be, functionally, a configural difference*" (p. 24). Yet, Rakover and Teucher (1997) also found that inversion impaired recognition of features presented in isolation. To this point, Bruce and Humphreys (1994) state that "*it seems to be difficult or impossible to encode a particular part or 'feature' of an upright face without some influence from other, more distant features*" (p. 152). This hypothesis seems to converge with the view that faces are processed holistically (Tanaka & Farah, 1993). Tanaka and Sengco (1997) found that changing the configural information of the eyes not only impaired the featural processing of the eyes but also impaired the featural processing of the nose and mouth, whose configural information was not directly changed. Therefore, Tanaka and Sengco (1997) concluded that the featural and configural information has interdependent contributions for face processing. From this conclusion, it is hypothesized that familiarity may improve holistic representation of faces because recognition of familiar faces is always more accurate than recognition of unfamiliar faces (e.g. Burton et al., 1999).

1.6 UNFAMILIAR FACE RECOGNITION AND EYEWITNESS RELIABILITY

In everyday life, the advantage of familiar face recognition may have fewer obvious consequences than the disadvantage of unfamiliar face recognition. Namely, errors of recognising familiar people, when it occurs, may cause some social embarrassment (Young, Hay & Ellis, 1985), but the more frequent errors of recognising unfamiliar persons may, for example, result in the imprisonment of an innocent person. Indeed, it has been found that between 60 % (Huff et al., 1986) and 90 % (Wells et al., 1998) of cases of wrongful imprisonment involved eyewitness misidentifications (for further evidence of error-prone eyewitness accounts, see Cutler & Penrod, 1995; Kassin, 2005; Lindsay & Pozzulo, 1999; Narby et al., 1996; Wells et al., 1999; Westcott & Brace, 2002; Wright & Davies, 1999 for reviews).

The unreliability of eyewitness evidence may be caused by the difficulty in recognizing unfamiliar faces in general or by the difficulty of encoding unfamiliar faces in particular. There are two sources of evidence that could support the latter hypothesis. First, some studies show a positive correlation between performance on the Benton face-matching test and eyewitness identification accuracy (Hosch, 1994; Searcy, Bartlett & Memon, 1999). Second, Davies and Thasen (2000) found that giving eyewitnesses an image of the target did not *greatly* improve their identification from memory (hit rates of 78% and 85% were found for identification from memory or from view, respectively).

Note that this hypothesis has been challenged in a number of ways. First, it has been argued that seeing a target in motion may facilitate subsequent identification accuracy (e.g. Pike et al., 1997). Second, person recognition is "*more than a pretty face*" and may also involve other cues, such as body posture and gait (Patterson, 1978). Some authors also point out that eyewitnesses "*have ears*", and may therefore rely on voice recognition cues whenever possible (Bull, 1978). However, the effects of movement on unfamiliar face recognition are at best marginal (see section 1.3.1), and the eyewitness identification literature reports very low recognition rates of suspects seen on video or live. For example, Memon and Bartlett (2002) recorded hit rates of only 35% for targets seen on video and Yarmey (2004) obtained hit rates of 49% for live targets.

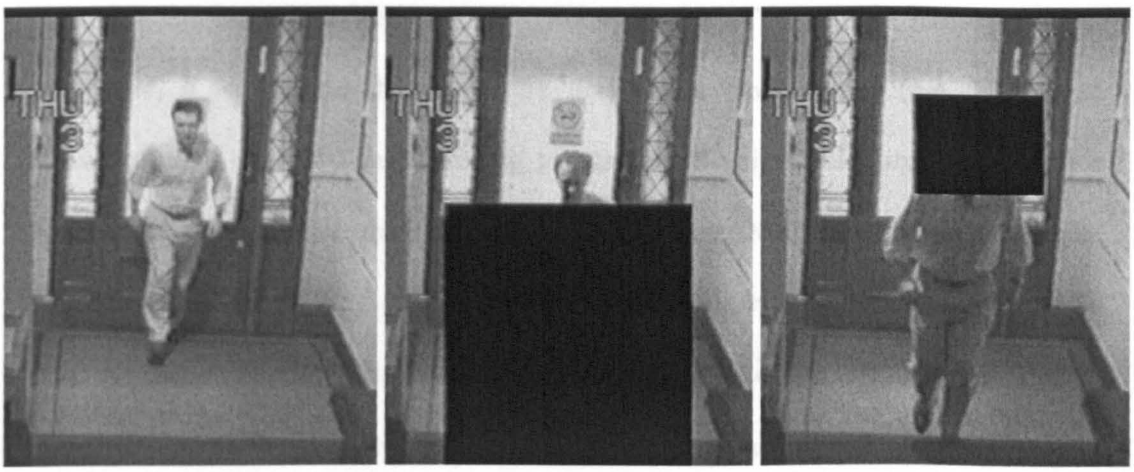


Figure 1.7 shows example stills from video sequences used in Burton et al's (1999) study.

In one particular study, Burton et al. (1999) examined the reliability of faces, compared to the whole body and gait, as a cue of identity. Subjects were asked to identify some personally familiar identities from their faces without bodies, bodies without faces, gaits without faces, and whole persons (see Figure 1.7). In each condition targets were seen on motion in video clips, each of which lasted for 3 seconds. When faces were obscured, identification rates were significantly worse than any other condition. Burton et al. (1999) concluded that information received from faces is more useful for person identification than information received from the gait or the body. Pryke, Lindsay, Dysart and Dupuis (2004) supported this conclusion using unfamiliar faces. Namely, Pryke et al. (2004) found that identification of a target seen live was significantly worse from a body line-up than from a face-line-up.

Ear-witness identification is also not as reliable as eyewitness identification. Some evidence indicates that identification from voices is significantly worse than identification from faces (Pryke et al., 2004; Yarmey, Yarmey & Yarmey, 1994). Moreover, it is thought that faces are dissociable from voices (e.g. Neuner & Schweinberger, 2000). Thus, listening to someone's voice while studying the face has no effect on the accuracy of facial identification (McAllister, Dale, Bregman, McCabe & Cotton, 1993), and seeing someone's face while listening to the voice does not improve the accuracy of voice recognition (Legge, Grosmann & Pieper, 1984). On the contrary, it impairs voice recognition (Cook & Wilding, 1997).

Thus, the three strands of research reviewed so far in this chapter – the difficulty that people generally have in matching unfamiliar faces, the poor recognition of unfamiliar persons seen in live situations, and the fact that faces provide the most powerful means of person identification – suggest that the unreliability of eyewitness identification may be due particularly to the difficulty of *encoding* unfamiliar faces in the first place. However, as we will see in the next section, there are also some other factors that may affect eyewitness identification.

1.7 FACTORS AFFECTING EYEWITNESS IDENTIFICATION

The poor recognition of unfamiliar faces appears to be the most general source of eyewitness identification errors. However, there are also some other variables governing the accuracy of eyewitness identification. Wells (1978) distinguished two kinds of variables: (i) estimator variables, which are beyond the control of the criminal justice system, such as the exposure duration of witnessing a crime; and (ii) system variables, which refer to the factors that are directly under the control of the criminal justice system, such as presenting eyewitnesses to culprit-absent prior to culprit-present line-ups. Estimators and system variables have been subject to a number of archival studies (e.g. Wright & McDaid, 1996), and to several experimental reviews (Lindsay & Pozzulo, 1999; Memon et al., 2003; Narby et al., 1996; Shapiro & Penrod, 1986; Wells & Olson, 2003; Wells et al., 1999; Westcott & Brace, 2002).

1.7.1 Estimator Variables

Estimator variables include factors related to eyewitnesses, perpetrators, and the crime situations. Gender is one of the eyewitness factors, but it has no effect on identification accuracy (e.g. Clifford & Scott, 1978; Valentine, Pickering & Darling, 2003). Unlike gender, race has a reliable effect. There is a consensus that cross-race identification is poorer than same-race identification (Behrman & Davey, 2001; Wright & McDaid, 1996; Valentine, et al, 2003). Age is the most investigated factor of eyewitnesses' characteristics. Adults are more likely to correctly identify the target than children (e.g. Clifford, 1993; but see Pozzulo & Lindsay, 1998) or seniors (e.g.

Memon & Bartlett, 2002; Searcy, Bartlett & Memon, 1999); On the other hand, there is a relatively dearth of work on the impact of individual differences on identification accuracy. Neuroticism (Bothwell, Brigham & Pigott, 1987) and self-monitoring (Hosch, 1994) have moderate effects on identification accuracy, but there is no effect for extraversion (Clifford & Scott, 1978).

Distinctiveness is one of the perpetrator factors that may affect identification accuracy. Namely, unusual-looking targets are easier to identify than typical targets (e.g. Shepherd, Gibling & Ellis, 1991). Another perpetrator factor is disguise. It is not surprising that disguised targets are more difficult to identify than non-disguised targets (e.g. Henderson et al., 2003; Patterson & Baddeley, 1977). Other factors such as age, gender, or attractiveness seem to have no effect on identification accuracy (see Shapiro & Penrod, 1986 for a review).

There is a large body of work investigating the role of situational factors on identification accuracy indicating that: (i) there is an advantage for longer exposure duration (Memon, Hope & Bull, 2003; Valentine et al., 2003); (ii) there is a disadvantage for the presence of weapon (Maass & Kohnken, 1989; Tooley, Brigham, Maass & Bothwell, 1987); (iii) being alcohol intoxicated while witnessing the crime has a detrimental effect on identification (Dysert, Lindsay, MacDonald & Wicke, 2002); (iv) identification accuracy in violent crimes is poorer than in non-violent crimes (Clifford & Hollin, 1981); (v) expecting a subsequent identification test while viewing the target has a beneficial effect on identification accuracy

(Kerstholt, Raaijmakers & Valenton, 1992); (vi) accurate identifications are more likely to be elicited for high serious crimes than for low serious ones (Leippe, Wells & Ostrom, 1978); (vii) there is a disadvantage for longer retention intervals (Behrman & Davey, 2001; Flin, Boone, Knox & Bull, 1992); and (viii) increasing the number of perpetrators has a significant detrimental effect on identification accuracy (Clifford & Hollin, 1981).

1.7.2 System Variables

Because system variables are largely under the control of the justice system, the second largest part of the identification literature has investigated the factors that might improve eyewitness identification procedures. This research indicates that identification could be significantly impaired by: (i) biased instructions (e.g. Malpass & Devine, 1981); (ii) presenting the line-up members sequentially, rather than simultaneously (Memon & Bartlett, 2002; Memon & Gabbert, 2003), though this significantly reduces false positives (e.g. Lindsay, Lea, Nosworthy, Fulford, Hector, et al., 1991; Lindsay & Wells, 1985); (iii) investigator bias (Garrioch & Brimacombe, 2001; Haw & Fisher, 2004; Phillips, McAuliff, Kovera & Cutler, 1999); (iv) giving eyewitnesses misleading information such as wrong composites (Comish, 1987; Gibling & Davies, 1988; Jenkins & Davies, 1985); (v) exposure to Mugshots (Davies, Shepherd & Ellis, 1979; Dysart, Lindsay, Hammond & Dupuis, 2001; Memon, Hope, Bartlett & Bull, 2002); (vi) verbal descriptions of targets (e.g. Schooler & Engster-Schooler, 1990), though this effect seems to be not universal

(Lyle & Johnson, 2004; Memon & Bartlett, 2002); (vii) line-up bias (e.g. Luus & Wells, 1991); and (viii) clothes bias (Lindsay, Wallbridge & Drennan, 1987).

Although presenting eyewitness with target-present and target-absent line-ups is a very common procedure in the real forensic practice, the effectiveness of this procedure was not evaluated in the eyewitness identification literature. However, some evidence from the face recognition literature does not support this procedure. Thus, it has consistently been found that hits and false positives do *not* correlate with each other (Bruce, Burton & Dench, 1994; Hancock, Burton & Bruce, 1996; Lewis & Johnston, 1997; Vokey & Read, 1992). This implies that eyewitnesses who are likely to incorrectly identify an innocent person from a target-absent line-up may still be able to correctly identify the actual culprit from a target-present line-up.

1.7.3 Post-Dictors Of Identification Accuracy

After completing the identification process, the investigator may be able to distinguish between accurate and inaccurate identifications via a few factors. One of these factors is to ask eyewitnesses about their confidence in their decisions. Although there is some evidence indicating that confidence could significantly predict identification accuracy (Sporer, Penrod, Read & Cutler, 1995), confidence is malleable (Wells, Olson & Charman, 2002). For example, giving eyewitnesses positive post-identification feedback (e.g. "*good, you identified the suspect*") inflates their confidence (Semmler, Brewer & Wells, 2004; Wells & Bradfield, 1998, 1999; Wells, Olson & Charman, 2003), and reduces the relationship between confidence and accuracy (Bradfield, Wells & Olson, 2002). The second post-dictor factor concerns decision processes. Accurate eyewitnesses are more likely to describe that their decisions result from automatic recognition processes (e.g. to state that the target just "popped out" to them), whereas inaccurate eyewitnesses are more likely to describe their decisions as a result of an elimination process (Dunning & Stern, 1994; Kneller, Memon & Stevenage, 2001). The third post-dictor is response times. Accurate identifications are usually made faster than inaccurate identifications (Dunning & Stern, 1994; Kneller et al., 2001). For example, Dunning and Scott (2002) found that a time boundary of roughly 10 to 12 seconds could significantly differentiate between accurate and inaccurate positive identifications, although other does not support this particular time boundary (Weber, Brewer, Wells, Semmler & Keast, 2004). Smith, Lindsay and Pryke (2000) compared between confidence, response latency, decision processes, and line-up fairness as post-dictors of identification accuracy, and found that decision times and line-up fairness are the best.

Several of estimator and system variables are examined in this thesis, namely individual differences, distinctiveness, the number of perpetrators, and the presence vs. absence of targets. Some post-dictors are also examined, namely confidence and decision processes. If these factors have an effect on face matching, then one could conclude that their effects on identification accuracy might be mediated by the effects on encoding unfamiliar faces in the first place.

1.8 STRUCTURE OF THIS THESIS

The aim of this thesis was to examine the processing of unfamiliar faces. The first experimental chapter examined individual differences in encoding unfamiliar faces, which was measured with a face-matching task. Experiment 1 hypothesized that unfamiliar faces may share some characteristics with other visual patterns during processing. To test this hypothesis, the covariation between face encoding and some general visual recognition tests (e.g. cognitive styles, perceptual speed, and visual short term memory) was examined. Experiment 2 examined the relationship between face encoding across and within identities, by examining the association between subjects' performance on face matching and face change detection tasks. Experiment 3 examined the intra-individual consistency of face matching. Subjects were presented twice with a match/mismatch task, with an intervening period of approximately one week.

The relationship between upright and inverted unfamiliar face processing and its relationship with the processing of upright and inverted familiar faces was then examined in Chapter 3. Subjects were shown unfamiliar face targets either in an upright or an inverted orientation, and were presented with simultaneous (Experiment 4) or sequential (Experiment 5) line-ups of 10 upright unfamiliar faces. In Experiment 6, the targets and 10-face line-ups were both presented as upright or inverted in a simultaneous face-matching task. The 1 in 10 face matching arrays were reduced to match/mismatch pairs, and were presented as upright or inverted in Experiment 7. Experiment 8 examined the relationship between processing upright and inverted famous faces, and its relationship with upright unfamiliar face processing, which was measured both by perceptual matching and immediate memory tasks. In subsequent experiments, the relationship between processing upright unfamiliar faces and upright (Experiment 9a) and inverted (Experiment 9b) familiarised faces was explored.

The purpose of Chapter 4 was to examine the relationship between hits and FPS as a function of familiar and unfamiliar face processing. It is well documented in the face memory literature that hits and FPS do *not* correlate with each other (Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston, 1997; Vokey & Read, 1992). This relationship was examined using a 1 in 10 (Experiment 10), ABX (Experiment 12), or match/mismatch (Experiment 13) face-matching task using both by-people and by-item analyses. Experiment 11 more directly examined the relationship between hits and FPS, by presenting subjects repeatedly with the same targets in target-present and target-absent line-ups. Subsequent experiments employed an object-matching task (Experiment 14) and used familiarised faces that were presented upright (Experiments 15a and 15b) or inverted (Experiment 16).

The final chapter investigated the encoding capacity for unfamiliar faces. Experiment 17 started with examining the effect of multiple potential face targets on the task of identifying just one of these faces. Subjects were presented with a target face, which was either displayed alone or accompanied by a second face, and were then asked to identify the target from a target-present or target-absent line-up.

Experiment 18 examined the way that presentation may affect memory for more than one target. Subjects were asked to identify one of two unfamiliar faces that were presented either simultaneously or sequentially. Subsequent experiments aimed to replicate Experiment 17 using tasks, which required the matching of unfamiliar faces (Experiment 19) or of objects (Experiment 20). The final study examined the effects of spatial distance between the two targets on the accuracy of face matching. Subjects were presented with face-matching arrays, in which two targets were presented either close together or far apart (Experiment 21).

Chapter 2

Individual Differences In Unfamiliar Face Processing

Introduction

Humans differ remarkably from each other across the various attributes and characteristics of our species. For example, people differ in terms of their individual personalities (e.g. see Hampson & Colman, 1995 for a review), their cognitions (e.g. see Dillon & Schmeck, 1983 for a review), emotional experiences (e.g. see Winter & Kuiper, 1997 for a review), their interpersonal social communication skills (e.g. see Hargie, Saunders & Dickson, 1994 for a review), or even to perform music (e.g. see Sloboda, 2000 for a review), and also in their neuropsychological characteristics (e.g. see O'Boyle & Hellige, 1989 for a review). The main aim of this chapter is to examine the extent to which people differ in their ability to encode unfamiliar faces, and to explore the predictability of such individual differences using a range of general visual recognition tasks and some specific face processing tasks.

The ability to recognise unfamiliar faces differs from group to group, and from one individual to another. Although some studies found that females have a better face memory than males, gender has no reliable effect on face recognition (see Shapiro & Penrod, 1986 for a review). However, age significantly affect face processing. A great deal of evidence suggests that face recognition improves with development (e.g. Bonner & Burton, 2004; Cary, Diamond & Woods, 1980), but declines with ageing (e.g. Bächman, 1991; Searcy et al., 1999). In addition, it is well established that it is more difficult to recognise faces of a different race than faces of one's own race (e.g. Ferguson, Rhodes & Lee, 2001; Wright, Boyd & Tredoux, 2003).

In addition to these group differences, face recognition significantly differs between subjects of the same group. Across a set of studies involving a total of 400 participants, Woodhead and Baddeley (1981) showed recognition memory for previously unfamiliar faces to be highly variable, ranging from d' of –0.5 to 6.8 in their sample. Experiment 1 of this thesis converges with these findings by demonstrating quite significant individual differences in matching unfamiliar faces, ranged from 50% to 96% accurate. It therefore seems reasonable to ask what factors might predict this performance.

There has been some previous research on individual differences in face recognition, though this has generally addressed the issue of face memory, rather than face matching. Woodhead and Baddeley (1981) found that people who were good at recognising unfamiliar faces from memory were also good at recognising images of objects and scenes. Fagan (1985) replicated this positive association between recognition memory for faces and non-face objects. Moreover, Fagan (1985) found that visual (face and object) recognition memory correlates positively with intelligence. Facial recognition memory has also been shown to correlate positively with processing speed in infants (Rose, Feldman & Jankowski, 2003), and with perceptual speed in 11 year-old children in a longitudinal study (Rose & Feldman, 1995).

The search for further predictors of face memory has produced inconclusive results. Mueller, Bailis and Goldstein, (1979) found that anxiety predicted false positives, but not hits in a recognition memory procedure. However, Nowicki, Winograd and Millard (1979) found anxiety to predict hits (negatively), but to be uncorrelated with false positives. This inconsistency is also apparent for field dependence. Witkin, Dyk, Faterson, Goodenough and Karp (1974) predicted that field dependents would be more accurate in face recognition than field independents as they are giving more attention to the social content of their surroundings. Some findings have supported this prediction (Messick & Damarin, 1964); others have found the precise converse pattern (Lavrakas, Buri & Mayzner, 1976), while others show no relationship between field dependence and face recognition performance (Courtois & Mueller, 1982; Ryan & Schooler, 1998).

Brigham, Maass, Martinez and Whittenberger (1983) examined the effect of arousal on face recognition. Two levels of arousal were manipulated by giving subjects an electric shock. The moderate arousal level was operationally defined by receiving a single electric shock, and the high arousal level was defined by receiving a series of shocks with different intensities. The level of arousal was assessed by self-report and three psychophysiological measures: heart rate, finger volume response, and skin conduction response. The self-reports of arousal differed significantly between the moderate and high levels of arousal for females, but not for males. Therefore, only data from females was used. Face recognition deteriorated as arousal increased. Subjects in the moderate arousal condition made higher hits and lower false positives than those in the high arousal condition. However, none of the three psychophysiological measures showed any relation with the manipulated level of arousal or self-reported arousal, and none of them correlated with face recognition.

These studies, rather inconclusive as they are, all addressed face memory. The literature contains very few reports analysing individual differences in face matching. Schretlen, Pearlson, Anthony and Yates (2001) found that performance of normal adults on the Benton Facial Recognition Test (BFRT) correlated positively with perceptual speed and total cerebral volume. Alexander, Mentis, van Horn, Grady, Berman, et al. (1999) asked subjects to match photographs of frontal faces to two photographs in different views. They found that individual differences in PET activation of the general object perception and attention system predicted the accuracy of matching unfamiliar faces. In Experiment 1, a small battery of visual cognition tests was administered to subjects to examine what could predict performance on unfamiliar face matching.

Experiment 1

The aim of this experiment was to examine the predictability of matching unfamiliar faces with established visual cognitive tests. Some of these tests were previously found to predict face matching including perceptual speed (Schretlen et al., 2001) and confidence (Bruce et al., 1999), while others were found to predict face memory including visual memory (Fagan, 1985; Woodhead & Baddeley, 1981) and field dependence (e.g. Messick & Damarin, 1964, but see Courtois & Mueller, 1982; Ryan & Schooler, 1998). There were also two further tasks: Matching strategy and matching objects. The precedent was included because previous studies found that recognition strategies could significantly differentiate between accurate and inaccurate eyewitness identifications (Dunning & Stern, 1994; Kneller et al., 2001). The latter was included because matching unfamiliar faces was found to activate brain regions involved in the processing of non-face objects (Alexander et al., 1999).

Method

Participants

30 students (16 females) from the University of Glasgow participated in the experiment. Age ranged from 18 to 32 years. All had normal or corrected to normal vision.

Stimuli and procedure

Subjects were tested individually in a session lasting approximately 90 minutes. All completed the following tests.

1. Matching Unfamiliar Faces

160 matching arrays were used as illustrated in Figure 1.1. These were the same arrays as used by Bruce et al. (1999). Each stimulus showed a still image, taken from a high-quality video camera, and showing a full-face view in neutral expression. Beneath this, there were ten further images of faces, each a full-face photograph in neutral expression, taken with a studio camera. All images were shown in grey-scale, and the size of each face image was approximately 7x10cm.

Stimuli were presented in a large booklet, one array (1 video still + 10 photos) per page. These images were taken from the UK Home Office PITO database, and all showed young, clean-shaven Caucasian men. All images had been taken on the same day, and under similar conditions, so that individuals showed little variation in hairstyle, face shape etc.

In half of the arrays, the target person (video still) was also present among the 10 face photographs. These arrays were constructed such that the nine distractors were those faces rated most like the target in a prior similarity-ratings study. For each target (video still) a target-absent array was also constructed, where ten distractor images were used, which were judged most similar to the target in a previous study. Full details of this database, and construction of the arrays, can be found in Bruce et al. (1999).

Each subject completed 80 trials: 40 target present trials and 40 target absent trials, intermixed in a random order. Two sets of stimuli were constructed, and presentation counter-balanced across the experiment, such that each target face was seen in a target-present array by half the subjects, and in a target-absent array by the remaining subjects.

The subjects' task was to match the identity of the target in the video-still image to the line-up photographs of faces. They were instructed that the target might or might not be present in each array. If they decided that it was present, they should write its number in the answer sheet, and otherwise they should mark an X. There was no time limit for this task, and subjects were encouraged to perform as accurately as possible.

2. Ratings Of Confidence

Subjects were asked to assign a rating of 1 to 7 to each array. A score of 7 indicated that subjects were sure of their decisions; a score of 1 indicated that subjects were not sure. Such procedure has been commonly used in face recognition literature (e.g. Burton et al., 1999).

3. Matching Strategy

Subjects were asked to describe the strategy by which they identified the targets. They had to choose one of three alternative strategies given for each trial: (i) elimination process, which indicated that subjects compared the faces to each other to narrow the choices; (ii) automatic recognition or "pop-out" process, which indicated that the face was just popped out to the subjects' eyes; and (iii) elimination and pop-out together. These strategies have previously been found to discriminate between accurate and inaccurate eyewitnesses, with an advantage for the pop-out strategy (Dunning & Stern, 1994; Kneller et al., 2001).

4. Visual Short Term Memory

45 line drawings of objects were used as stimuli. All pictures were presented in black and white. They belonged to different classes of object including foods,

clothes, instruments, animals, plants, birds, fruits, fish, transport, insects, and furniture. Pictures were formed into six sets, containing (in steps) between 5 and 10 objects. For each set, objects were arranged in a circular display on a single sheet of paper, and were chosen so that each set contained objects from several categories (see Figure 2.1). The procedure followed in this task was very simple, and is also described by Miller (1956). Subjects were shown each of the six sets of objects for 3 seconds, starting with the set containing the fewest items. They were asked to recall as many stimuli as possible for each set. The measure of performance is the total number of stimuli that could be remembered across trials.

Figure 2.1 An example of stimuli used in the visual short-term memory task used in Experiment 1.

5. Group Embedded Figures Test

Field dependence was measured by the Group Embedded Figures Test (GEFT), which requires subjects to separate an item from the field in which it is incorporated (Witkin et al., 1974). The test consisted of 8 target simple geometric figures and 18 complicated geometric figures split into two sets (see Figure 2.2). The subjects' task was to find the specific simple figure embedded into the complex figures. A maximum of 5 minutes was allowed for each set, and the measure of performance was accuracy.

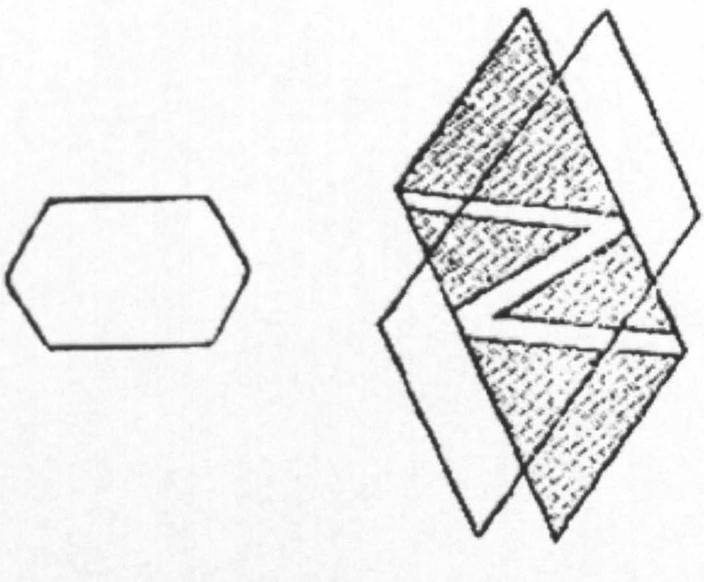


Figure 2.2 An example of stimuli used in Group Embedded Figures Test.

6. Matching Familiar Figures Test

The Matching Familiar Figure Test (MFFT) is a common measure for the cognitive style of impulsivity vs. reflexivity (Kagan, 1965). The test consists of 20 standard line drawing of a common objects (targets) and six variants of each object. The subjects' task was to find the variant that identically matches the target object. Figure 2.3 shows an example of stimuli used in this test.

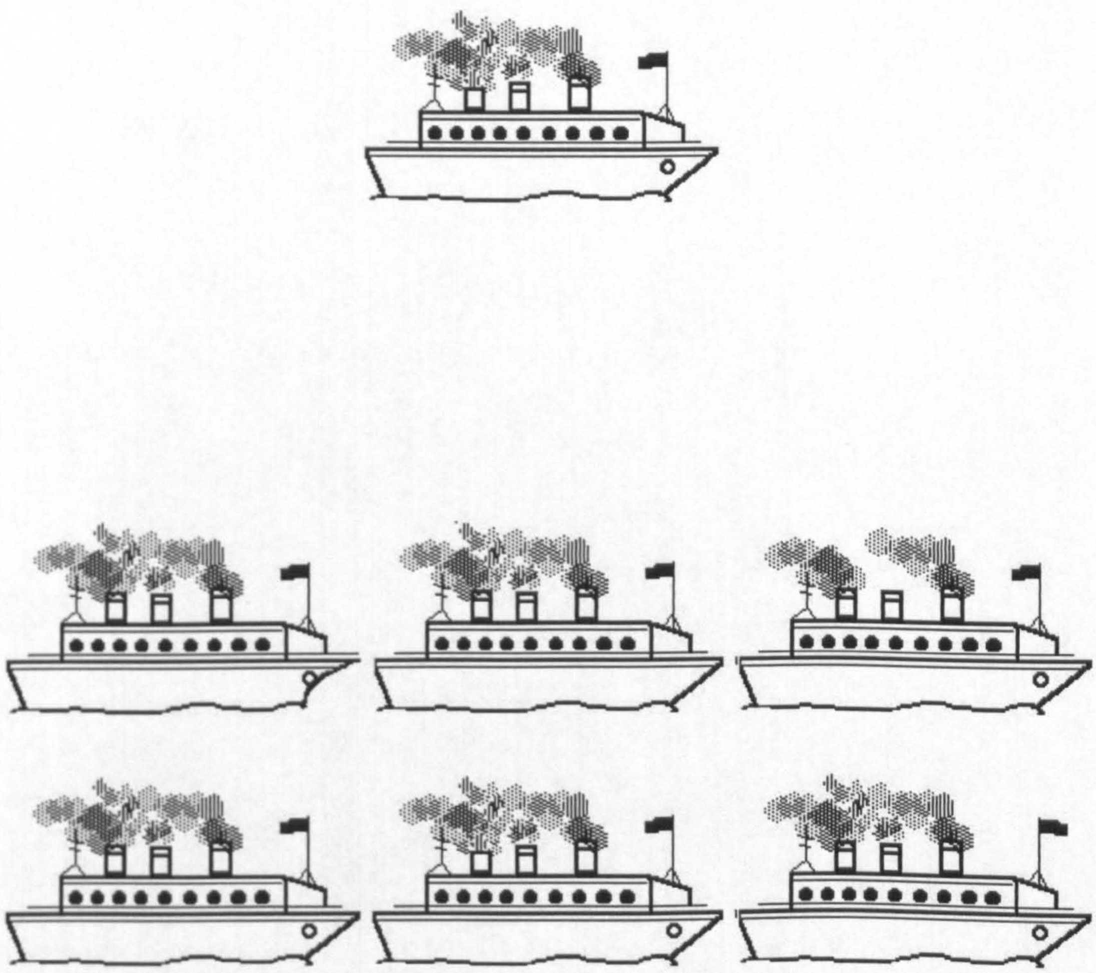


Figure 2.3 An example of stimuli of Matching Familiar Figure Test used in Experiment 1. The correct match is the ship numbered 5.

7. Perceptual Speed Test

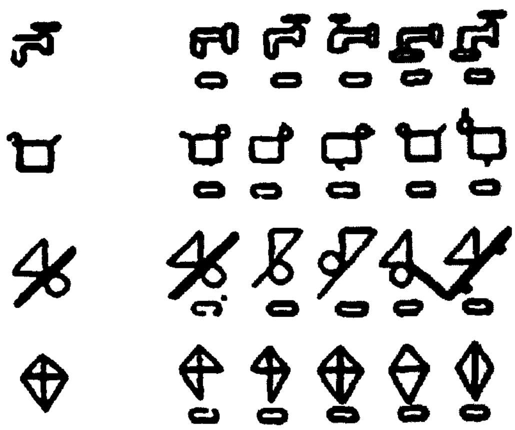
The Perceptual Speed Test was taken from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French & Harman, 1979). This has three sub-tests: (I) Finding A's Test, in which subjects are shown sets of words, and must find as many A's as possible within two minutes. (II) Number Comparison Test, in which subjects are shown pairs of multi-digit numbers, and must classify these as the same or different. Scores reflect the number of correct classifications made within two minutes. (III) Identical Pictures Test, which requires subjects to match a target line-drawn figure to an array of five variants. Scores reflect the number of correct matches within 90 seconds. Figure 2.4 shows examples of these tests.

8. Recognition Memory For Unfamiliar Face Pictures

35 images of unfamiliar faces were used as stimuli. These were taken from a different database to that used for the face-matching test. All images were of young, clean-shaven, Caucasian males, and image software was used to remove background and clothing. Images were all presented in grey scale. Fifteen of these images were presented to subjects for 5 seconds each. They were told that they would subsequently be asked to pick out these same images, from among a larger set of faces. The Perceptual Speed tests (which does not involve any face stimuli) were then administered before the test phase. At test, subjects were shown the original 15 images, intermixed with the remaining 20 images. Images were shown one at a time, and subjects were asked to decide, for each image, whether it had been seen in the learning phase.

meet	river	winner
thrifty	flush	govern
flowing	justice	term
engineer	sought	lawn
errand	balmy	chum
profit	fence	limit
vigor	belief	snow
forceful	cunning	organ

Finding A's Test



Identical Figures Test

289414	289414
17906	17806
16719581024	16719581024
3965701746	3665701746
135299235127	135299235127
13897143	13897143
84215073508	74216074508
941856031195	941836431195
8041638	8041438
70317494	70327494

Number Comparsion Test

Figure 2. 4 Examples for the sub-tests of the perceptual speed test used in Experiment 1.

Results

Table 2.1 Summary Data For All Measures In Experiment 1

Measures	Mean	SD
Face Matching		
Accuracy (/80)	65.9	9.7
Hit (/40)	35.3	3.8
Miss (/40)	3.2	3.1
Misid (/40)	1.5	2.1
FPS (/40)	9.3	8.6
Confidence (/ 7)	5.4	0.8
Other tests		
Visual STM (/45)	27.8	4.3
GEFT (/18)	14.0	3.9
Perceptual speed		
Finding A's Test (/100)	62.4	12.5
Number Comparison (/48)	35.0	6.6
Identical Picture Test (/96)	67.5	12.2
MFFT (/20)	13.3	4.2
Face Image Memory		
Accuracy (/35)	28.3	3.2
Hit (/15)	11.6	2.0
Miss (/15)	3.3	2.0
FPS (/20)	3.2	2.3

Table 2.1 shows the mean performance on each measure. In this, and subsequent experiments, the face-matching data has been broken down as follows. For the target-present trials, three were three measures: hits (i.e. correctly picking the target), misses (i.e. falsely responding that the target is absent), and misidentifications

(choosing the wrong face as a match). For target-absent trials, false positives (i.e. incorrectly picking a target) were calculated. In addition, the overall accuracy was calculated by combining the hit rates and correct rejections (i.e. correctly responding that the target is absent). Data for the face image recognition memory test is similarly broken down into hits, misses and false positives.

Table 2.2 shows Pearson's correlation coefficients between performance on the face matching task, and subjects' performance on the psychometric variables. The top line shows correlations with overall accuracy, and the remaining table shows correlations with the other measures of performance on face matching. Table 2.3 shows Pearson's correlation coefficients between performance on face matching and performance on recognition memory for face images.

Table 2.2 Pearson Correlation Between Face Matching Performance And The Other Variables In Experiment 1

N = 30; P < 0.05*; P < 0.01**.

Variables	Visual STM	GEFT	Perceptual Speed			MFFT	Conf.
			Finding A's test	Number Comparison	Identical Pictures		
Accuracy	.493**	.172	.455*	.359	.649**	.528**	.271
Hits	.485**	.085	.597**	.124	.302	.487**	.489**
Miss	–.277	–.011	–.350	–.043	–.121	–.362*	–.438*
Misid	–.436*	–.131	–.523**	–.154	–.348	–.315	–.207
FPS	–.346	–.157	–.254	–.352	–.603**	–.385*	–.092

Table 2.3 Pearson Correlation Between Face Matching And Face Image Memory In Experiment 1

N = 30; $P < 0.05^*$; $P < 0.01^{**}$.

Variables		Recognition Memory			
		Accuracy	Hits	Miss	FPS
Matching	Accuracy	.442*	.250	–.261	–.413*
	Hits	.405*	.429*	–.404*	–.199
	Miss	–.215	–.414*	.382*	–.056
	Misid	–.389*	–.138	.142	.429*
	FPS	–.323	–.095	.119	.381*

One-way within subject analyses of variance (ANOVA) were conducted to examine the effect of matching strategy (elimination, pop-out and both together) on hits and confidence. Figure 2.5 shows the mean hit and confidence scores to the matching strategies. There was a significant main effect on hits [$F(2, 29) = 68.512$, $p < 0.001$]. Post-hoc comparisons were conducted by Tukey's HSD test. Automatic recognition produced significantly higher hits than elimination process ($q = 14.81$, $p < 0.001$) or the pop out and elimination together ($q = 13.81$, $p < 0.001$), and the latter two processes did not differ significantly from each other ($q = 0.99$, $p > 0.05$). The same pattern of results was found for confidence. There was a significant main effect [$F(2, 29) = 15.681$, $p < 0.001$]. Post-hoc Tukey's HSD test revealed that pop-out process associated with significantly higher confidence than elimination process ($q = 7.67$, $p < 0.001$) or both processes together ($q = 5.55$, $p < 0.001$). But, there was no significant difference between the elimination and elimination plus pop-out processes ($q = 2.12$, $p > 0.05$).

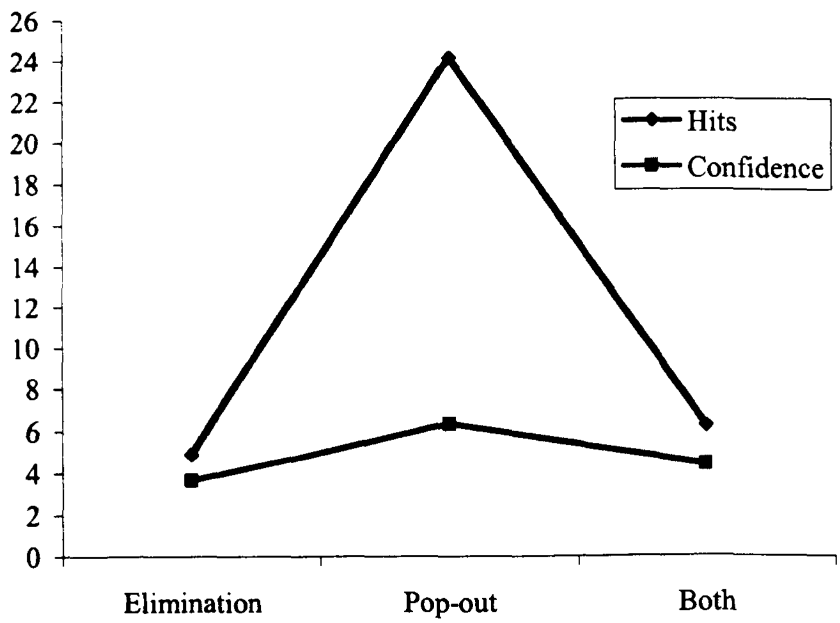


Figure 2.5. Means of hits and confidence scores given to the three matching strategies

Table 2.4 shows the relationship between recognition memory for face images, and subjects' performance on the psychometric variables.

Table 2.4 Pearson Correlation Between Memory For Face Images And The Other Variables In Experiment 1.
N = 30; P < 0.05*; P < 0.01**.

Variables	Visual STM	GEFT	Perceptual Speed			MFFT
			Finding A's test	Number Comparison	Identical Pictures	
Accuracy	.586**	.350	.495**	.064	.326	.511**
Hits	.541**	.256	.327	.198	.221	.520**
Miss	–.524**	–.223	–.265	–.213	–.227	–.498**
FPS	-.358	–.271	–.416*	.075	–.270	–.262

Discussion

(1) Summary scores

The overall scores on the face-matching task replicate results reported by Bruce et al. (1999). Out of 80 arrays, subjects score on average about 66 (82%) correct. Furthermore, there are significant individual differences, with a large standard deviation, and a range of 50% to 96% correct on this task. This further emphasises an intriguing finding: given no time pressure and good quality images taken in good lighting, from the same viewpoint and on the same day, subjects nevertheless find it surprisingly hard to match faces of unfamiliar people. Notably, subjects seem to find it particularly difficult to decide that a face is not present. In the 40 target-present arrays, subjects picked the correct person on average 35 times (i.e., 88% of the time). However, in the 40 target-absent arrays, subjects were only correct on average 31 times (77% percent of the time).

The remaining variables provide good overall scores for examining individual differences in face matching performance. There are no obvious ceiling or floor effects in the psychometric variables, and reasonably large standard deviations suggest that it is worthwhile trying to establish whether there are systematic relationships between these variables and the face matching performance of interest.

(2) Individual differences in matching unfamiliar faces

As mentioned above, there were large performance variations among subjects on the unfamiliar face-matching task. It seems from some of these results, that this variation can be predicted to some extent by other visual tests.

The GEFT provided no significant associations with measures of face matching. Using face *memory* tests, this task has sometimes predicted performance, and sometimes not (Courtois & Mueller, 1982; Lavrakas et al., 1976; Ryan & Schooler, 1998). Using face *matching* there is no suggestion of an effect.

The visual STM measure did provide a significant association with face matching. This is most pronounced for the overall accuracy measure, but appears to be being carried by significant associations with hits and misidentifications. A possibly more interesting pattern of effects arises from measures of perceptual speed. Schretlen et al. (2001) found that perceptual speed could significantly predict individual differences in matching unfamiliar faces on the Benton test. That test uses images taken with the same camera, but at different angles, while the replication here uses same viewpoint, but different cameras. Interestingly, the three measures all show quite different patterns. The Finding A's task correlates with overall accuracy, and seems to mimic visual short term memory, in that this appears to be being carried by significant associations with hit and misidentification rates. The number comparison task, on the other hand, showed no reliable associations. Finally, the Identical Pictures task again correlated highly with overall accuracy, but in this case the effect seems to be being carried by the false positives. It seems then, that the Finding As task and the Identical Figures task are picking up different aspects of the unfamiliar face matching results. The Finding A's task is associated only with performance on the target-present stimuli, while the Identical Pictures task is associated only with performance on the target-absent trials. In some ways, the Identical Figures task is most like the face matching task in format: both require a match to target for simultaneously presented material. However, in the Identical Figures task there is always a target present, and so subjects do not have to make the present/absent judgement, which is a key feature of the face-matching task.

The MFFT seems to be the best predictor of the face matching performance. As with other variables, there is a good correlation with overall accuracy, and this is carried by hits, but also by misses and false positives. So, this is the only psychometric variable producing a reliable association with miss scores.

Subjects' confidence of their decisions could also predict to some extent performance on the face-matching task, but only when the targets were present. There were moderate associations between confidence and hit and miss scores, but there was a close to zero correlation between confidence and false positives. This pattern of results replicated the finding of Bruce et al. (1999) that subjects were more confident in target-present trials than in target-absent trials.

Matching strategy had a significant effect on hits. Pop out process significantly associated with more hits and higher confidence than elimination process, converging with the results of the effects of these processes on eyewitness identification accuracy (Dunning & Stern, 1994; Kneller et al., 2001). This finding could explain why subjects were confident when they picked the correct matches (Bruce et al, 1999).

The association between face matching and face image recognition memory is relatively straightforward, though comparatively modest. Three sub-components of each test are associated significantly (hits with hits, misses with misses and FPS with FPS) but not highly.

(3) Individual differences in face image recognition memory

In general, the pattern of the associations between matching and the psychometric variables was similar to the associations between memory and such variables. This is probably because matching and memory were positively correlated with each other. However, there were some differences. Visual STM showed stronger associations with face image memory, and was able to predict miss scores. This is probably because these two tasks are more similar to each other, such that both measure memory. On the other hand, perceptual speed showed weaker associations with face memory. There was no correlation between the Identical Picture task and any measure of face memory. In contrast, this task was a good predictor for the face matching performance, specifically in target-absent trials. This might be because the

Identical Figures task is most like the face matching task in format. The finding A's task produced a different pattern of association for matching and memory. It was associated with hits in matching, whereas it was associated with FPS in memory. Also, the MFFT predicted hits, but failed to predict FPS in face memory. On the other hand, the MFFT was able to predict both hits and FPS in the face-matching task. In general, the most interesting finding here was that recognition of old (studied) faces was associated with some tests (visual STM and MFFT), whereas recognition of new (non-studied) faces was associated with different tests (Finding A's). This finding was also observed for the face-matching task. Together, this suggests that the processes underlying the correct recognition of target faces when present differ from those underlying the correct rejection of distractor faces (see Chapter 4).

In sum, this experiment demonstrates large individual differences in matching unfamiliar faces, which could be moderately predicted by general visual recognition tests such as the visual STM and perceptual speed tests. However, the best predictor was matching objects. The purpose of the next experiment was to explore further potential predictors of face matching by examining the covariation with face change detection.

Experiment 2

Although a large amount of visual information may fall onto the retina of the human eye, not all of this information is sufficiently represented in a person's encoding or memory systems (Pashler, 1988; Rensink, O' Regan & Clark, 1997; Simons, 1996). Several terms have been given to this phenomenon including *inattentional blindness* (see Mack & Rock, 1998 for a review), *change blindness* (see Simons & Levin, 1997 for a review), *inattentional amnesia* (see Wolfe, 1999 for a review), and *looking without seeing* (O'Regan, Deubel, Clark & Rensink, 2000). This effect is very robust and has been replicated with many classes of stimuli such as scenes (e.g. Rensink, et al., 1997), objects (e.g. Levin & Simons, 1997), verbal sentences (e.g. Reder & Kusbit, 1991), and even people, whether they were seen on video displays (Angelone et al., 2003) or during a real-world situation (Levin et al, 2002; Simons & Levin, 1998; see Chapter 1 for more discussion of this topic). Faces are also subject to the change blindness phenomenon, whether they are presented sequentially (Austen & Enns, 2003; Barton, Deepak & Malik, 2003; Davies & Hoffman, 2002) or simultaneously (Barton, Keenan & Bass, 2001; O'Donnell & Bruce, 2001).

O' Donnell and Bruce (2001) examined how well people could detect featural and configural changes to internal (eyes and mouth) and to external (hair and chin) features. Featural changes were manipulated by replacing the original feature with a feature foil from another face. Configural changes were manipulated by changing the spacing of features such as changing the distance between the mouth and the nose. Except for hair changes, people were very poor at detecting featural and configural changes in faces. However, O' Donnell and Bruce (2001) found that familiarisation selectively improved detecting changes to the eyes.

The present experiment had two main goals: (i) to investigate the relationship between detecting changes within and across identities by examining the covariation between face change detection and face matching performance; and (ii) to examine the relationship between the processing of featural and configural information. In addition, there was a secondary goal, namely to examine the relationship between distinctiveness and face matching. In the face memory literature, it is well documented that distinctive faces are easier to remember than typical faces (e.g. Bruce et al., 1994; Courtois & Mueller, 1981; Hancock et al., 1996; Lewis & Johnston, 1997). The present experiment will re-test this relationship using a face-matching task.

Method

Participants

Thirty-four paid participants from the University of Glasgow participated in this experiment (20 female and 10 male). Age ranged from 17 to 25 years. All had normal or correlated to normal vision.

Stimuli and procedure

Subjects were tested in individual sessions lasting approximately 40 minutes. Each subject completed two tasks: unfamiliar face-matching task and face change detection task, which they were counter-balanced in order.

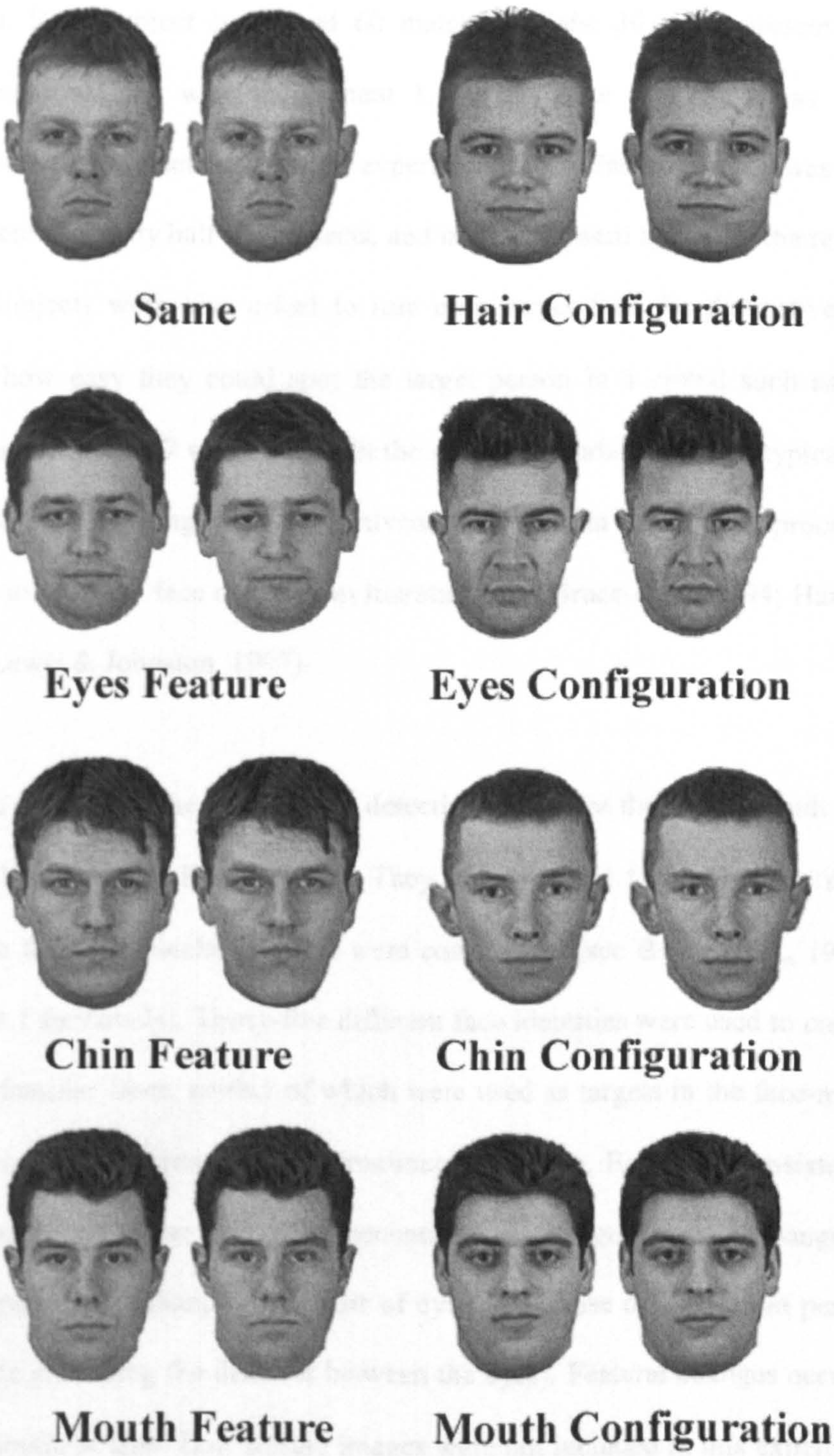


Figure 2.6 Examples of the face change detection stimuli used in Experiment 2.

The face-matching arrays from Experiment 1 were also used in this experiment. Each subject completed 60 matching trials: 30 target-present and 30 target-absent trials. As with Experiment 1, the presence of targets was counter-balanced between subjects across the experiment, such that each face was seen in target-present arrays by half the subjects, and in target-absent arrays by the remaining subjects. Subjects were also asked to rate each target face for distinctiveness by indicating how easy they could spot the target person in a crowd such as a train station. A scale of 1 to 7 was used, with the score of 1 indicating high typicality and the score of 7 indicating high distinctiveness. Note that this rating procedure is commonly used in the face recognition literature (e.g. Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston, 1997).

The stimuli for the face change detection task were the same stimuli as were used by O'Donnell and Bruce (2001). They were derived from the same database from which the face matching arrays were constructed (see Bruce et al., 1999, and Experiment 1 for details). Thirty-five different face identities were used to create 105 pairs of unfamiliar faces, neither of which were used as targets in the face-matching task. The size of each image was approximately 5x7 cm. Each pair consisted of an original image and either this same unchanged or changed image. Changes were either <u>featural</u> (e.g. exchanging one pair of eyes with those of a different person) or <u>configural</u> (e.g. altering the distance between the eyes). Featural changes occurred in the eyes, mouth, or chin. Hair feature images were not included in this experiment as O'Donnell and Bruce (2001) found that subjects were performing at the ceiling level in this condition. However, configural changes in hairstyle were also used here in addition to configural changes to the eyes, mouth, and chin. Examples of these stimuli are presented in Figure 2.6.

An apple Macintosh computer was used to present stimuli and record responses, using Superlab Pro software. Each pair of faces was presented on the screen until subjects responded, and there was a 1 second ISI. Subjects' task was to decide whether the two images were same or different, by pressing one of two labelled response keys in the standard computer keyboard. Each subject completed 105 trials: 35 same trials and 70 different trials, with 10 trials in each of the seven change conditions. Subjects were instructed to respond as accurately and as quickly as possible. The order in which the stimuli were presented was randomised independently for each subject.

Results

Reaction times were deemed inadequate for analysing differences between the experimental conditions, because overall performance in the face change detection task was highly inaccurate. Therefore, only accuracy of change detection is reported here. Table 2.5 shows the mean percentages for subjects' performance in face matching and face change detection tasks.

Table 2.5 Descriptive Statistics For Subjects' Performance (%) On Face Matching And Face Change Detection In Experiment 2.

Measures	Mean	SD
Face matching		
Overall accuracy	80.8	10.4
Hits	79	13.7
Miss	14.7	11.7
Misid	6.3	6.9
FPS	17.3	15.3
Distinctiveness	54.9	8.0
Change detection		
Featural changes		
Eyes	34	18.9
Mouth	65.1	23.9
Chin	63	28.8
Configural changes		
Eyes	42.4	26.2
Mouth	51.7	29.4
Chin	64.3	27.7
Hair	59.7	26.4
Same	82.9	12.5

Table 2.6 shows Pearson's correlation coefficients between performance on face matching and face change detection tasks. Distinctiveness ratings were subjected to a by-item analysis to examine the relationship between face matching accuracy and the distinctiveness of the targets. The results are reported in Table 2.7 (the first column from the right).

Table 2.6 Pearson Correlations Between Face Matching And Rated Distinctiveness And Face Change Detection. $N = 34$; $P < 0.05$*; $P < 0.01$**.

	Change Detection							Dist.
	Featural			Configural				
	Eyes	Mouth	Chin	Eyes	Mouth	Chin	Hair	
Accuracy	.498**	.360*	.141	.587**	.356*	.213	.421*	.270*
Hits	.443**	.262	.157	.581**	.329	.227	.294	.377*
Miss	–.354*	–.040	–.192	–.412*	–.166	–.147	–.119	–.439**
Misid	–.281	–.453**	.012	–.456**	–.373*	–.203	–.382*	–.007
FPS	–.283	–.256	–.052	–.280	–.190	–.087	–.312	–.021

A 2 (featural vs. configural) x 3 (eyes, mouth and chin) within-subjects ANOVA was conducted to examine change detection performance between the face regions as a function to the type of information. The detection of configural changes in hairstyle was not included in this analysis as there was no equivalent featural condition. There was no significant main effect of information type [$F (1, 33) = 0.251$, $p > 0.05$], but a main effect for face region was found [$F (2, 66) = 22.938$, $p < 0.001$]. There was also a significant interaction between information type and face regions [$F (2, 66) = 7.638$, $p < 0.01$].

Post-hoc Tukey's HSD tests were conducted to examine the differences between each of the face regions within each information type. For featural changes, detecting changes to the eyes was significantly poorer than detecting changes to the mouth ($q = 7.85$, $p < 0.001$) and to the chin ($q = 7.32$, $p < 0.001$). There was no significant difference between detecting changes to the chin and mouth regions ($q =$

0.53, $p > 0.05$). For configural changes, detecting changes to the eyes was poorer than detecting changes to the chin ($q = 5.51$, $p < 0.001$), but there was no significant difference between detecting changes to the eyes and the mouth ($q = 2.33$, $p > 0.05$), and between detecting mouth and chin changes ($q = 3.18$, $p > 0.05$). The differences between face regions as a function of the type of information were also examined using Tukey's HSD test. There was no significant difference between detecting featural and configural changes to the eyes ($q = 2.73$, $p > 0.05$), or the chin ($q = 0.41$, $p > 0.5$). However, detecting changes on mouth was significantly poorer when they were featural than when they were configural ($q = 4.37$, $p < 0.01$).

Table 2.7 Pearson Correlations Between Featural And Configural Processing In Experiment 2.

N = 34; P < 0.05*; P < 0.01**

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">Featural</th><th colspan="3">Configural</th></tr>
<tr><th>Eyes</th><th>Mouth</th><th>Chin</th><th>Eyes</th><th>Mouth</th><th>Chin</th></tr>
<tr><td rowspan="3">Featural</td><td>Eyes</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Mouth</td><td>.379*</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Chin</td><td>.427*</td><td>.109</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Configural</td><td>Eyes</td><td>.653**</td><td>.509**</td><td>.348*</td><td></td><td></td><td></td></tr>
<tr><td>Mouth</td><td>.410*</td><td>.503**</td><td>.382*</td><td>.510**</td><td></td><td></td></tr>
<tr><td>Chin</td><td>.418*</td><td>.312</td><td>.611**</td><td>.345*</td><td>.648**</td><td></td></tr>
<tr><td>Hair</td><td>.392*</td><td>.418*</td><td>.345*</td><td>.609**</td><td>.615**</td><td>.304</td></tr>
</table>

Table 2.7 shows Pearson's correlation coefficients between featural and configural processing. There were generally good inter-correlations within change detection conditions, suggesting that the task is constructionally valid. More

importantly, there were strong positive associations between the processing of featural and configural information of the eyes, mouth, and chin.

Discussion

Once again, subjects significantly differed in their ability to match unfamiliar faces. Individual differences in the overall accuracy ranged from 60% to 100%. However, the average matching accuracy across subjects was very low (81%), which converges with the results of Experiment 1, and replicates previous findings by Bruce et al. (1999). In addition, subjects were very poor at detecting facial changes within identities, replicating the results of O'Donnell and Bruce (2001).

There were small but significant positive associations between distinctiveness and face matching, albeit only when the targets were present in the line-ups. This finding converges with the results of Lewis and Johnston (1997) that distinctiveness correlated with hits but not with FPS using recognition memory procedure. However, the effects of distinctiveness on face recognition usually occurs by increasing FPS to unstudied typical faces, rather than increasing hits to old distinctive faces (e.g. Bartlett, Hurry & Thorley, 1984; Light, Kayra-Stuart & Hollander, 1979).

As with O'Donnell and Bruce's (1999) study, detecting changes to the eyes was the poorest. However, it was the best predictor for performance in the face-matching task, specifically when targets were present. In addition, detecting changes to the hair and mouth, but not to the chin, moderately predict face matching. These results confirm importance of the eyes as the *key* cue for face identification (Schyns, Bonnar & Gosselin, 2002; Vinette, Gosselin & Schyns, 2004), and also support the importance of the hair in matching unfamiliar faces (Bruce et al., 1999; Duchaine & Weidenfeld, 2003). Interestingly, there was no relationship between any change detection condition and subjects' performance on target-absent trials. This suggests that qualitatively different processes might be involved in encoding changes within *and* across identities.

More importantly, there were high positive associations between the processing of featural and configural information. As discussed in Chapter 1, the relative contributions of features and configurations to face recognition are controversial (see Bartlett et al., 2003 for a review). Some researcher have suggested that configuration is the *key* component of face processing (e.g. Bartlett & Searcy, 1993; Friere et al., 2000), while others have argued that individual features already provide sufficient information for face recognition (e.g. Macho & Leder, 1998; Rakover & Teucher, 1997). The present finding supports the theory that faces are encoded holistically (Tanaka & Farah, 1993), such that features and their configurations have inter-dependency contribution to face recognition (Tanaka & Sengco, 1997).

Experiment 3

This experiment examines two questions. The first question regards the effect of multiple distractors on matching unfamiliar faces. It has been argued that poor face matching performance as was first reported by Bruce et al. (1999) and replicated in Experiment 1 and 2, might be attributed to the presence of multiple distractors. Liu and Chaudhuri (2000) assumed that "*unfamiliar face recognition is highly sensitive to signal-to-noise ratios. When the number of distractors is minimized, recognition of unfamiliar faces can be remarkably good, provided that the image parameters remain congruent*" (p.446). The present experiment provides a test for this hypothesis by reducing the 10-face line up task to a match/mismatch task, in which subjects were shown only two images of unfamiliar faces, and had to decide whether they were of the same person or two different people.

A number of studies have already examined face matching with a single item verification task. Bruce et al. (2001) asked subjects to match a poor quality video image of a three-quarter face to a high quality image of a full-face, which consisted of either the same face identity or a similar distractor. There were only 24 trials (half match and half mismatch), and were performed by two different sets of subjects. Hit rates of 78% and 74%, and false positive rates of 21% and 28% were recorded for the two sets of subjects, respectively. In addition, Henderson et al. (2001) presented subjects with one trial only, using high quality full-face images. In this case, hit rates of 55% were found, with false positive rates of 27.5%. These rather low levels of performance do not support Liu and Chaudhuri's (2000) hypothesis. Furthermore, Liu et al. (2003) tested this hypothesis by presenting subjects with pairs of unfamiliar faces, which were congruent or incongruent in resolution. Video target images were of poor quality from the sort used in Burton et al's (1999) study, half of which were males and half were males. It is worth mentioning that "*the pairing of targets and distractors was completely random*" (p 37), which probably made the matching task easier by pairing dissimilar targets and distractors. However, subjects' performance on this task was still very poor. And more importantly, there was no effect for congruency. Hit rates of 62% and 73%, and false positive rates of 13% and 15% were recorded for congruent and incongruent pairs, respectively.

The match/mismatch task used in the current experiment differs from these tasks in a number of ways: (i) pairs consisted of high quality images; (ii) all images consisted of head-on images of faces; and (iii) it is constructed from a very large database of faces, all of which were men.

The second question addressed in this experiment regards the intra-individual consistency in matching unfamiliar faces. Experiments 1 and 2 showed large individual differences in subjects' performance on the 1 in 10 matching task. The present experiment examined the extent to which these individual differences are consistent. In other words, if subjects perform the same matching task twice, how similar are their performance levels across both instances? Face recognition consistency has widely been neglected in the face domain. Morris and Wickham (2001) tested recognition memory for faces after a short delay and again after 5 weeks. They did not aim to examine the consistency of recognition performance, but fortunately they reported the whole correlation matrix of their variables. In the immediate recognition test, hit rates of 67%, and false positive of 28% were found. In the delayed test, hit rates dropped to 56%, but false positives did not change (31%). In spite of this long retention period, there were significant positive associations for hits and false positives between the immediate and delayed recognition tests. In fact, it is not surprising that subjects who were poor at the immediate test were also poor at the delayed test. However, to date there are no studies in the face memory literature that have examined the intra-subject consistency with repeating the study and test phases on the same subjects using the same faces. The present experiment examined the consistency of matching unfamiliar faces using a match/mismatch task.

Method

Participants

Thirty students (18 female and 12 male) from the University of Glasgow participated in the experiment. Ages ranged from 17 to 23 years. All had normal or corrected to normal vision.

Stimuli and procedure

Pairs of images were used as stimuli. Each pair showed one high quality video still image and one high quality photograph. These images came from the same database that was used to construct the face matching arrays used in Experiments 1 and 2 (Bruce et al., 1999). 120 matching and 120 mismatching pairs were constructed, such that the non-matching pairs were similar in appearance. All images were cropped using graphics software, and were presented in full-face view in greyscale. The size of each image was approximately 5x7 cm. Examples of match and mismatch pairs are presented in Figure 2.7.

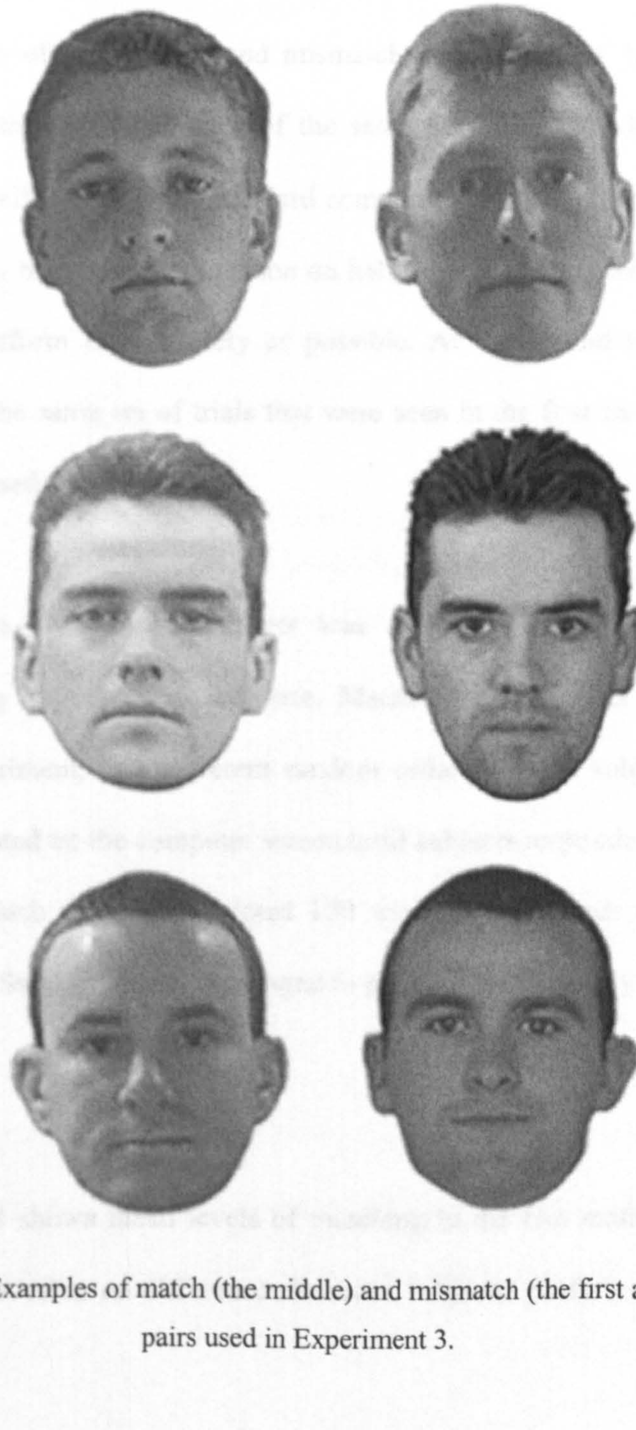


Figure 2.7. Examples of match (the middle) and mismatch (the first and third) pairs used in Experiment 3.

Each subject was tested twice, with an intervening period of approximately one week. In the first test, subjects were presented with 120 trials. Half the trials showed match pairs while the other half showed mismatch pairs. Match-mismatch items were counter-balanced across the experiment such that each stimulus item appeared equally often in match and mismatch trials. Subjects' task was to decide whether or not the two faces were of the same person or two different people by pressing two labelled keys in the standard computer keyboard. Subjects were told that faces would only be of the same person on half the trials. They were self-paced, and instructed to perform as accurately as possible. At the second test, subjects were presented with the same set of trials that were seen in the first test, and an identical procedure was used.

An apple Macintosh computer was used to present stimuli and record responses, using Superlab Pro software. Match-mismatch trials were inter-mixed during the experiment, in a different random order for each subject. Each pair of faces was presented on the computer screen until subjects responded, and there was a 1 second ISI. Each subject completed 120 trials for each test: 60 match and 60 mismatch trials. Subjects were encouraged to perform as accurately as possible.

Results

Table 2.8 shows mean levels of matching in the two match/mismatch tests. Related t-tests revealed no differences between subjects' performance on two tests.

Table 2.9 shows Pearson's correlation coefficients between the two tests. Significant correlations were found.

Table 2.8 The Differences Between Subjects' Performances On The Two Match/Mismatch Tests In Experiment 3.
N = 30; $P < 0.05$*; $P < 0.01$**

Variables	Test-1		Test-2		t-Tests
	Mean	SD	Mean	SD	
Accuracy	80.7	9.0	81.6	8.8	0.768 n.s.
Hits	79.4	15.2	81.0	12.9	0.954 n.s.
FPS	18.1	12.5	17.8	11.9	0.147 n.s.

Table 2.9 Pearson's Correlation Coefficients Between The Two Match/Mismatch Tests In Experiment 3.
N = 30; $P < 0.05$*; $P < 0.01$**.

Variables		Test-1		
		Accuracy	Hits	FPS
Test-2	Accuracy	.695**		
	Hits		.796**	
	FPS			.483**

Discussion

The purpose of this experiment was to examine two issues: the accuracy of matching unfamiliar faces on a match/mismatch task, and the intra-individual consistency in performance on this task. Intriguingly, there was a rather low level of performance on matching, even in this simple task. For match trials, subjects still only managed correct responses on roughly 80% of matches. Notably, there were no distractors present at all, and to perform correctly, subjects simply had to confirm that the two images were of the same person. However, subjects could not do this more accurately than in the previous experiment with many distractors, which is consistent with previous work on face matching (Bruce et al., 1999, 2001; Henderson et al., 2001; Liu et al., 2003) and carries forensic implications.

After approximately one week of performing the match/mismatch task, subjects participated in the experiment again to provide an indication of the consistency of face matching performance. At both tests, there were the typical vast differences across individuals on matching performance (note the high standard deviations for hits and false positives in the two tests), confirming the results reported in Experiments 1 and 2. However, there was high intra-individual consistency for performance on this task. Neither quantitative nor qualitative differences were found between the two tests. This further emphasises the generally low level of unfamiliar face recognition accuracy on this simple match/mismatch task.

General discussion

It is very difficult to match two different images of unfamiliar faces. This intriguing finding was first reported by Bruce et al. (1999), and was consistently replicated by Experiments 1 and 2, where an overall accuracy rate of roughly 80% was found. Moreover, when the 1 in 10 face matching arrays were reduced to match/mismatch pairs in Experiment 3, this low level of performance persisted. In this experiment, subjects were asked to decide whether or not two face images were of the same or two different people. Interestingly, subjects managed correct responses on roughly 80% of occasions in both match and mismatch trials. Note that this task differs in many ways from that used previously in the face-matching domain (Bruce, et al., 2001; Henderson et al., 2001; Liu et al., 2003). Namely, a large database of high quality and head-on images of male faces was used. Moreover, Experiment 3 provided evidence to indicate that this task is *reliable.* Subjects were tested twice using the same match/mismatch trials, with an intervening period of approximately one week. Subjects' performance in the two tests was quantitatively and qualitatively very similar to each other, which suggests high intra-individual consistency for face matching in this task.

Although matching unfamiliar faces is generally poor, there were very large individual differences. For example, Experiment 1 showed that the overall matching accuracy ranged from 50% to 96%. The central question in this chapter was what predicts individual differences in matching unfamiliar faces. This question was examined by very few experiments in the literature, showing that perceptual speed (Schretlen et al., 2001) and the activation of brain areas involved in object recognition (Alexander et al, 1999) could significantly predict unfamiliar face matching.

Experiment 1 provided some support to these findings. First, matching objects was found to be the best predictor for matching unfamiliar faces, suggesting that the processes involved in the two tasks are similar, converging with the results of Alexander et al. (1999). In addition, some parts of the Perceptual Speed Test, namely Finding As and Identical Figures, significantly predict different aspects of face matching performance. For example, Finding A's Test predicted picking the correct match in target-present trials, whereas the Identical Figures Test predicted rejecting matches in target-absent trials. Similarly, Visual STM and confidence predicted hits, but not false positives. Together, this suggests that performance on target-present and target-absent trials might involve different processes (see Chapter 4). However, performance on a non-face object matching task and recognition memory for face images predicted both hits and FPS. In addition, the "pop out" recognition strategy associated with more hits and higher confidence than elimination strategy, converging with the eyewitness identification studies (Dunning & Stern, 1994; Kneller et al, 2001).

Experiment 2 examined the relationship between face change detection and face matching. Although detecting changes to the eyes was the poorest compared to detecting changes to the mouth, hair, and chin, it was the best predictor of face matching, specifically in target-present arrays. This is in agreement with previous studies indicating that eyes are the *diagnostic* feature for face identification (Schyns et al., 2002; Vinette et al., 2004). Interesting, neither detecting changes to the eyes nor to any other face regions predicted FPS. Therefore, there was no relationship between encoding changes within and between face identities. More importantly, this experiment reported high positive associations between the processing of featural and configural information. This supports the theory that faces are processed as being a gestalt, in which features and configurations are both important for face recognition (Tanaka & Farah, 1993; Tanaka & Sengco, 1997). Following these data, the next chapter investigated the relationship between upright and inverted familiar and unfamiliar face processing using a variety of encoding and immediate memory tasks.

Chapter 3

Unfamiliar Faces Aren't Faces

Introduction

The preceding chapter showed that people differ significantly in their ability to match unfamiliar faces, with performance ranging from 50% to 96% accuracy. Across a battery of some general visual recognition and face specific processing tasks, some tests could moderately predict subjects' performance on target-present trials including Visual STM, Finding A's Perceptual Speed Test, confidence, target distinctiveness, and detecting changes to the eyes, whereas the Perceptual Speed Identical Pictures Test could predict performance on target-absent trials. However, the best predictor was an object-matching task, which significantly predicted matching performance in *both* target-present and target-absent trials.

There is good evidence in the literature that inverted faces are not processed in the same manner as upright faces. Faces suffer considerable performance deficits, across a number of measures, when inverted. It has been suggested that this might reflect a disruption of the processes normally engaged in face recognition, and particularly configural processing (see Chapter 1). Several authors have suggested that inverted faces are therefore processed in a manner more similar to the general object processing system, than to the normal face recognition system (de Gelder & Rouw, 2000; Farah, Wilson, Drain & Tanaka, 1995; Haxby, Ungerleider, Clark, Schouten, Hoffman & Martin, 1999; Moscovitch, Winocur & Behrmann, 1997). Combining this finding with the positive correlation between matching unfamiliar faces and objects suggests that matching upright and inverted unfamiliar faces might correlate with each other. This same suggestion could also be made from the positive association between the processing of featural and configural information that was in Experiment 2. As discussed in Chapter 1, it is thought that recognition of upright faces depends on configural information, whereas recognition of inverted faces relies on featural information (e.g. see Bartlett et al., 2003 for a review). If this is true, then the high positive association between featural and configural processing would suggest a positive correlation between upright and inverted unfamiliar face processing. Before examining this hypothesis, I will review the existing evidence for the qualitative mechanisms of upright and inverted face processing.

The Relationship Between Upright And Inverted Face Processing

There are three main methodologies to examine the qualitative mechanisms of the processing of upright and inverted faces. Perhaps the most straightforward method is to correlate upright and inverted face processing in neurological normal participants (Flin, 1985; Phillips & Rawles, 1979; Yin, 1969). The second method is to examine the continuity or discontinuity of face processing as a function of orientation (Murray, Yong & Rhodes, 2000; Valentine & Bruce, 1988). The third methodology is to examine upright and inverted face processing in neuropsychological patients who suffer either from the inability to process faces (prosopagnosia) or objects (agnosia).

(I) The Association Between Upright And Inverted Face Processing

There are very few studies in the literature that examined the association between upright and inverted face processing (see Valentine, 1988 for a review).

Using t-Tests, Yin (1969) found that subjects who scored highly in recognition memory for upright unfamiliar faces were those who scored poorly in recognition memory for inverted unfamiliar faces. Similarly, subjects who scored poorly in upright condition were those who scored highly in inverted condition. However, this negative correlation conflicts with the face inversion effect. According to this effect, recognition of upright faces is *always* greater than recognition of inverted faces (see Chapter 1). Consequently, it seems reasonable to assume that people who perform well in recognising inverted faces would perform better for recognising upright faces. Similarly, people who are poor at recognising upright faces should be even poorer in recognising inverted faces. The face inversion effect therefore suggests a positive, rather than a negative, association between upright and inverted unfamiliar face processing.

Phillips and Rawles (1979) examined the association between memory for upright and inverted unfamiliar faces using an old/new recognition test. In each condition, subjects learned 20 faces, each of which was presented for 1.5 seconds. In test, subjects were shown 10 old and 10 new faces. In addition, subjects were asked to name a set of 24 celebrities; half presented upright and half presented inverted. Phillips and Rawles (1979) found no correlation between the recognition of upright and inverted unfamiliar faces, but they found a significant positive correlation between the recognition of upright and inverted familiar faces. However, there are some problems in this study. For familiar faces, small database of faces was used, and faces were not counter-balanced between the upright and inverted conditions.

Moreover, subjects failed to recognise third of the celebrities presented upright, and more than two-thirds of them presented upside down. This suggests that celebrities' faces were not well known. For unfamiliar faces, subjects learned 20 faces but tested in only 10 faces. This was done without counter-balancing test items. Last and more importantly, it might be difficult to memorise inverted faces presented serially for such a brief time (1.5 secs).

In a more controlled study, Flin (1985) found a low but significant positive association between recognition memory for upright and inverted unfamiliar boys' faces in children at age 12 years. However, this finding was not replicated in children who were younger or older than this age.

(II) The Continuity Of Face Processing As A Function Of Rotation

The second method to examine the qualitative processing of upright and inverted faces is to examine the effect of gradual rotation on face processing. If processing of upright and inverted faces differs qualitatively, a discontinuity should be observed in face processing as a function of rotation. On the other hand, if the processing of upright and inverted faces is qualitatively similar, continuity or a linearity of processing should be observed. Unfortunately, studies that used this methodology are also inconclusive.

On one hand, Valentine and Bruce (1988) found a liner relationship between upright and inverted unfamiliar face processing. Subjects were presented with a sequential face-matching task, in which the first face was always presented upright for 1.5 seconds. Following a brief gap, the second face was presented for 2 seconds in one of five different orientations, varied in 45° steps between fully upright (0 degree) and fully inverted (180 degree). The subjects' task was to indicate whether the two faces were the same or different. Valentine and Bruce (1988) found that reaction times increased with increasing rotation angles. This linearity suggests that the processing of upright and inverted faces is qualitatively similar.

On the other hand, Murray, Yong and Rhodes (2000) found a discontinuity between upright and inverted unfamiliar face processing. Subjects were asked to rate bizarreness for unchanged, featurally- or configurally-changed faces. Featural changes were manipulated by whiting the eyes or blacking the teeth, whereas configural changes were made by Thatcherising faces or changing the distance between the eyes or between the mouth and nose. For unchanged or featurally changed faces, rated bizarreness increased linearly as orientation increased from 0° to 180 (in 15° steps). However, for configurally-changed faces, a discontinuity in the function relating orientation and bizarreness was observed between 90° and 120° that suggests a qualitative difference in the processing of upright and inverted faces.

(III) Neuropsychological Evidence For The Processing Of Upright And Inverted Faces

There is little agreement for a dissociation in cerebral lateralisation as a function of face orientation. It is well documented that right hemisphere processes are important for upright face processing (e.g. see Rhodes, 1985 for a review). Some studies report that face inversion removes this lateralisation (Leehey, Carey, Diamond & Cahn, 1978; Rapaczynski & Ehrlichman, 1979; Yin, 1970), while others have found right hemisphere advantage for both upright and inverted faces (Bradshaw, Taylor, Patterson & Nettleton, 1980; Ellis & shepherd, 1975).

The neuropsychological impairments of recognising objects (agnosia) and faces (prosopagnosia) provide some important suggestions for the processing of upright and inverted stimuli. Farah et al. (1995) found that a prosopagnosic patient was normal in the recognition of inverted faces, but was severely impaired in the recognition of upright faces. Although this "inversion superiority" was replicated by other studies (de Gelder, Bachoud-Lèvi & Degos, 1998; de Gelder & Rouw, 2000), it might be not face-specific. Prosopagnosics are also superior in the recognition of objects (shoes) when inverted than when upright (de Gelder et al., 1998; de Gelder & Rouw, 2000). Moreover, some recent studies did not find significant difference between the processing of upright and inverted faces in prosopagnosia (Boutsen & Humphreys, 2002; Delvenne, Seron, Coyette & Rossion, 2004).

In contrast, Moscovitch et al. (1997) found that an agnosic patient was normal in the recognition of upright faces, but was severely impaired in the recognition of inverted faces. In addition to the face inversion superiority in prosopagnosia (de Gelder et al., 1998; de Gelder & Rouw, 2000; Farah et al, 1995), this suggests that inverted faces might be processed in the same manner as objects. This argument is supported by some functional brain imaging studies, which have found that inverted faces activate brain regions involved in object recognition (e.g. Haxby et al., 1999).

Moreover, Moscovitch and Moscovitch (2000) found an agnosic patient who was normal in the recognition of upright internal features of familiar faces, but was severely impaired in the recognition of upright external features, suggesting that external facial features may be processed similarly to objects.

In face recognition literature, there is some good evidence that recognition of familiar faces relies on internal greater than external features, whereas internal and external features are equally useful for recognition of unfamiliar faces (Bonner & Burton, 2004; Ellis et al., 1979; Young et al., 1985). However, an external feature advantage for unfamiliar faces is sometimes reported (Bruce et al., 1999; Duchaine & Weidenfeld, 2003). This suggests that the processing of upright unfamiliar faces, which relies on external features that are in turn processed similarly to objects, may be similar to the processing of inverted familiar or unfamiliar faces, which are processed as the same as objects.

To summarise, existing correlational and linearity as well as neuropsychological studies of face inversion are rather inconclusive. The results of the correlational studies are extremely inconsistent to the extent that all three possible correlations have been reported: negative correlations (Yin, 1969), positive correlations (Flin, 1985), and no correlation (Flin, 1985; Phillips & Rawles, 1979). Sometimes a linear relationship between face processing and orientation was reported (Valentine & Bruce, 1996) and sometimes not (Murray et al., 2000). Neuropsychological studies also report a dissociation between upright and inverted face processing in some cases (e.g. Farah, et al, 1995) but not in others (Boutsen &

Humphreys, 2002; Delvenne et al., 2004). Consequently, the current chapter further explores this topic by examining the relationships between the processing of upright and inverted familiar and unfamiliar faces.

Experiment 4

The positive associations between matching unfamiliar faces and objects (Experiment 1) and between featural and configural processing (Experiment 2), suggest that upright and inverted unfamiliar face recognition might correlate with each other. The present experiment examined this hypothesis using Bruce's face-matching task.

Method

Participants

Thirty students (9 males and 21 females) from the University of Glasgow participated in the experiment, ranging in age from 17 to 23. They participated in return for a sum of payment. All had normal or corrected to normal vision.

Stimuli and procedure

The face matching arrays produced by Bruce et al. (1999) were used as stimuli. There were 160 arrays, which were divided into two sets, such that in half, the target face was presented upside down as in Figure 3.1. The ten photographic images in each array were *always* presented in the correct orientation.

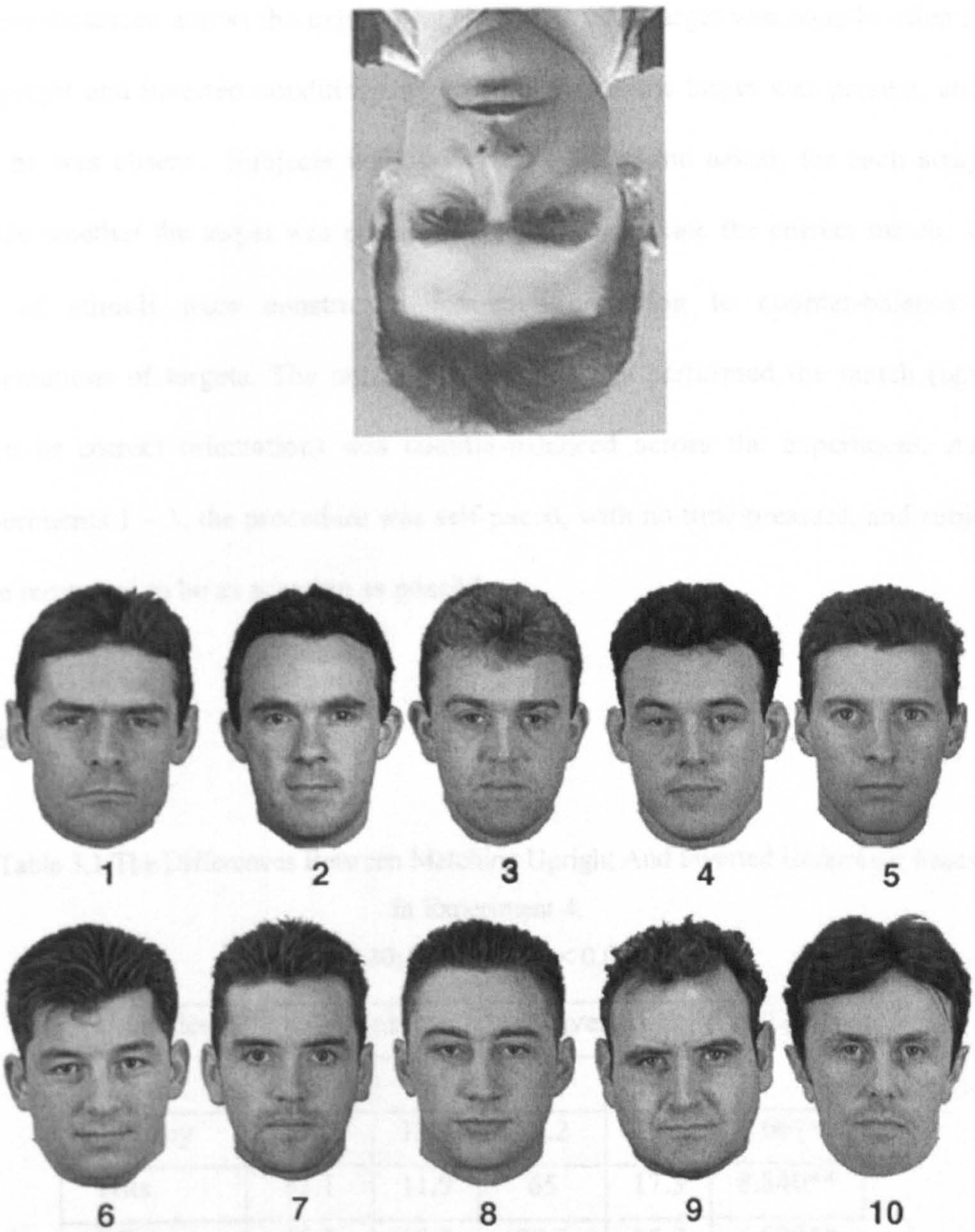


Figure 3.1 An example of inverted-target arrays used in Experiment 4.
The correct match is face numbered 1.

Each subject completed 40 matching trials with the target face oriented correctly, and 40 trials with the target upside down. The orientation of the targets was counter-balanced across the experiment, such that each target was equally often seen in upright and inverted conditions. In half the arrays the target was present, and in half he was absent. Subjects were informed of this, and asked, for each array to decide whether the target was present, and if so to indicate the correct match. Two sets of stimuli were constructed for each condition to counter-balance the presentations of targets. The order in which subjects performed the match (upside down or correct orientation) was counter-balanced across the experiment. As in Experiments 1 – 3, the procedure was self-paced, with no time pressure, and subjects were requested to be as accurate as possible.

Results

Table 3.1 The Differences Between Matching Upright And Inverted Unfamiliar Faces In Experiment 4.

$N = 30$; $P < 0.05$*; $P < 0.01$**

Variables	Upright		Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	77.7	13.9	65.2	15.4	7.667**
Hits	83.1	11.9	65	17.3	8.840**
Miss	10.7	10.2	20.5	15.9	5.609**
Misid	6.2	8.6	14.4	14.4	4.380**
FPS	27.8	23.0	34.7	23.3	2.997**

Table 3.1 shows the differences between matching upright and inverted unfamiliar faces. Related t-tests revealed better performance for upright compared to inverted unfamiliar face matching. Table 3.2 shows Pearson's correlation coefficients between each measure of matching upright and inverted faces. There were significant associations between these conditions in all matching measures.

Table 3.2 Pearson's Correlation Between Matching Upright And Inverted Unfamiliar Faces In Experiment 4

N = 30; P < 0.05*; P < 0.01**.

Variables		Upright				
		Accuracy	HIT	MISS	MISID	FPS
Inverted	Accuracy	0.818**				
	Hits		0.764**			
	Miss			0.817**		
	Misid				0.717**	
	FPS					0.855**

Discussion

The summary data in Table 3.1 provide a further replication of the findings of Bruce et al. (1999) and of Experiments 1 – 3 in that subjects find the standard upright match of unfamiliar faces surprisingly difficult (overall performance of 77% in this case). Presenting targets upside down had a significant detrimental effect on face matching (overall accuracy level of 65%). Notably, this is the first instance to replicate the face inversion effect using a perceptual identification task. Previous research used either memory (e.g. Yin, 1969) or sequential matching (e.g. Freire et al., 2000). This suggests that the effect occurs at the perceptual level of face processing, a conclusion that was previously put forward by Rossion and Gauthier (2002).

There were very strong positive associations between matching upright and inverted unfamiliar faces in all the five line-up measures. It appears that the best predictor of the unfamiliar face-matching task is performance on a version of the same test in which the target face is inverted. This is rather a striking finding, since it suggests that the processes involved in unfamiliar face matching do not engage the sophisticated configural processing normally held to be the exclusive characteristic of upright face processing. This is the first hint in these data that rather unsophisticated processes may be taking place in unfamiliar face matching. This is a hypothesis put forward previously by Bruce et al. (1999) and Hancock et al. (2000). These authors have proposed that *unfamiliar* face matching may be better thought of as simple image-matching, rather than involving any face-specific processes.

The face processing literature generally does not show evidence for an association between upright and inverted face processing (see Valentine, 1998 for a review). In fact, in some experiments, a *negative* correlation has been found for performance in upright and inverted face processing (Yin, 1969). While this negative association is not always found (e.g., Phillips & Rawles, 1979), positive correlations are very rarely reported (Flin, 1985). However, previous research on face inversion has generally used a face memory task of some sort. This may provide the explanation for the difference between the present experiment and the more usual findings. Furthermore, tests of face memory have often used the same image of each person at learning and test phases, such as the recognition memory test used in Experiment 1. Image *matching* (as opposed to image memory) is a very simple task, and arrays of the sort in Figure 3.1 are solved trivially if the target image is one of the same images as the ten test faces. This observation begins to suggest that there may be important aspects of unfamiliar face processing which are missed by studies deploying the same images throughout. Therefore, the next experiment examined the association between upright and inverted face processing using a face memory task, in which two different images of targets were used.

Experiment 5

This experiment aimed to replicate the results of Experiment 4 using a memory, rather than matching task. For this purpose, a face immediate memory task was introduced using Bruce et al's (1999) arrays. Subjects were presented with the targets and 10-face line-ups sequentially, intervened by a short gap.

Method

Participants

Thirty-two paid undergraduate students (18 female) from the University of Glasgow participated in the experiment. Age ranged from 18 to 27. All had normal or corrected to normal vision. None of the subjects had taken part in experiments 4.

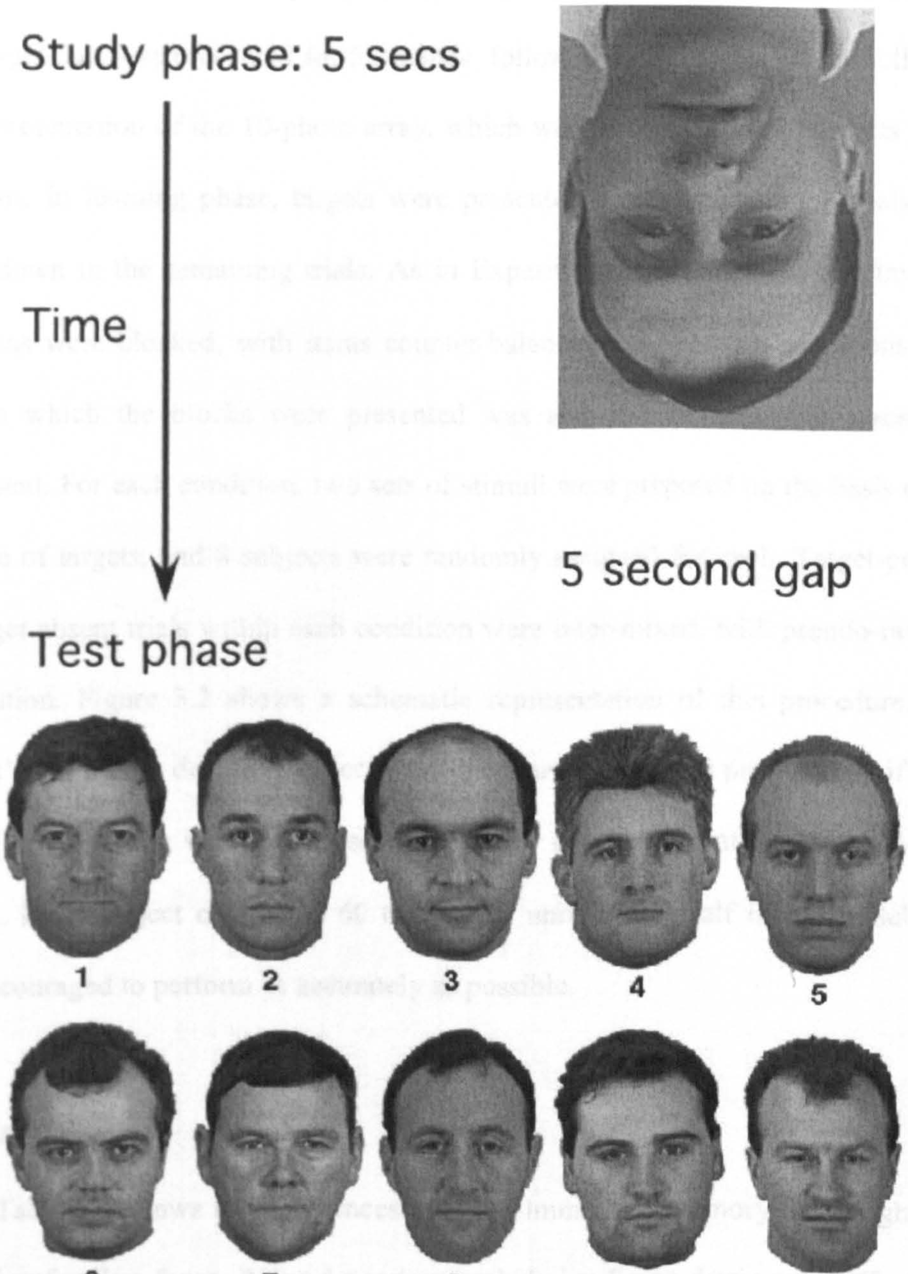


Figure 3.2 A schematic representation of the procedure used in Experiment 5. The correct match is face numbered 8.

Stimuli and procedure

120 arrays from those produced by Bruce et al. (1999) were used as stimuli. Each target face was presented for 5 seconds, followed by a 5 seconds gap, followed by the presentation of the 10-photo array, which were presented until subjects made responses. In learning phase, targets were presented upright in half the trials, and upside down in the remaining trials. As in Experiment 4, the upright and inverted conditions were blocked, with items counter-balanced between the conditions. The order in which the blocks were presented was also counter-balanced across the experiment. For each condition, two sets of stimuli were prepared on the basis of the presence of targets, and 8 subjects were randomly assigned for each. Target-present and target-absent trials within each condition were inter-mixed, with pseudo-random presentation. Figure 3.2 shows a schematic representation of this procedure. The subjects' task was to decide whether or not the learned face was present, and if so to identify him. Testing was performed individually in a session of approximately 30 minutes. Each subject completed 60 trails: half upright and half inverted. Subjects were encouraged to perform as accurately as possible.

Results

Table 3.3 shows the differences between immediate memory for upright and inverted unfamiliar faces. Related t-tests revealed significant detrimental effects for inversion upon face memory.

Table 3.3 The Differences Between Immediate Memory For Upright And Inverted Unfamiliar Faces In Experiment 5.

N = 32; P < 0.05*; P < 0.01**

Variables	Upright		Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	65.8	14.2	51.8	13.6	7.191**
Hits	63.3	14.6	42.9	14.9	7.357**
Miss	22.9	11.7	31.7	12.8	3.162**
Misid	13.8	11.2	25.4	16.2	5.162**
FPS	31.7	20.0	39.4	17.0	3.075**

Table 3.4 shows Pearson's correlation coefficients between recognition immediate memory for upright and inverted unfamiliar faces. There were significant positive associations between these conditions in all measures, but not in misses.

Table 3.4. Pearson's Correlation Between Memory For Upright And Inverted Unfamiliar Faces in Experiment 5.

N = 32; p < 0.05*; p < 0.01**.

Variables		Upright				
		Accuracy	Hits	Miss	Misid	FPS
Inverted	Accuracy	0.685**				
	Hits		0.431*			
	Miss			0.187		
	Misid				0.618**	
	FPS					0.716**

Discussion

Immediate memory for upright unfamiliar faces was rather poor. Hit rates of 63% were recorded, with FP rates of 32%. This became much poorer when targets were presented upside down, showing the normal face inversion effect (e.g. Yin, 1969). More surprisingly, the results of this experiment showed positive correlation between upright and inverted face memory. This supports Valentine's (1988) conclusion that upright and inverted face memory is quantitatively but not qualitatively different. Notably, the results of this experiment were different to those reported by previous experiments reported no correlation between upright and inverted unfamiliar face memory (see Valentine, 1988 for a review). This contrast might be attributed to important methodological differences. Namely, an immediate memory task was used here, rather than old/new (e.g. Flin, 1985) or forced choice (e.g. Yin, 1969) recognition memory tasks. And more importantly, two different images of the targets were used, rather than the same image. In addition, faces were usually presented upside down in both study and test in the previous studies (e.g. Yin, 1969). However, in Experiments 4 and 5 targets only were presented inverted whereas the test items were presented upright. Therefore, the next experiment re-examined the association between matching upright and inverted unfamiliar faces when the *whole* arrays were presented either upright or inverted.

Experiment 6

The results of Experiment 4 suggested that the processes engaged in unfamiliar face matching are simple image matching. The present experiment investigated this hypothesis by examining association between upright unfamiliar face matching, and inverted face matching in which *both* the target face and the ten faces for matching are presented upside down. This was to reserve the configuration of faces in the upright and inverted condition.

Method

Participants

Thirty University of Glasgow undergraduate students (7 males, 21 females) participated in the experiment, ranging in age from 18 to 23 years. All had normal or corrected to normal vision. None of the subjects had taken part in experiments 4 and 5. They were either paid a small sum for participation, or received course credit.

Stimuli and procedure

Stimuli and procedure were identical to Experiment 4, with the sole exception that here, the inverted face matching trials involved a match from an inverted target to ten inverted faces. An example of the inverted arrays is present in figure 3.3. Once again, order of presentation (upright or inverted) was counter-balanced across subjects. Each subject completed 80 trials: 40 upright (half present and half absent) and 40 inverted (half present and half absent) trials, with presence counter-balanced across the experiment.

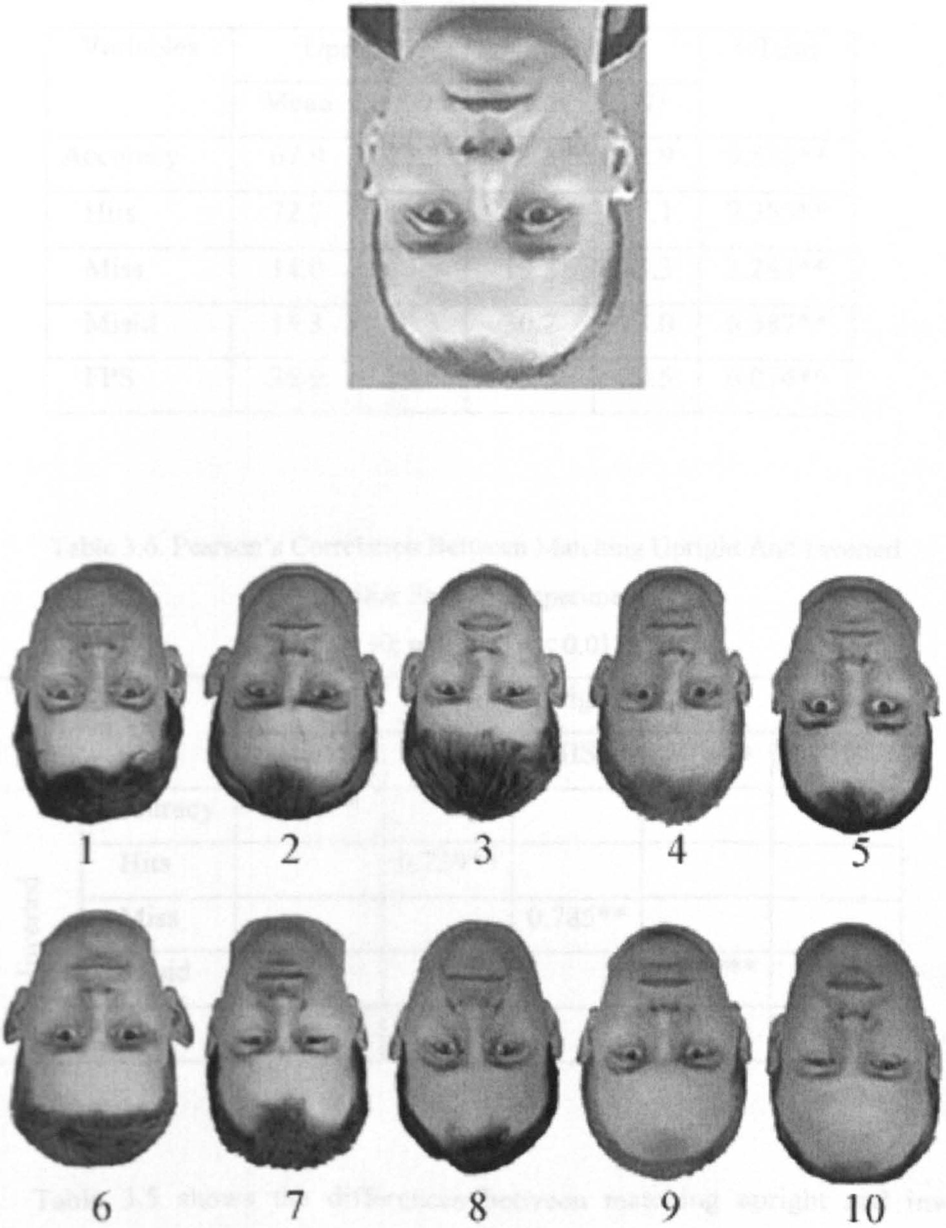


Figure 3.3. An example of the inverted face matching arrays used in Experiment 6. The correct match is face numbered 5.

Results

Table 3.5 The Differences Between Matching Upright And Inverted Unfamiliar Faces In Experiment 6.

N = 30; P < 0.05*; P < 0.01**

Variables	Upright		Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	67.9	17.3	47.3	12.9	9.530**
Hits	72.7	18.6	50.5	17.1	9.355**
Miss	14.0	13.8	19.3	13.3	3.283**
Misid	13.3	12.3	30.2	17.0	6.387**
FPS	36.0	24.7	55.5	20.5	6.074**

Table 3.6. Pearson's Correlation Between Matching Upright And Inverted Unfamiliar Faces In Experiment 6.

N = 30; p<0.05*; p < 0.01**.

Variables		Upright				
		Accuracy	HIT	MISS	MISID	FPS
Inverted	Accuracy	0.730**				
	Hits		0.739**			
	Miss			0.785**		
	Misid				0.537**	
	FPS					0.712**

Table 3.5 shows the differences between matching upright and inverted unfamiliar faces. Related t-tests revealed significantly poorer accuracy for inverted as opposed to upright matches. Table 3.6 shows Pearson's correlation coefficients between matching upright and inverted unfamiliar faces.

Discussion

Once again, the face inversion effect was observed by a perceptual identification task, but it was here much bigger than in Experiment 4. The overall accuracy fell from 68% when upright to 47% when inverted, and subjects were significantly poorer in the inverted than the upright condition for every sub-component of this overall accuracy score.

As with Experiment 4, there were very high associations between matching unfamiliar faces on the normal array task, and completing the same task with the entire display inverted. It seems that, to some considerable extent, the same processes are being employed in both tasks. It is relatively uncontentious to claim that the upside-down version of this task is not employing the configural processing usually thought to be a hallmark of face processing. However, if this is the case, then it seems to follow that these processes cannot be being engaged in the upright unfamiliar face-matching task.

Of course, one cannot conclude from these data that unfamiliar face matching is *only* image matching. If this were the case, then one would expect the overall performance measures for the upright and inverted versions of this task to be the same. However, they are not. The data in Table 3.5 clearly show that the task is easier for upright than inverted faces. I will return to this difference in the General Discussion. The following experiment examined whether the effects reported so far are tied to the specific 1 in 10 line-up task.

Experiment 7

Experiments 4 – 6 showed very high positive associations between upright and inverted unfamiliar face processing. A possible explanation for this effect might concern the effects of multiple distractors. There were nine different distractors in target-present arrays, all of which had some overall similarity to the targets. This might encourage subjects to rely on relatively small, part-based differences between the faces, which is not normally employed for upright faces (e.g. Bartlett & Searcy, 1996). To test this hypothesis, the present experiment examined the association between upright and inverted unfamiliar face processing using a match/mismatch task from the sort that was previously used in Experiment 3.

Method

Participants

Thirty students from the University of Glasgow (16 females and 14 males) participated in the experiment either for payment or course credits. Age ranged from 18 to 22 years. All had normal or corrected to normal vision, and none had taken part in Experiment 4 – 6.

Stimuli and procedure

Stimuli and procedure were the same as used in Experiment 3, except that match/mismatch pairs were either presented upright or inverted. An apple Macintosh computer was used to present stimuli and record responses, using Superlab Pro software. Each pair of faces was presented on the computer screen, until subjects responded by pressing one of two labelled keys of the standard computer keyboard. The subjects' task was to indicate whether the two faces were of one person or two different people. Each subject was presented with 120 trials during the experiment. Half the trials were presented upright, and half inverted (both faces). Furthermore, half the pairs showed the same person, and half a different person. Match/mismatch items, and upright/inverted items were counter-balanced across the experiment such that each stimulus item appeared equally often in each trial type. Upright and inverted stimuli were inter-mixed during presentation. There was a 1 second ISI, and the order in which the stimuli were presented was randomised across subjects. The experiment was self-paced, and subjects were told that faces would only be of the same person on half the trials.

Results

Table 3.7 shows the differences between matching upright and inverted unfamiliar faces using a match/mismatch task. Related t-tests showed significant effects, with an advantage for the upright condition.

Table 3.7 The Differences Between Matching Upright And Inverted Unfamiliar Faces In Experiment 7.

N = 30; P < 0.05*; P < 0.01**

Variables	Upright		Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	79.8	9.8	68.0	11.2	8.954**
Hits	81.5	9.7	74.3	14.5	3.125**
FPS	21.9	14.3	38.2	16.4	6.433**

Table 3.8 shows Pearson's correlation coefficients between subjects' performance on the upright and inverted match/mismatch tasks. There were significant positive associations between these conditions.

Table 3.8 Pearson's Correlation Between Matching Upright And Inverted Faces In Experiment 7.

N = 30; p < 0.05*; p < 0.01**

Variables		Upright		
		Accuracy	Hits	FPS
Inverted	Accuracy	.772**		
	Hits		.514**	
	FPS			.598**

Discussion

The face inversion effect was replicated here by a simultaneous simple match/mismatch task. The overall accuracy fell from 80% when the two faces were upright to 68% when both were inverted. This provides the strongest evidence so far that this effect has a perceptual basis (see Rossion & Gauthier, 2002 for a review).

Replicating the results of Experiments 4 – 6, there were very high levels of associations between upright and inverted conditions, suggesting that similar processes underlie the two tasks. It seems, then, that the correspondence between upright and inverted unfamiliar face processing is robust across different tasks, and is not an artefact of the 1 in 10 line-up task used so far. The subsequent experiments examined the relationship between familiar and unfamiliar faces.

Experiment 8

The high positive associations between upright and inverted unfamiliar face processing reported by Experiments 4 – 7 suggest that unfamiliar faces are not engaging the processes normally engaged by familiar faces. In order to further examine this possibility, the present experiment investigated the relationship between upright and inverted familiar face recognition, and its relationship with matching and memorising upright unfamiliar faces.

One of the difficulties in comparing familiar and unfamiliar face processing is that familiar face processing is so robust. People are able to recognise the faces of those familiar to them in a very wide range of viewing conditions, even in very severely degraded visual environments, such as security CCTV (Burton et al 1999). Given this, it is not possible directly to compare an array task from the sort used for unfamiliar faces in this thesis, with the equivalent stimulus constructed with highly familiar faces. In such a situation, matching would be trivially easy. For example, Figure 3.4 shows a possible array for Tony Blair. Although the two images of him are very different (in expression, lighting, and age), the correct line-up match is popped-out.

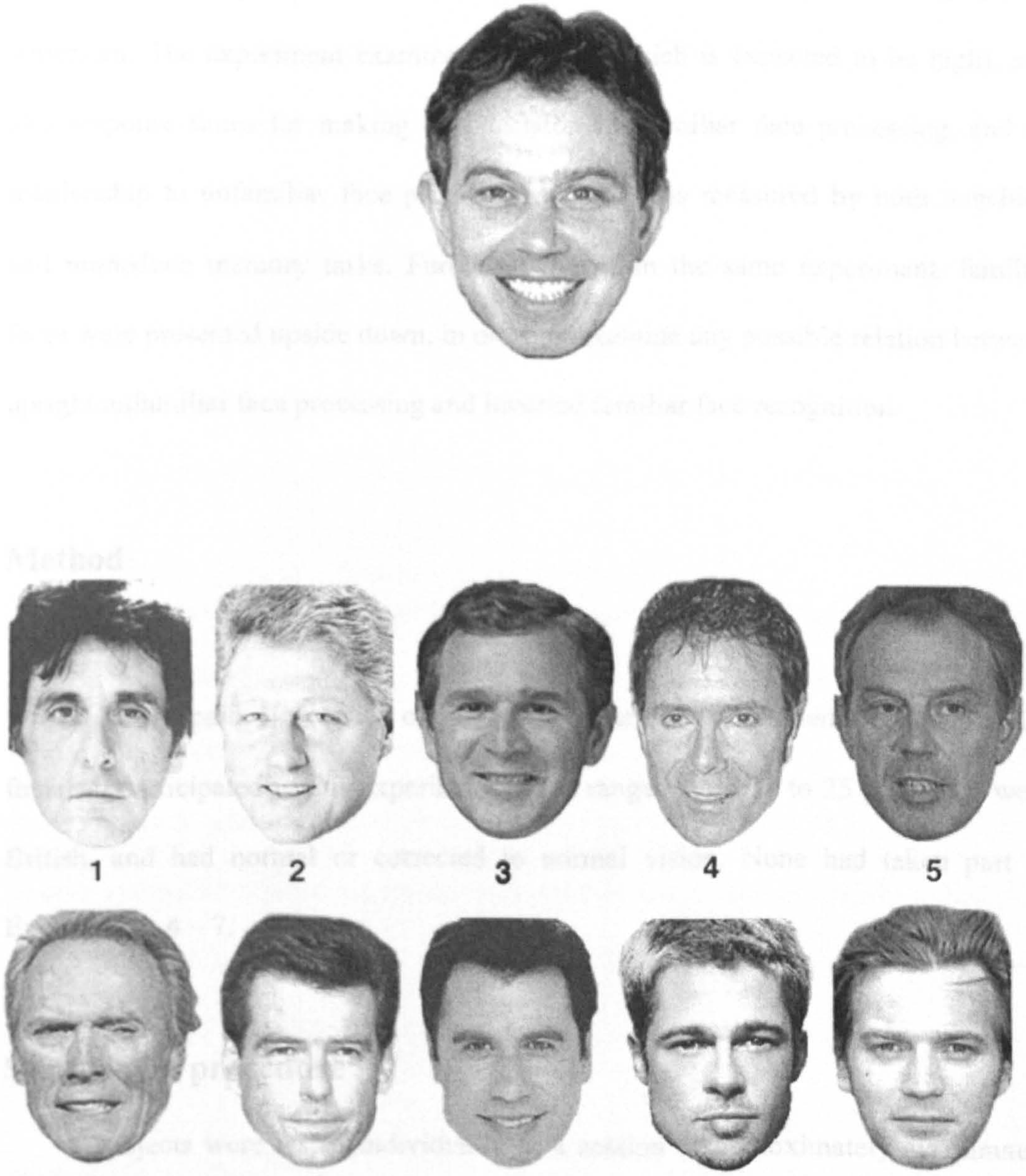


Figure 3.4 A familiar face-matching array.

To deal with this, this experiment examined subjects' ability to make a simple personal decision to a familiar (famous) face. Namely, subjects were asked to make a speeded nationality decision for a set of faces all of whom are either British or American. The experiment examined accuracy (which is expected to be high), and also response times for making this decision for familiar face processing, and its relationship to unfamiliar face processing, which was measured by both matching and immediate memory tasks. Furthermore, within the same experiment, familiar faces were presented upside down, in order to examine any possible relation between upright unfamiliar face processing and inverted familiar face recognition.

Method

Participants

Thirty paid University of Glasgow undergraduate students (10 males, 20 females) participated in this experiment. Ages ranged from 17 to 25 years. All were British, and had normal or corrected to normal vision. None had taken part in Experiments 4 – 7.

Stimuli and procedure

Subjects were tested individually in a session of approximately 40 minutes. The arrays for the matching task were the same as those used in Bruce et al. (1999), and in the previous Experiments. These were divided into two sets such that, for each subject, half the arrays were presented simultaneously, while the remaining half were presented sequentially (as in Experiment 5). Sets were counter-balanced such that across the experiment, each target face occurred equally often in a simultaneous and a sequential array.

For the famous face tasks, a set of 80 celebrity faces were collected: half British, and half American. All of the famous faces were presented in greyscale, and were of Caucasian males, but with variations in age, hairstyle, expressions, lighting conditions, and viewing angles. For display on a computer screen, these were scaled to roughly 10cm x 7cm. The faces were split into two groups, half of which would be presented upright, and half inverted. The stimuli were counter-balanced, such that, across the experiment, all faces occurred equally often upright and inverted.

Recognition of the celebrity faces was tested by a semantic task, and was run on a G3 Macintosh computer using Superlab Pro software. Each face was presented on the screen until subjects responded, and there was a 1 second ISI. Subjects' task was to classify each face as American or British, by pressing one of two labelled response keys. They were instructed to respond as fast and as accurately as possible. The orientation of stimuli was mixed during the presentation, with independent randomisation of the order of stimuli for each subject.

Results

Table 3.9 shows the effects of inversion on familiar face processing. Related t-tests showed better recognition (higher accuracy and shorter RTs) for upright compared to inverted familiar faces. Table 3.10 shows Pearson's correlation coefficients between the recognition of upright and inverted familiar faces. There was no correlation between these conditions.

Table 3.9 The Differences Between Upright And Inverted Familiar Face Recognition In Experiment 8.

N = 30; P < 0.05*; P < 0.01**

Variables	Upright		Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	92.7	3.2	68.4	9.6	13.847**
RTS (msec)	1303	243	1792	398	6.653**

Table 3.10 Pearson's Correlation Between Classifying Upright And Inverted Famous Faces In Experiment 8.

N = 30; P < 0.05*; P < 0.01** .

<table>
<tr><th colspan="2" rowspan="2">Variables</th><th colspan="2">Upright</th></tr>
<tr><th>Accuracy</th><th>RTs</th></tr>
<tr><td rowspan="2">Inverted</td><td>Accuracy</td><td>.178</td><td></td></tr>
<tr><td>RTs</td><td></td><td>.287</td></tr>
</table>

Table 3.11 shows the differences between matching and immediate memory. Related t-tests showed that subjects were poorer in memory than in matching, but only when targets were present. Table 3.12 shows Pearson's correlation coefficients between these tasks. Significant associations were found.

Table 3.11 The Differences Between Matching And Memorising Unfamiliar Faces In Experiment 8.

N = 30; P < 0.05*; P < 0.01**

Variables	Matching		Memory		t-Tests
	Mean	SD	Mean	SD	
Accuracy	70.1	12.4	65.2	12.7	3.511**
Hits	72.0	14.5	62.5	17.2	4.240**
Miss	14.3	11.2	22.2	13.3	5.001**
Misid	13.7	11.0	15.3	9.6	1.011
FPS	31.8	14.3	31.6	16.6	0.074

Table 3.12 Pearson's Correlation Between Matching And Memorising Unfamiliar Faces In Experiment 8.

N = 30; P < 0.05*; P < 0.01**.

Variables		Matching				
		Accuracy	Hits	Miss	Misid	FPS
Memory	Accuracy	0.820**				
	Hits		0.713**			
	Miss			0.768**		
	Misid				0.623**	
	FPS					0.694**

Table 3.13 shows Pearson's correlation coefficients between upright unfamiliar face processing (matching and memory) and recognition of upright and inverted familiar faces. RTs for familiar face classification refer to correct responses only.

Table 3.13 Pearson's Correlation Between Familiar And Unfamiliar Face Processing Measures In Experiment 8

N = 30; $P < 0.05$*; $P < 0.01$**.

		Familiar Faces			
		Accuracy		RTs	
		Upright	Inverted	Upright	Inverted
Unfamiliar faces					
Matching	Accuracy	.010	.612**	–.294	–.088
	Hits	–.020	.483**	–.336	–.009
	Miss	.076	–.110	.314	–.071
	Misid	–.051	–.524**	.123	–.084
	FPS	–.038	–.571**	.169	.143
Memory	Accuracy	.077	.643**	–.319	–.035
	Hits	.104	.473**	–.309	.116
	Miss	–.123	–.147	.224	–.060
	Misid	–.017	–.642**	.241	–.125
	FPS	–.008	–.512**	.168	.162

Discussion

In this experiment subjects were asked to make speeded nationality classification decisions for familiar faces, which were presented either upright or inverted. In addition, they were given matching and immediate memory tasks of upright unfamiliar faces. A number of interesting findings was revealed.

First, recognition from memory was significantly poorer than recognition from view (matching when targets were present. Surprisingly, subjects' performance on target-absent trials was very similar in matching and memory tasks. This suggests that FP errors are not caused by the difficulty of recalling faces. Instead, subjects might have a bias to identify someone. Hit rates of 72% were recorded for matching; these fell to 62% for memory. This rather low level of performance stands in contrast to the extreme ability to upright familiar face recognition. Subjects recognise more than 90% of celebrities. However, inversion significantly impaired familiar face recognition, showing the normal face inversion effect. This impairment was observed also for RTs.

Second, there were high positive association between matching and memory tasks, replicating the results of Experiment 1 that face matching correlated with memory for face images. This suggests that encoding and memory are quantitatively but not qualitatively different processes. This contrasts with the results of Haxby, Ungerleider, Horwitz, Maisog, Rapoport and Grady (1996). These researchers used the standard recognition memory paradigm to examine brain activation associated with encoding (at learning) and recognition (at test) of unfamiliar faces. Haxby et al. (1996) found that face encoding activated left prefrontal cortex, whereas recognition activated right prefrontal cortex. This contrast might be attributed to the differences between encoding components between learning and matching faces. Encoding during learning has no recognition interference, whereas encoding during matching associates with recognition. Similarly, immediate and recognition memory paradigms include different components of memory. Subjects have to match a face to many memorised faces in recognition memory, whereas they have to match 10 faces to only one memorised face in immediate memory.

Third, there was no association between upright and inverted familiar faces for both accuracy and RTs. This finding stands in contrast to the high positive associations found for upright and inverted unfamiliar face processing in Experiments 4 – 7. Together, these data suggest that the processes underlying familiar face processing are different to those underlying unfamiliar face processing.

Finally, there is no evidence of an association between unfamiliar face processing and upright familiar face processing, regardless of whether a matching or memory task is used for measuring performance on unfamiliar faces. Of course, it is difficult to interpret this data, since there is a ceiling effect in the upright face classification task. However, there is a very striking, high level of association between the upright unfamiliar face recognition and the inverted famous face classification. These high levels of association strongly suggest that the processing of *upright* unfamiliar faces is closely related to the processing up *inverted* famous faces. Since there was no association between upright and inverted famous face classification, this is again suggestive that there is a qualitative differences between familiar and unfamiliar faces. In contrast to accuracy, RT data for the familiar face tasks do not provide any reliable associations with the measures of unfamiliar face processing.

While these data are potentially interesting, the ceiling effect for upright familiar face processing may raise some problems for interpreting its associations with unfamiliar face processing. The strong associations between inverted famous faces and upright unfamiliar faces could be proposed as a novel and important finding. There was good variability for inverted familiar face processing (standard deviations of roughly 10%), and subjects' performance was far from the ceiling level. The next experiment pursued the issue of familiar and unfamiliar face processing further, using a familiarisation procedure. The intention is to provide an experiment in which tasks for familiar and unfamiliar faces can be equated, without giving rise to ceiling or floor effects.

Experiment 9

The target images of matching arrays are stills from a high quality video. The original source videos from this database comprise 30-second clips of each person moving his head left-right, up-down, and non-rigidly through talking (though no sound is present). This was used to familiarise subjects with target people before showing the matching arrays. This is a manipulation that, despite the relatively brief exposure, has been shown to significantly improve subjects' matching ability (Bruce et al., 2001). In this experiment, subjects were presented with the 1 in 10 face matching arrays, for half of which they had been familiarised with the targets. The associations between matching upright unfamiliar faces and matching upright (Experiment 9a) and inverted (Experiment 9b) familiarised faces were examined. By this, the comparison between familiar and unfamiliar face processing was done using the same task, and (through counterbalancing of stimuli) across the same faces.

Experiment 9a

The purpose of this experiment was to investigate the relationship between upright unfamiliar and familiar face processing using a familiarisation procedure.

Method

Participants

Thirty students (20 females and 10 males) from the University of Glasgow participated in this experiment. They received either a sum of payment or course credits for participation. Ages ranged from 17 to 25 years, and all had normal or corrected to normal vision. None had taken part in Experiment 8.

Stimuli and procedure

The face matching arrays were split into two sets, each of which was equally often seen in the two familiarity conditions across the experiment. Participants were tested individually in a session of approximately an hour. First, the standard 1 in 10 face-matching task (Bruce et al., 1999) was applied. Then, subjects were familiarised with a set of faces, which were seen as targets in a subsequent matching task.

80 high quality video clips were used for the familiarisation procedure. These clips showed rigid and non-rigid motion, but were presented without sound. Each clip

showed a target sitting on a rotating chair, which gradually (in 10-degree steps) moved from fully frontal to profile, and from the opposite profile to fully frontal again. The target then looked up, looked down, and smiled toward the camera. The clips were each 30 seconds long, and were shown one after another, with 1 second gaps between them. During this learning phase, subjects were instructed to try to learn the faces, and told that they would later be asked to recognise the people depicted. Each subject completed 80 trials: Half unfamiliar and half familiarised. In each, targets were always upright and were present on half trials only. Subjects were self-paced, and were encouraged to perform as accurately as possible.

Results

Table 3.14 The Differences Between Matching Unfamiliar And Familiarised Faces In Experiment 9a.

N = 30; P < 0.05*; P < 0.01**.

Variables	Unfamiliar		Familiarised		t-Tests
	Mean	SD	Mean	SD	
Accuracy	74	10.8	87.4	8.6	6.214**
Hits	76	16.7	87	9.1	3.779**
Miss	16	15.4	9.2	6.8	2.555*
Misid	8.0	7.1	3.8	5.2	3.169**
FPS	28.2	15.7	12.3	9.7	4.935**

Table 3.14 shows the effects of familiarisation on face matching. Related t-tests showed better performance for matching familiarised compared to unfamiliar

faces. Table 3.15 shows Pearson's correlation coefficients between these conditions. No significant correlations were found.

Table 3.15 Pearson's Correlation Between Matching Upright Unfamiliar And Familiarised Faces In Experiment 9a.
N = 30; P < 0.05*; P < 0.01**

Variables		Unfamiliar faces				
		Accuracy	Hits	Miss	Misid	FPS
Familiarised	Accuracy	.277				
	Hits		.356			
	Miss			.328		
	Misid				.353	
	FPS					.103

Discussion

Familiarisation was successful, to some extent, in teaching subjects the identities. Mean accuracy increased from 74% when unfamiliar to 87% when familiarised, even though the familiarisation procedure was relatively brief (30 seconds per face), converging with the results of Bruce et al. (2001). Interestingly, once these identities have become familiar, performance on the matching task did not correlate with performance on the same task, with unfamiliar faces. Note that items were rotated around conditions across the experiment, and so the same faces were used equally often as familiar and unfamiliar. The only difference between the conditions is the level of familiarity to subjects. Furthermore, this absence of correlations is not due to a ceiling effect, as was the case in Experiment 8. Rather, the short familiarisation phase appears to be sufficient to change the way in which the faces are matched, but is not sufficient to reach ceiling levels of performance. The next experiment examined the relationship between matching upright unfamiliar faces and matching inverted familiar faces.

Experiment 9b

This experiment used the same familiarisation procedure of Experiment 9a to replicate the positive associations between upright unfamiliar and inverted familiar face processing reported by Experiment 8.

Method

Participants

Thirty students (17 females and 13 males) from the University of Glasgow participated in the experiment either for payment or course credits. Subjects' age ranged from 17-27 years. All had normal or corrected to normal vision.

Stimuli and procedure

The stimuli and procedure were the same as described in Experiment 9a, the sole exception was that familiarised targets were presented upside down. In short, subjects were presented with upright unfamiliar face matching arrays, followed by the familiarisation phase, and followed by the familiar inverted face-matching task.

Results

Table 3.16 The Differences Between Shows Matching Upright Unfamiliar And Inverted Familiarised Faces In Experiment 9b.

N = 30; P < 0.05*; P < 0.01**

Variables	Unfamiliar Upright		Familiarised Inverted		t-Tests
	Mean	SD	Mean	SD	
Accuracy	77.2	15.5	67.5	15.2	4.342**
Hits	78.0	14.5	65.0	16.0	5.697**
Miss	14.5	10.5	23.5	13.5	5.458**
Misid	7.5	9.5	11.5	9.5	2.269*
FPS	23.0	23.0	29.5	23.0	2.045*

Table 3.17 Pearson's Correlation Between Performance On Matching Upright Unfamiliar And Inverted Familiarised Faces In Experiment 9b.

N = 30; P < 0.05*; P < 0.01**.

Variables		Unfamiliar Upright				
		Accuracy	Hits	Miss	Misid	FPS
Familiarised Inverted	Accuracy	0.673**				
	Hits		0.666**			
	Miss			0.741**		
	Misid				0.526**	
	FPS					0.732**

Table 3.16 shows the differences between matching upright unfamiliar and inverted familiar faces. Related t-tests showed that subjects were significantly worse in matching inverted familiar faces than in matching upright unfamiliar faces. Table

3.17 shows Pearson's correlation coefficients between these tasks. Significant correlations were found.

Discussion

The rotation of familiarised faces upside down here produced two main findings. First, it removed the familiarisation advantage found by Experiment 9a. Instead, matching upright unfamiliar faces became significantly better than matching inverted familiar faces. Second and more intriguingly, it produced high positive associations between matching unfamiliar and familiar faces, replicating the results of Experiment 8. This pattern of results provides the clearest evidence so far for the hypothesis outlined above: processes involved in unfamiliar face processing show a strong association with those recruited for *inverted* familiar face processing. However, using the same task, familiar and unfamiliar face processing appear to dissociate when both are tested in normal (upright) conditions.

General Discussion

The purpose of the experiments reported in this chapter was to examine the relationship between upright and inverted unfamiliar face processing, and its relationship with the processing of upright and inverted familiar faces. On one hand, there was high positive association between upright and inverted unfamiliar face processing, regardless of whether matching (Experiments 4, 6, and 7) or memory (Experiment 5) was used. This effect persisted even when the 1 in 10 face matching arrays were reduced to match/mismatch pairs (Experiment 7). On the other hand, upright unfamiliar face recognition dissociated to upright familiar face recognition (Experiments 8 and 9a), but highly associated with inverted familiar face processing (Experiment 8 and 9b).

These data could be interpreted as evidence that the processes involved in upright unfamiliar face processing are similar to those underlying on inverted familiar and unfamiliar face processing, but qualitatively different to those responsible for upright familiar face recognition. The face inversion effect (see Chapter 1) is generally attributed to the notion that inverted faces cannot be processed configurally, a key component of normal face recognition (e.g., Bartlett & Searcy, 1993; Friere et al., 2000). If this is true, then the present findings suggest that unfamiliar faces in general do not support configural processing. Without such processing, one has to ask what information remains, on which the task can be performed.

One extreme solution to this problem would be to assert that unfamiliar faces are processed only as patterns, and matched in the same way as any other visual stimulus, without recourse to any information about faces in general (see Hancock et al., 2000 for a review). However, this is not a completely satisfactory explanation for this data, because unfamiliar face processing was harder when one or all of the faces are inverted. There were very high levels of association between performance upright and inverted, but there is a straightforward advantage in matching the upright versions. Since the same visual information is present in all the displays, the advantage for upright recognition must reflect some processing at a more sophisticated level than simple pattern matching. In fact, recent research by Sekular, Gaspar, Gold and Bennett (2004) has suggested that inversion effects are due to quantitative rather than qualitative differences in processing. These researchers used a visual discrimination approach, and unfamiliar faces only. They found that observers use the same regions of a face to make visual discriminations, regardless of orientation. It seems that these results are quite consistent with this position. If subjects are somehow matching particular areas of a face ("features") in both cases, then general face knowledge may help in the upright case. However, this leaves open to question whether the inversion effect for familiar faces reflects the same operations as inversion for unfamiliar faces.

The dissociation between familiar and unfamiliar face processing is strongly supported by the current results. There is a very large literature which high lights differences between familiar and unfamiliar faces processing (see Chapter 1), and these differences were the focus of considerable early work in the field (e.g., see Bruce, 1986; Klatzky & Forrest, 1984; Young et al., 1985). Indeed, a dissociation between unfamiliar face matching and familiar face recognition has long been established in the neuropsychological literature (e.g. Malone et al., 1982; Young et al., 1993). Current theoretical work tends to focus on one or other type of face processing, and modals of familiar face processing (Bruce & Young, 1986; Burton et al., 1999) have little to say on the subject of unfamiliar faces. This seems to be rational in the light of the present data.

Returning to the title of this chapter, the data presented here suggests that unfamiliar faces are not processed like faces, in exactly the same sense in which inverted faces are not processed like faces. Conflating familiar and unfamiliar faces into a single theory of face processing, therefore seems to be an unpromising approach. Having said this, it is obvious that unfamiliar faces become familiar all the time, as we come to know new people. Given the large processing differences between these two types of visual stimulus, development of a satisfactory account of face learning poses a significant challenge. In the next chapter, I would introduce another evidence for the dissociation between familiar and unfamiliar faces processing by examining the relationship between hits and false positives.

Chapter 4

Hits And False Positives In Face Matching:

A Familiarity-Based Dissociation

Introduction

How do we know that we have not previously experienced something? This is a very difficult question. In recognition memory experiments, people frequently report recognising items that were never previously seen (e.g. Roediger III & McDermott, 1999 for a review). These errors have been given several names including "false positives", "false alarms" and "false recognition". False positives in face recognition can also be observed beyond the laboratory. For example, people might approach an unfamiliar person believing them to be familiar (Young et al., 1985), or, of rather graver consequences, they might identify an innocent person as being a culprit (Huff et al., 1986; Wells et al., 1998). In contrast to these errors, people sometimes cannot recognise previously seen persons. Errors of this sort can be observed both in the laboratory (e.g. Bruce, 1982), and in real life (Young et al., 1985) as well as in eyewitness situations (e.g. Memon & Bartlett, 2002). The present chapter examines the relationship between these two types of errors, i.e. identifying new items as being old and identifying old items as being new.

Arguably, one might expect a positive correlation between identifying old items as being old (hits) and identifying new items as being new (correct rejection). This is precisely because if some items are easily identified as being old when they are old, then they should also be easily identified as being new when they are new. This may relate to the mirror effect, which is commonly considered as one of the regularities of recognition memory (see Glanzer & Adams, 1985; Glanzer, Adams, Iverson & Kim, 1993 for reviews). This effect could be summarised as follows: "*If* *there are two classes of stimuli, and one is more accurately recognised than the other, then the superior class is both more accurately recognised as old when old and also more accurately recognised as new when new*" (Glanzer & Adams, 1990, p. 5). In other words, the mirror effect suggests that the probability of hits is in direct opposition to the probability of FPS; as hits increase FPS decrease. This is a very robust effect, which has been replicated with many procedures and with a variety of stimulus categories (e.g. see Glanzer & Adams, 1985 for a review), including faces (Hockley, Hemsworth & Consoli, 1999).

Several theories have been proposed for the mirror effect, including the attention-likelihood theory (Glanzer et al., 1993), the subjective-likelihood model (McClelland & Chappell, 1998), the retrieving effectively from memory (REM) model (Shiffrin & Steyvers, 1997), and the variance reaction time model (Sikström, 2004). On one hand, the dual factor theories suggest that hits result from the differential ease of recollection-based recognition, whereas FPS result from the differential reliance on familiarity-based recognition (Cary & Reder, 2003; Joordens & Hockley, 2000; Reder, Nhouyvanisvong, Schunn, Ayers, Angstadt & Hiraki, 2000). On the other hand, single factor theories explained the mirror effect by familiarity only, suggesting that people with repeated exposure become better at identifying items as old when old and as new when new (Glanzer et al., 1993; Hintzman, 1988; McClelland & Chappell, 1998; Murdock, 1997; Shiffrin & Steyvers, 1997). In support of the latter, no mirror effect is observed for pseudowords

(Maddox & Estes, 1997), unless these are subject to successful familiarisation (Reder, Angstadt, Cary, Erickson & Ayers, 2002).

It should be noted that the mirror effect occurs across *two* classes of items, one of which should be easier than the other, for example, low frequency vs. high frequency words (e.g. Glanzer et al., 1993) or non-disguised vs. disguised faces (Hockley et al., 1999). Therefore, the mirror effect cannot indicate the relationship between hits and FPS within one class of items such as non-disguised faces.

Vokey and Read (1992) have provided a framework for the relationship between hits and FPS. Their theory is based on the effects of typicality on face recognition. It is well known that faces that are rated as distinctive are recognised more accurately (given higher hits and/or lower FPS) than those rated as typical (e.g. Bartlett et al., 1984; Bruce et al., 1994; Courtois & Mueller, 1981; Hancock et al., 1996; Lewis & Johnston, 1997; Light et al., 1979). Vokey and Read (1992) examined the source of this effect by analysing the correlations between rated typicality and other facial attributes including attractiveness, likeability, familiarity and memorability (Experiment 1). Familiarity was defined by the confusability between the presented faces and those of some people the subjects knew; memorability indicates how relatively easy it is to remember a face. The correlation matrices of these ratings were then subjected to principal component analysis (PCA). They found that rated typicality was composed of two orthogonal components, which were termed "*general familiarity*" and "*memorability*". A distinctive face is both more memorable and less generally familiar than a typical one.

Furthermore, Vokey and Read (1992) examined the interactions between these two components and face recognition accuracy. Subjects were presented with an old/new recognition test. At learning, subjects were asked to rate likeability of unfamiliar faces. At test, they were shown the same (experiment 2) or different (experiment 3) images of the targets previously rated for likeability along with an equal number of distractors. The two components affected recognition discrimination in opposite directions: Recognition was increased by increasing memorability, but decreased by increasing general familiarity. In addition, Vokey and Read (1992) examined the relationship between hits and FPS as a function of these two components. General familiarity had a significant positive effect on FPS, but had no effect on hits. On the other hand, memorability had a significant negative effect on FPS, but had nonconsistent effect on hits (a positive effect was found for one set of faces but no effect was found for another set). Thus, the combined effects on FPS of general familiarity and memorability further suggest that these two components are functionally opposite to each other.

The two-component theory of Vokey and Read (1992) has received support from several studies (Deffenbacher, Johanson, Vetter & O'Toole, 2000; O'Toole, Deffenbacher, Valentin & Abdi, 1994). For example, O'Toole et al. (1994) found that rated typicality is composed of two orthogonal components (attractiveness/familiarity and memorability) for the same race, but not for the other race faces. However, Morris and Wickham (2001) failed to replicate this pattern, as there were low loadings for typicality on familiarity component.

Vokey and Read's (1992) theory suggests that hits and FPS do *not* correlate with each other. Indeed, Bruce et al. (1994) found no correlation between hits and FPS, though each correlated with distinctiveness. Consequently, Bruce et al. (1994) suggested that faces that are easy to remember are not those that are easy to reject. This suggestion was supported by Hancock et al. (1996) and Lewis and Johnston (1997), as there was no correlation between hits and FPS in by-item analyses.

As was stated at the start of this chapter, the absence of a negative correlation between hits and FPS is really an intriguing finding. This is because if target faces are well learned, then subjects should be able to identify old faces as being old and new faces as being new. On the other hand, if some targets are not learned properly, then subjects might miss some old faces and falsely accept some new faces. Thus, hits would be expected to negatively correlate with FPS. According to Vokey and Read's (1992) theory, this absence of correlation is primarily memorial. If this turns to be true, then the "expected" negative correlation should be observed using perceptual tasks. Intriguingly however, Bruce et al. (1999) replicated the *dissociation* between hits and FPS with a face-matching task, which suggests that the relationship between hits and false positives cannot be satisfactorily explained by Vokey and Read's (1992) theory. Consequently, the aim of this chapter was to further explore the relationship between hits and FPS as a function to familiar and unfamiliar face processing using a variety of encoding tasks.

Experiment 10

The purpose of this experiment was to examine the relationship between hits and FPS by tasks of immediate memory and matching, and the relationship between these tasks using both by-people and by-item analyses. It has been previously found by recognition memory experiments that hits and FPS do not correlate with each other (Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston et al., 1997; Vokey & Read, 1992). However, immediate memory and recognition memory paradigms involve different components of memory. Namely, subjects in recognition memory learn many serially presented faces, and recognition is tested for individual faces. In contrast, subjects learn only one face in immediate memory, and identification is tested in the presence of multiple faces. This dissociation between hits and FPS was also previously observed using a matching task (Bruce et al., 1999). Nonetheless, it would be examined here more systematically using both by-people and by-item analyses. In addition, Experiment 8 found high positive associations between matching and memory, suggesting that faces that were easy to match were also easy to remember. The present experiment also tested this suggestion by examining the association between matching and memory by-item analysis.

Participants

Eighty students (53 females and 27 males) from the University of Glasgow participated in the experiment in return for a sum of payment or course credits. Ages ranged from 17 to 21 years. All had normal or corrected to normal vision.

Stimuli and procedure

The face matching arrays produced by Bruce et al. (1999) were used as stimuli. The procedure of matching and immediate memory was the same as previous experiments (see Experiment 1 for matching and Experiment 5 for memory). In short, the targets and ten face candidates were presented either simultaneously or sequentially, intervened by a 5 seconds gap. Items were rotated between these tasks across the experiment. This rotation divided the stimuli in two separate sets for the by-item analyses (half subjects saw the arrays from 1 – 40 in matching and the arrays from 41 – 80 in memory, while the other half saw the arrays from 1 – 40 in memory and the arrays from 41 – 80 in matching). The tasks were blocked, with order counter-balanced across the experiment. Each subject completed 80 trials: 40 matching trials (half present and half absent) and 40 memory trials (half present and half absent). As with the previous experiments, the presence of targets was counter-balanced across the experiment, and subjects were encouraged to perform as accurately as possible.

Results

Table 4.1 shows the differences between subjects' performance on matching and immediate memory tasks. There were significant differences for measures of target-present trials, with an advantage to matching task. However, there was no difference for performance on target-absent trials.

Table 4.1 The differences between matching and immediate memory In Experiment 10.

N = 80; P < 0.05*; P < 0.01**.

Variables	Matching		Memory		t-Tests
	Mean	SD	Mean	SD	
Accuracy	72.6	13.1	65.7	12	6.241**
Hits	73.1	15.1	61.7	15.4	7.937**
Miss	16.2	12.8	24.5	14	6.343**
Misid	10.7	10.1	13.8	10	3.015**
FPS	27.9	18.5	30.2	17.1	1.187 n.s.

Table 4.2 shows Pearson's correlation coefficients between matching and immediate memory using by-people and by-item analyses. Note that these two sets of the by-item analyses resulted from the rotation of items between matching and memory tasks across the experiment. Thus, each item was seen in both tasks by half subjects only.

Table 4.2 Pearson's Correlation Coefficients Between Matching And Memory By-People (N = 80) And By-Item (N = 40) Analyses In Experiment 10 (Accuracy With Accuracy, Hits With Hits, etc).

P < 0.05*; P < 0.01**.

		Matching				
		Accuracy	Hits	Miss	Misid	FPS
Memory	By-people	.695**	.649**	.637**	.557**	.548**
	By-items /set1	.494**	.696**	.485**	.506**	.313*
	By-items /set2	.563**	.602**	.166	.573**	.620**

Table 4.3 shows the inter-correlations within matching measures by-people and by-item analyses. The pattern of correlations within memory measures was the same as that of matching. Specifically, there was no correlation between hits and FPS both by-people [r (78) = –.089, p > 0.05] and by-item analyses [r (38) = –.044, p > 0.05 for set 1; and r (38) = –.280, p > 0.05, for Set 2].

Table 4.3 Pearson's Correlation Coefficients Between Matching Measures By-People (N = 80) And By-Item (N = 40) Analyses In Experiment 10. P < 0.05*; P < 0.01**.

	Hits	Miss	Misid	FPS
By-people analysis				
Miss	–.747**			
Misid	–.546**	–.149		
FPS	–.213	–.180	.543**	
Accuracy	.725**	–.302**	–.697**	–.827**
By-item analysis/ set 1				
Miss	–.824**			
Misid	–.676**	.139		
FPS	–.207	–.164	.576**	
Accuracy	.750**	–.421**	–.764**	–.757**
By-item analysis/ set 2				
Miss	–.664**			
Misid	–.833**	.131		
FPS	–.245	–.260	.518**	
Accuracy	.732**	–.190	–.829**	–.839**

Discussion

Similar to Experiment 8, subjects' performance was significantly poorer in immediate memory than in matching, but only when targets were present. In addition, both by-people and by-item analysis consistently showed strong positive correlation between matching and memory. This confirms the suggestion that faces that are easy to match are also easy to remember. Examining the inter-correlations within matching and memory measures provided two interesting findings. First, there were positive associations between FPS and misidentifications, suggesting that faces that elicited misidentifications in target-present trials were highly likely to elicit FPS in target-absent trials. There is a piece of evidence in the literature that could support this suggestion. Namely, Wells (1993) found that the foil, which was the second best choice in target-present line-up attracted the highest rates of FPS when the target was removed without replacement. Second and more importantly, by-people and by-item analyses consistently showed no correlation between hits and FPS using both immediate memory and matching tasks. Therefore, this dissociation has been observed so far using recognition memory (Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston, 1997; Vokey & Read, 1992), immediate memory, and matching. However, the replication of this dissociation using matching task is the most intriguing finding, which suggests that the ability to match a face is unrelated to the ability to reject that face. The next experiment would provide a more direct test for this suggestion by examining the relationship between correct identification of a face and correct rejection of the same face.

Experiment 11

If a subject picks the correct match in a target-present array, this would indicate that the subject successfully encoded the identity cues of this target. Consequently, this subject should reject any line-up, in which this target is absent. Although this appears reasonable, the dissociation between hits and FPS suggests a different scenario. Namely, that this subject is not less likely to choose a face in the absence of the target. The present experiment provided an interesting test for this intriguing hypothesis. Each subject was repeatedly presented with every target in both target-present and target-absent arrays. Thereby, the relationship between hits and FPS for the same faces could be examined.

Method

Participants

Thirty students from the University of Glasgow participated in the experiment (18 female and 12 male), whose ages ranged from 18-26 years. They received a sum of payment or course credit for their participation. All had normal or correct to normal vision, and none had taken part in Experiment 10.

Stimuli and procedure

Subjects were presented with the normal face-matching task, in which targets were present in half the line-ups and absent from the other half (the stimuli used in this task will be called Version-1, in which targets were present for example in trials 1, 3, 6 and absent in trials 2, 4, 5). Immediately after completing this task, they were presented with an identical task except that targets that were seen in target-present trials in the first task were now seen in target-absent trials. Similarly, targets that were seen in target-absent trials in the first task were now seen in target-present trials (the stimuli used in this task will be called Version-2, in which targets were absent for example in trials 1, 3, 6 and present in trials 2, 4, 5). Thus, over the course of experiment each subject saw each face in both target-present and target-absent trials. These versions were blocked, with order counter-balanced across the experiment. The order of stimuli within each version was independently randomised for each subject. The experiment was run on a G3 Macintosh computer using Superlab Pro software, and lasted approximately 50 minutes. Each array was presented on the screen until subjects responded, and there was a 1 second ISI. Each subject completed 80 trials in each version; in half the targets were present and in half the targets were absent. 11 labelled keys in the standard computer keyboard were used to record subjects' responses. Subjects were self-paced, and were encouraged to perform as accurately as possible.

Results

Table 4.4 shows the differences between subjects' performance on the two versions of matching task. No significant differences were found. Table 4.5 shows Pearson's Correlation coefficients between these versions. Significant positive associations were found.

Table 4.4. The differences Between The Two matching Versions In Experiment 11.

N = 30; P < 0.05*; P < 0.01**.

	Version 1		Version 2		t-Tests
	Mean	SD	Mean	SD	
Accuracy	73.2	13.9	71.5	14.8	1.029 n.s.
Hits	71.9	15	70.4	14.3	.695 n.s.
Miss	19.4	14.2	18.8	14.2	.312 n.s.
Misid	8.7	6.7	10.8	11.4	1.282 n.s.
FPS	25.5	21.7	27.4	22.5	.968 n.s.

Table 4.5. Pearson's Correlation Between The Two Matching Versions In Experiment 11.

N = 30; P < 0.05*; P < 0.01**.

		Version 1				
		Accuracy	Hits	Miss	Misid	FPS
Version 2	Accuracy	.791**	.359*	–.057	–.686**	–.760**
	Hits	.494**	.639**	–.564**	–.234	–.188
	Miss	–.004	–.599**	.741**	–.233	–.410*
	Misid	–.614**	–.055	–.216	.584**	.745**
	FPS	–.726**	–.067	–.283	.754**	.880**

Within each version of stimuli, there was no correlation between hits and FPS [r (28) = –.107, p > 0.05, for version 1; and r (28) = –.258, p > 0.05, for version 2], and high positive associations between FPS and misidentifications [r (28) = .869, p < 0.01, for version 1; and r (28) = .859, p < 0.01, for version 2]. Across the two versions, by-people analysis showed no correlation between hits in one version and FPS in the other, and high positive associations between FPS in one version and misidentifications in the other (see Table 4.5). Similarly, the by-item analyses showed no relationship between hits in version 1 and FPS in version-2 [$r(38) = .032$, $p > 0.05$] and between hits in version-2 and FPS in version-1 [$r(38) = .012$, $p > 0.05$], and high positive associations between misidentification in version-1 and FPS in version-2 [$r(38) = .621$, $p < 0.01$] and between FPS in version-1 and misidentification in version-2 [$r(38) = .536$, $p < 0.01$].

Discussion

In this experiment, each subject was presented with two versions or counterparts of the matching task. These were constructed on the basis of the presence of targets in the line-up; targets that were present in one version were absent in the other. Subjects' performance on these two versions was quantitatively and qualitatively very similar to each other, suggesting high consistency within subjects' ability to match unfamiliar faces. This converges with the strong consistency reported by Experiment 3, where subjects were re-examined by the same match/mismatch task after approximately one week.

By-people and by-item analyses showed high positive associations between FPS and misidentification across the two matching versions (misidentification in one version and FPS in the other). This further supports the hypothesis that distractors that are misidentified in the presence of targets are highly likely to elicit FPS in the absence of targets.

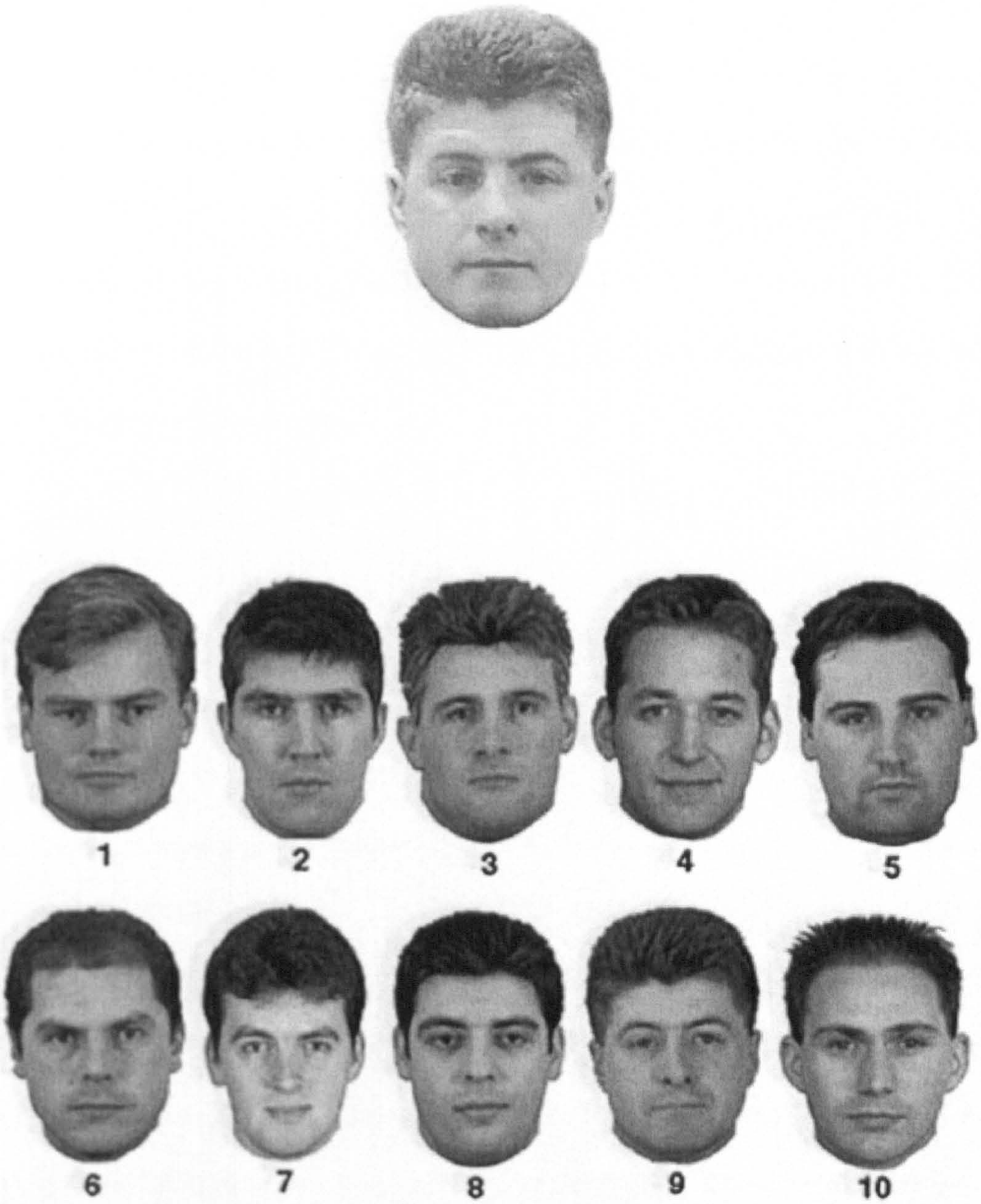


Figure 4.1. 80% of subjects correctly picked up face numbered 9 as a match in Experiment 11.

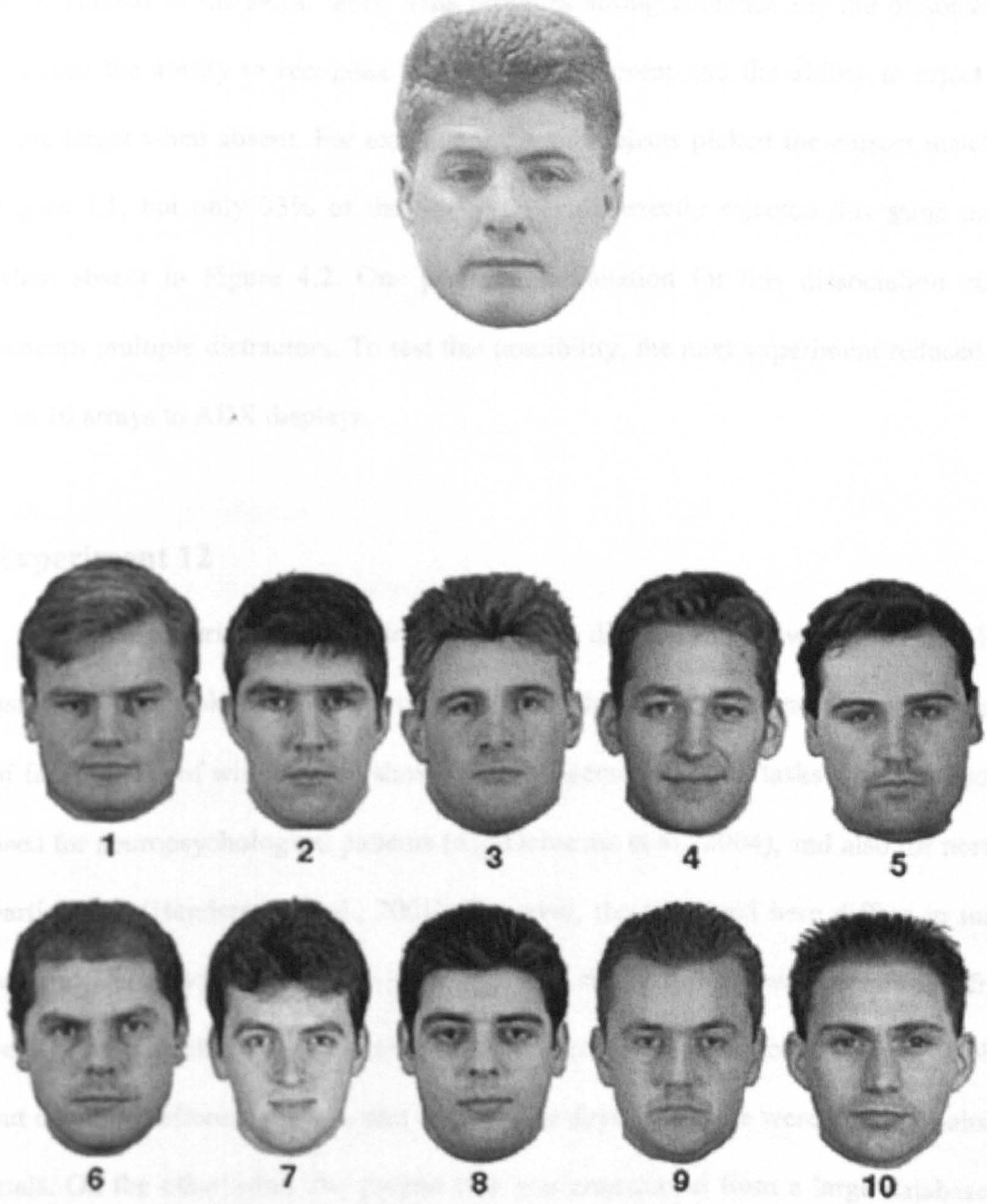


Figure 4.1. 67% of subjects incorrectly picked up face numbered 3
as a match in Experiment 11.

More surprisingly, By-people and by-item analyses showed no correlation between hits in one version and FPS in the other version. Note that hits and FPS here were elicited to the same faces. This provides strong evidence for the dissociation between the ability to recognise a target when present and the ability to reject the same target when absent. For example, 80% of subjects picked the correct match in Figure 4.1, but only 33% of the same subjects correctly rejected this same target when absent in Figure 4.2. One possible explanation for this dissociation might concern multiple distractors. To test this possibility, the next experiment reduced the 1 in 10 arrays to ABX displays.

Experiment 12

This experiment aimed to replicate the dissociation between hits and FPS using an ABX task. Subjects were presented with a target face and two photographs of faces, either of which might show the target person. Similar tasks were commonly used for neuropsychological patients (e.g. Delvenne et al., 2004), and also for normal participants (Henderson et al., 2001). However, the task used here differs in many ways to Henderson et al's (2001) task. Namely, this latter task was constructed from very limited database of faces, all of which were of the same format (photographs), but taken by different camera, and on different days, and there were no target-absent trials. On the other hand, the present task was constructed from a large database of faces, taken by different camera, with different format, and on the same day, and targets were present in half the trials only. This task was used to examine the relationship between hits and FPS using both by-people and by-item analyses.

Method

Participants

Forty students (18 males and 22 females) from the University of Glasgow participated in the experiment, and ages ranged from 17 to 25 years. Twenty-three subjects were undergraduate students, who received a sum of payment or course credits for participation. The remaining participants were postgraduate volunteers from the Department of Psychology. All reported normal or corrected to normal vision. None had taken part in Experiments 10 and 11.

Stimuli and procedure

80 arrays from those produced by Bruce et al. (1999) were edited, such that there was a video still of a target presented above a photograph of the target himself and a paired distractor, or two photographs of distractors. The distractors were chosen from faces with which the targets were frequently confused in the previous experiments. All images were presented without background, and sized approximately 5x7cm. The experiment was run on a G3 Macintosh computer using Superlab Pro software. Each stimulus was presented on the screen until subjects responded, and there was a 1 second ISI. The order of the stimuli was randomised independently for each subject. Each subject completed 40 trials: half present and half absent, and the presence of targets was counterbalanced across the experiment. Subjects were encouraged to perform as accurately as possible and told that targets would be present in half trials only.

Results and discussion

Subjects' performance on this ABX was rather poor. Hit rates of 74.8% (sd = 15%) were recorded, with FP rates of 17.7% (sd = 11.8%). This provides further new evidence for the difficulty of matching unfamiliar faces (Bruce et al., 1999; Experiments 1 – 11). In addition, there was no correlation between hits and FPS both by-people [$r(38) = .029 > 0.05$] and by-item [$r(38) = -.224 > 0.05$] analyses. Thus, reducing the number of distractors from nine to one did not change the quantitative nor qualitative characteristics of hits and FPS in matching unfamiliar faces. The next experiment further examined the dissociation between hits and FPS using a match/mismatch task from the sort that was previously used in Experiments 3 and 7.

Experiment 13

This experiment provides a critical test for the dissociation between hits and FPS. Subjects were presented with only two images, and were asked whether these images were of the same person or two different people.

Method

Participants

Forty paid subjects (25 female and 15 male) from the University of Glasgow participated in this experiment, whose ages ranged from 18-27. All had normal or corrected to normal vision, and none had taken part in Experiments 10 – 12.

Stimuli and procedure

Stimuli and procedure were identical to those described in details in Experiment 3. Each subject completed 84 trials (half match and half mismatch), and items were counter-balanced across the experiment.

Results and discussion

Replicating Experiments 3 and 7, subjects performed poorly on this simple same/different task. Hit rates of 77.8% (sd = 17.1) and FP rates of 15.5% (sd = 12.4) were reported. More surprisingly, there was no correlation between hits and FPS on this task using both by-people [r (38) = .106 > 0.05] and by-item [r (38) = .098 > 0.05] analyses. This is the strongest evidence presented so far for the current hypothesis: subjects' ability to recognise an unfamiliar face is dissociable from their ability to reject that face. This dissociation is therefore robust across a variety of tasks of different demands. The next experiment aimed to explore the relationship between hits and FPS in the processing of non-face objects.

Experiment 14

The positive associations between matching unfamiliar faces and objects that were in Experiment 1 suggest that hits may not correlate with FPS in matching objects. To date, nothing is known about the relationship between hits and FPS in object processing domain (e.g. see Bruce & Humphreys, 1994 for a review). Besides, no correlation was observed between hits and FPS in inverted unfamiliar face processing (Experiments 4 – 7). This further suggests a similar dissociation in object processing. The present experiment examined this suggestion.

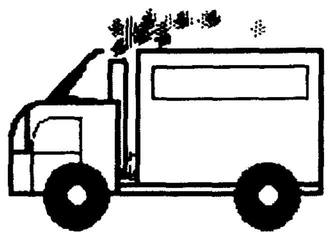
Method

Participant

Thirty students (17 female and 13 male) from the University of Glasgow participated in the experiment in return for a sum of payment or course credits. Ages ranged from 17-25 years, and all had normal or corrected to normal vision.

Stimuli and procedure

The stimuli were taken from the MFFT test, which was described in details in Experiment 1. Each stimulus in the original version shows a target object presented with a six-object array, one of which is the target. This was developed here, such that there were both target-present and target-absent arrays. Adobe Photoshop programme was used to edit the targets by eliminating or adding a basic feature to make them different to all line-up stimuli (see Figure 4.3). Two versions of stimuli were constructed to counter-balance the presence of targets across the experiment. Therefore, each target object was equally often seen in target-present and target-absent trials. An apple Macintosh computer was used to present stimuli and to record responses, using Superlab Pro software. Items were randomly inter-mixed during the experiment, with a 1 second ISI. The subjects' task was to indicate whether or not the target was present, and if so to indicate which one. Seven labelled keys in the standard computer keyboard were used for subjects' response. Each subject completed 48 trials: half present and half absent, and subjects were correctly informed that. Subjects were self-paced, and were encouraged to perform as accurately as possible.



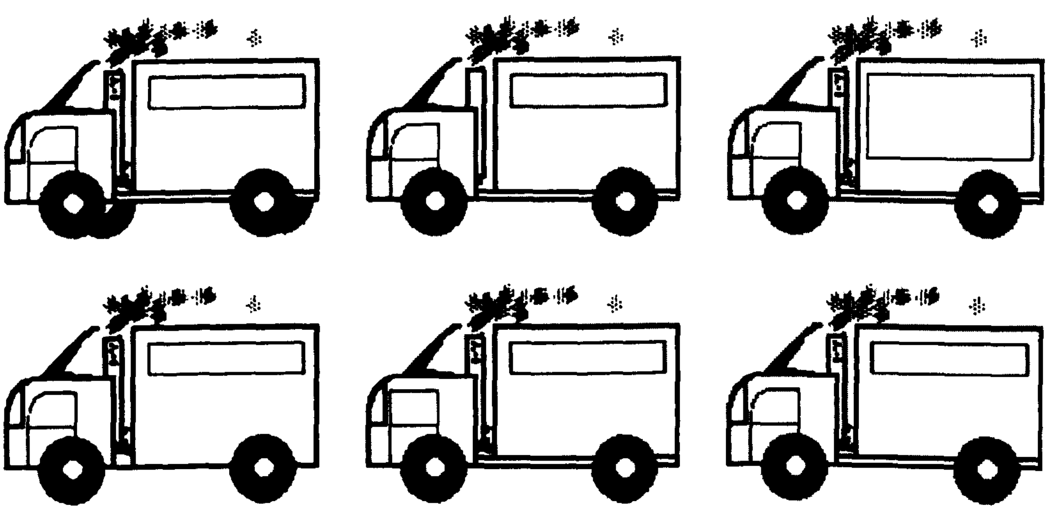


Figure 4.3 shows an example of target-absent arrays used in Experiment 14.

Results and discussion

Subjects had a very strong bias to choose a match in target-absent arrays, though they were told that targets would be present on half trials only. FP rates of 66.2% (sd = 17.5) were reported. By contrast, hit rates of 70.5% (sd = 15%) were recorded, which was very similar to those found by Experiment 1, where targets were always present. Consistently with the hypothesis of the experiment, there was no correlation between hits and FPS in matching objects [$r(28) = -.220$, $p > 0.05$]. Interestingly, in spite of this high response bias, the correlation between hits and FPS was *still* negative. A positive correlation between hits and FPS might be expected in the case of such response bias. However, the positive correlation between FPS and misidentifications [$r(28) = .364$, $p < 0.05$], and the high negative correlation between misidentifications and hits [$r(28) = -.898$, $p < 0.01$] seem to be the source of this negativity. In other words, FPS and misidentifications are increased together, but hits decreased *only* with the increase of misidentifications. Therefore, the correlation between hits and FPS should be negative. The high misidentification rates (23%) compared to the very low miss rates (5.8%) could further support this explanation. However, the over-riding finding of this experiment was the dissociation between hits and FPS in matching objects, which converges with matching unfamiliar faces (Experiments 10 – 13). The next experiment examined the relationship between hits and FPS in the processing of familiar faces.

Experiment 15

This experiment examined how familiarity may affect the relationship between hits and FPS. One of the difficulties of this concerns the robust recognition of familiar faces producing a ceiling level of hits and a flooring level of FPS (Burton et al., 1999), meaning that one cannot examine the correlation between them. In addition, it is not possible to apply the matching task to familiar face stimuli so that memory load can be minimised. To resolve these problems, the present experiment used a familiarised face-matching task, by which the relationship between hits and FPS was examined using by-people (Experiment 15a) and by-item (Experiment 15b) analyses.

Experiment 15a

Method

Data for this experiment was obtained from Experiment 9a, which was reported in detail in chapter 3. In short, subjects were presented with the standard 1 in 10 face-matching task. Then they were familiarised with a set of faces, which appeared as targets in a similar 1 in 10 face-matching task. The relationship between hits and FPS in the first (unfamiliar) and the second (familiarised) tasks were examined.

Results and discussion

Familiarisation had a significant effect on face matching accuracy. Hit rates were significantly higher for familiarised (87%) than for unfamiliar (76%) faces. In addition, FPS were significantly lower for familiarised (12.3%) than for unfamiliar (28.2%) faces. Therefore, recognition of familiar faces *mirrored* recognition of unfamiliar faces. This supports the theories indicating that familiarity is the cause of the mirror effect (Glanzer et al., 1993; Hintzman, 1998; McClelland & Chappell, 1998; Murdock, 1997; Shiffrin & Steyvers, 1997). However, similar mirror effects were previously observed between recognition of upright and inverted faces (Experiments 4 – 7). More interestingly, familiarisation had a significant effect on the relationship between hits and FPS. The standard dissociation between hits and FPS was observed for matching unfamiliar faces [r (28) = .093 > 0.05], replicating the results of Experiments 10 – 13. In contrast, there was strong negative association between hits and FPS in matching familiarised faces [r (28) = –.711 < 0.01]. Thus, familiarisation was able to re*concile* subjects' ability to recognise a face when present and their ability to reject that face when absent. In other word, accurate responses to target-present trials are now correlated with accurate responses to target-absent trials. This suggests that the negative correlation between hits and FPS seems to be semantic-based. And in turn, it is absent for unfamiliar face processing. The next experiment aimed to replicate this effect using by-item analysis.

Experiment 15b

By-item analysis was not possible in Experiment 15a because faces were rotated between familiarised and unfamiliar conditions. Therefore, more subjects were tested here to provide sufficient data to examine the relationship between hits and FPS using by-item analysis.

Method

Data from fifteen subjects were taken from Experiment 15a in the familiarity condition and twenty-five new subjects were tested here by the same stimuli and procedure.

Results and discussion

The effects of familiarisation on face matching accuracy were examined using the by-item analysis. Data for unfamiliar faces were taken from Experiment 10 (Set-1). These were the same faces, which subjects were familiarised with in the present experiment. Table 4.6 shows the differences between familiarised and unfamiliar face matching accuracy. Familiarised faces were significantly easier to match than unfamiliar faces, converging with the standard familiarity effect (Burton et al., 1999).

Table 4.6 The Differences Between Matching Familiarised And Unfamiliar Faces Using By-Item Analysis In Experiment 15b.

N = 40; $P < 0.05$*; $P < 0.01$**.

Variables	Unfamiliar		Familiarised		t-Tests
	Mean	SD	Mean	SD	
Accuracy	69.0	14.5	87.7	13.2	10.163**
Hits	69.2	18.6	86.7	15.5	8.923**
Miss	19.9	13.9	10.3	12.4	5.420**
Misid	10.9	10.7	3.0	6.2	4.984**
FPS	30.1	18.9	11.2	13.7	7.763**

Once again, by-people analysis showed high negative association between hits and FPS in matching familiarised faces [$r(38) = -.612$, $p < 0.01$], replicating the results of Experiment 15a. Consistently, by-item analysis showed this same effect [$r(38) = -.602$, $p < 0.01$].

To this point, there is a robust dissociation between hits and FPS in unfamiliar face processing across different tasks (Experiments 10 – 13). In marked contrast, there is high association between them in matching familiarised faces. This provides further evidence that familiar face processing is qualitatively different to unfamiliar face processing, converging with the conclusions of Chapter 3. The question raised now concerns the effect of inversion on the relationship between hits and FPS in matching familiarised faces. The next experiment investigated this question.

Experiment 16

Two main conclusions were previously put forward from the experiments reported in Chapter 3: (i) upright familiar and unfamiliar face processing is dissociable; and (ii) upright unfamiliar and inverted familiar face processing is associable. The relationship between hits and FPS further supports the first conclusion. Namely, they were dissociable for unfamiliar face processing, but they were associable for familiar face recognition. The second conclusion suggests that inversion might remove the association between hits and FPS in familiar face processing. The present experiment provides a test for this possibility. The same procedure of Experiment 15a was followed here, but familiarised targets were presented upside down.

Method

Data of this experiment was taken from Experiment 9b, which was reported in details in Chapter 3.

Results and discussion

In this experiment subjects were presented with the standard 1 in 10 unfamiliar face-matching task, and were then presented with a familiarised matching task, in which targets were presented inverted. Targets were rotated between these tasks. Consequently, by-item analysis was not possible here. The standard dissociation between hits and FPS was observed in matching upright unfamiliar faces [$r(28) = -.302$, $p > 0.05$]. Interestingly, a similar effect was observed for matching inverted familiarised faces [$r(28) = -.230 > 0.05$]. Thus, inversion removed the effects of familiarity on the relationship between hits and FPS. Instead, it produced the same pattern found for unfamiliar faces, supporting the hypothesis that the processes underlying upright unfamiliar and inverted familiar face recognition are qualitatively similar.

General Discussion

The main concern of the experiments carried out in this chapter was to examine the relationship between hits and FPS as a function to familiar and unfamiliar face processing. By-people and by-item analyses show no correlation between hits and FPS using an immediate memory task (Experiment 10). This dissociation was previously reported by face recognition memory literature (Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston, 1997; Vokey & Read, 1992), where it has been explained by Vokey and Read's (1992) theory that typicality could be broken into two orthogonal components: memorability and context-free familiarity. However, this same dissociation was observed using face-matching task (Bruce et al., 1999; Experiments 10 – 13, 15, and 16). Therefore, Vokey and Read's (1992) theory cannot explain the present finding because no memory is involved in the face-matching task.

In Experiment 11, each target was seen in both target-present and target-absent trials, and the associations between hits when the targets were present and FPS when the <u>same</u> targets were absent were examined. By-subject and by-item analyses showed no correlation between hits and FPS, confirming the suggestion that ability to match a face is unrelated to the ability to reject the face. When the line-up task was reduced to an ABX task (Experiment 12) or even a match/mismatch task (Experiment 13), by-subject and by-item analyses consistently showed no correlation between hits and FPS. This same pattern was also observed using an object-matching task (Experiment 14). However, prior familiarisation was successful in producing the expected negative correlation between hits and FPS when familiarised target faces were presented upright (Experiment 15), but not when they were presented inverted

(Experiment 16). Therefore, a negative correlation between hits and FPS could be observed provided that faces should be *both* familiar and upright.

The dissociation between hits and FPS in the processing of upright unfamiliar faces (Experiments 10 – 13, 15, and 16) and the association between them in the processing of upright familiar faces (Experiments 15a – 15b) strongly suggest that these two sorts of processing are qualitatively different. Moreover, the association between hits and FPS was *converted* to a dissociation when familiar faces were presented upside down (Experiment 16). This suggests that inversion made familiar faces processed in a manner similarly to upright unfamiliar faces. These findings are in great agreement with the conclusions put forward by Chapter 3, both of which indicate that the processes underlying recognition of upright unfamiliar faces are qualitatively different to those involved in upright familiar face recognition, but similar to those responsible for the processing of inverted familiar faces.

In addition to these theoretical implications, these data have very important implications for the forensic practice. The dissociation between hits and FPS suggests that eyewitnesses' ability to identify a suspect is *unrelated* to their ability to reject that suspect. Consequently, eyewitnesses who misidentified an innocent person in target-absent line-up may be able to identify the perpetrator if they were shown a target-present line-up. The next chapter would highlight another factor that could dramatically impair eyewitness identification, namely the number of perpetrators.

Chapter 5

Recognising Faces Seen Alone Or With Others: When Two Heads Are Worse Than One

Introduction

It has been known for many years that eyewitness identification is prone to error (e.g. see Cutler & Penrod, 1995; Huff et al., 2005; Wells et al., 1998; Wright & Davies, 1999 for reviews). Witnesses to incidents involving previously unfamiliar people can find it difficult to recall characteristics of the people they have observed, or subsequently to recognise their faces. Across several decades of research, psychologists have worked towards improving witnesses' memory using a variety of techniques (e.g. Memon et al., 2003; Wells & Olson, 2003). However, despite a very large literature in this field, the vast majority of research reports contain studies of memory for a single person. Although it is hard to establish reliable figures, it seems safe to assert that many incidents involve more than a single perpetrator. It is therefore important to establish the relationship between memory for faces seen alone, and seen with others.

In any recognition task, one would expect memory for multiple items to be poorer than memory for a single item. However, in the case of eyewitness testimony, it is important to establish the nature, and extent, of any reduction in accuracy. For example, it is possible that two faces could in some sense contaminate each other, or could be hard to differentiate and hence store accurately. Alternatively, it could be that observers form an association between faces of those seen together, which could support recognition. What little evidence exists, suggests that accompanying persons *damage* memory for a target face.

Clifford and Hollin (1981) examined the effect of the number of perpetrators on identification accuracy. Subjects were shown a videotape depicting either a violent robbery (a hand-bag theft) or a non-violent interaction (the same actor depicted asking for directions). The principal man (who played both thief and direction seeker across tapes) was shown alone, or with two or four accomplices. An unexpected ten-person identification line-up test revealed poor accuracy in identifying the main protagonist, even in the non-violent case (40% when alone, 30% and 20% when accompanied by two or four companions, respectively). The effect of group-size was also present in the violent incident (30%, 30% and 10% accurate, when alone, or with two or four companions respectively). Clifford and Hollin (1981) concluded that as the number of perpetrators increased, the accuracy of identification decreased, specifically for the non-violent situation.

There are two main problems with Clifford and Hollin's (1981) study. First, it was a between-subjects study, and there were a small number of subjects in each condition (10). This conflicts with the large individual differences in face recognition (see Chapter 2). In addition, it seems likely that subjects did not distribute their attention equally between the target and his accomplices. Less attention was paid to the companions compared to the target simply because he was performing the principle action. Therefore, the presence of the companions might be best described as "*noise*", rather than actual co-perpetrators.

In a more recent study, Fahsing, Ask and Granhag (2004) examined the effect of number of perpetrator on the accuracy of descriptions using real line-ups. They found that the number of perpetrators negatively correlated with the description accuracy. Witnesses of incidents involving two offenders gave significantly less accurate descriptions than those observing one offender.

In addition to issues of memory, there is a second reason to examine the nature of identification for multiple faces. As reviewed in Chapter 1, the unreliability of eyewitness evidence might not be due entirely to the difficulty of memory. Rather, it might be particularly difficult to *encode* unfamiliar faces in the first place. The problems in unfamiliar face encoding, rather than memory, may relate to some recent work on attention for faces. There is some evidence that individual faces might attract attention (e.g. Ro, Russel & Lavie, 2001; Vuilleumier, 2000). If this turns out to be true in witnessing settings, it is unclear how attentional resources might be divided between competing faces. In fact, evidence is beginning to accrue that in some experimental situations, it may be possible only to process a single face at one time (Boutet & Chaudhuri, 2001; Jenkins, Lavie & Driver, 2003; Palermo & Rhodes, 2002). Recent research suggests that attentional resources may in some sense be divisible into stimulus-specific components, such that no more than a single face is processed at once (Bindemann, Burton & Jenkins, in press). There is no evidence about how this may affect a realistic eyewitness memory situation. However, in order to establish patterns of performance for multiple faces, immediate memory and matching tasks were developed, such that there are two target faces, either of which may be present in the 10-face line-ups.

Experiment 17

This experiment examined how well people could identify one of two unfamiliar faces, following learning. Subjects were asked to study two faces until they felt confident that they could identify either of them later. They were then immediately shown a line-up of ten faces, in which one, or neither of the faces appeared. Identification accuracy was compared to a condition in which only a single face was studied at learning.

Method

Participants

Twenty paid volunteers participated in this experiment (12 female and 8 male). They were all undergraduate students at the University of Glasgow, with an age of 18 to 24 years. All had a normal or correction to normal vision.

Stimuli and procedure

40 arrays from those produced by Bruce et al. (1999) were used as stimuli. Each array consisted of a target video still, and the 10-face line-up. In addition, there were 40 video images of unfamiliar faces, which were used as companions to the targets in the two-face learning condition. None of the companion images were used as targets across the experiment or as distractors in the line-ups. Targets and their

companions were of the same format (video stills), size (approximately 5x8 cm), and had similar quality and lighting conditions.

Subjects were tested individually in a session of approximately 30 minutes. On each trial they were shown (i) a single or a double target; (ii) an intervening interval of 2 sec; (iii) a 10 face line-up. Manipulation of one/two targets was carried out within subjects, and was blocked, with order counter-balanced across the experiment. Subjects were instructed that on each trial the 10-face array might or might not contain a single target, and that they should study the target face(s) carefully until they felt confident enough to recognise it in a subsequent test. Figure 5.1 shows a schematic representation of the procedure.

A target face was present in the line up on half the trials, and faces were counter-balanced such that, across the experiment, each target appeared equally often in a target-present and a target-absent trial. Furthermore, between subjects, targets were counter-balanced such that each appeared equally often in single-face and two-face target conditions. In two-face target-present trials, the left/right position of the target was counter-balanced across the experiment. Each subject completed 40 trials: 20 trials in the single condition (10 target-present and 10 target-absent trials) and 20 trials in the two-face target condition (10 target-present and 10 target-absent trials). Subjects were encouraged to perform as accurately as possible.

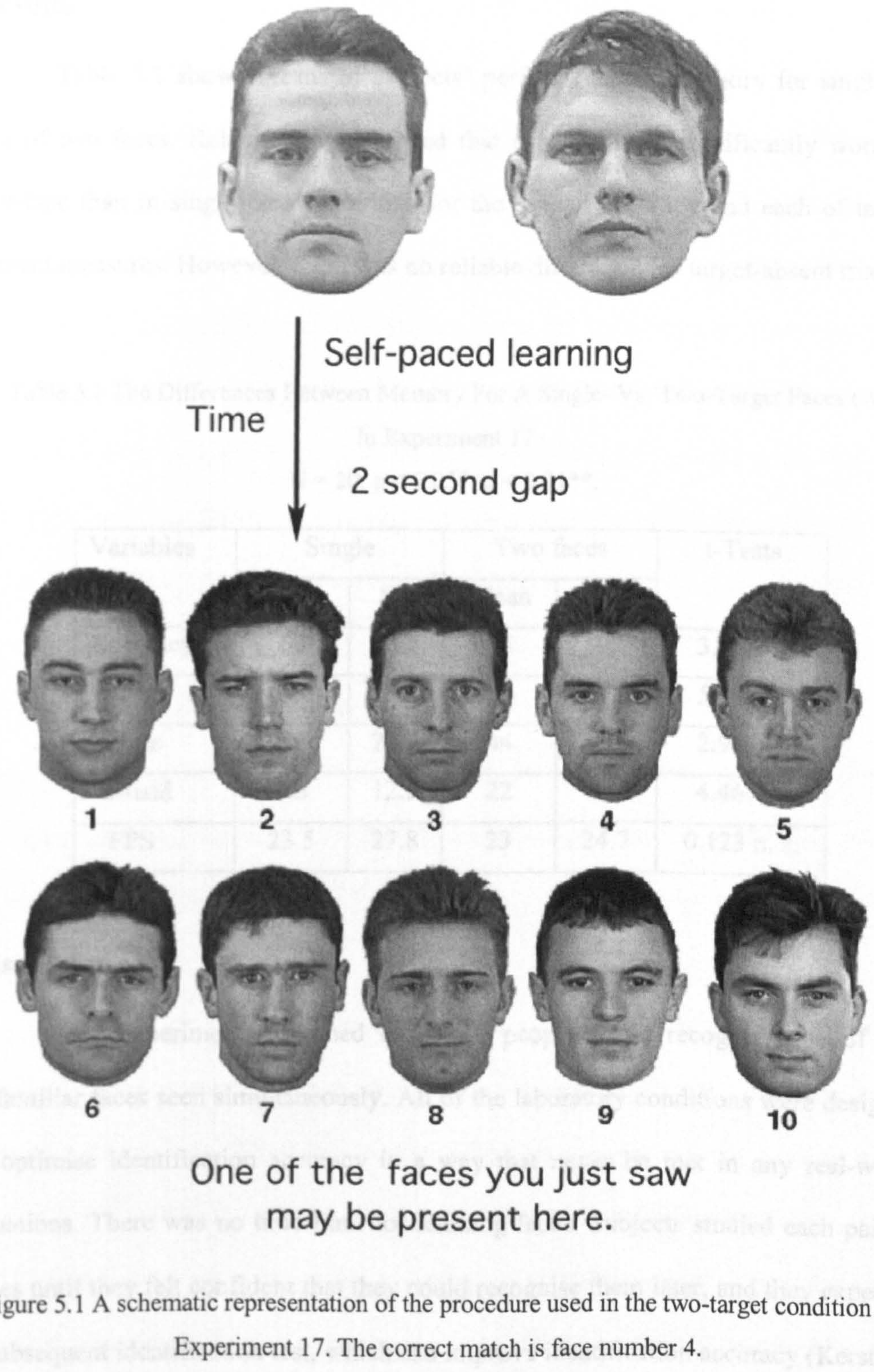


Figure 5.1 A schematic representation of the procedure used in the two-target condition in Experiment 17. The correct match is face number 4.

Results

Table 5.1 shows means of subjects' performance on memory for single vs. one of two faces. Related t-tests showed that subjects were significantly worse in two-face than in single-face conditions for the overall accuracy and each of target-present measures. However, there was no reliable difference for target-absent trials.

Table 5.1 The Differences Between Memory For A Single- Vs. Two-Target Faces (%) In Experiment 17.

N = 20; $p < 0.05$*; $p < 0.01$**.

Variables	Single		Two faces		t-Tests
	Mean	SD	Mean	SD	
Accuracy	68	18.1	55	17.7	3.948**
Hits	59.5	22.6	34	18.5	5.820**
Miss	31	22.9	44	23.9	2.942**
Misid	9.5	12.3	22	17	4.467**
FPS	23.5	27.8	23	24.7	0.123 n. s.

Discussion

This Experiment examined how well people could recognise one of two unfamiliar faces seen simultaneously. All of the laboratory conditions were designed to optimise identification accuracy in a way that never be met in any real-world situations. There was no time limit for learning faces. Subjects studied each pair of faces until they felt confident that they could recognise them later, and they expected a subsequent identification test, which can improve identification accuracy (Kerstholt et al., 1992). Furthermore, subjects did not experience any emotional stress during the course of the experiment, which may affect identification accuracy (e.g. see Christianson, 1992 for a review). There was a very short gap between the study and test phases (2 seconds), and so detrimental effect of the long retention intervals were avoided (Krafka & Penrod, 1985). In addition, the images were taken in good lighting conditions, showing full-face view and similar facial expressions, and they were taken on the same day, eliminating any transient differences in appearance such as hairstyle, health, or age. In spite of these optimal conditions, identification accuracy was remarkably poor. The hit rate for identifying a single unfamiliar face was 59%, and this fell to a very low 34% when accompanied by a second face. Notably, the low hit rates of single faces converging with those recorded by Experiments 5, 8, and 10. In addition, the presence of a second face made recognition of a target person *double* difficult. It is worth mentioning that some subjects tried to overcome the difficulty of recognising one of two faces by increasing the time that was spend studying the faces. Yet, despite such strategies they were still highly likely to produce an incorrect response.

Interestingly, there was no effect of one/two face targets in the target-absent trials. Accuracy is very poor here, with subjects falsely choosing a match on roughly a quarter of occasions. Whatever the reason for this, it seems unlikely to be based on matching of the faces in memory. If subjects were trying to match a seen face, and if the 10-face line up simply provides a number of plausible matches, then one would expect the number of false matches to increase with the number of targets. However, this was not observed. I will return to this position in the General Discussion.

The finding of an overall reduction in accuracy with two faces versus one supports the results of Clifford and Hollin's (1981) study. This reduction could be interpreted as a general effect of memory load, or might have characteristics, which are particularly evident in face recognition. In either case, it is important for forensic reasons to explore the effect further. The next experiment examined the nature of this two-face disadvantage.

Experiment 18

In our everyday interactions, we often see unfamiliar faces sequentially, rather than simultaneously. Perhaps the difficulty in recalling multiple faces is confounded by simultaneous presentation, and so experiment 17 might over-emphasise the effect. The present experiment directly compared simultaneous and sequential learning on recognition memory for two faces, and examined the possible effects of serial position in the sequential case.

Method

Participants

Twenty students from the University of Glasgow participated in this experiment in return for a small payment. Age ranged from 18 to 24, and seven were men. All subjects had normal or corrected to normal vision. None had taken part in Experiment 17.

Stimuli and procedure

The stimuli for this experiment were taken from the same database of face matching arrays (Bruce et al., 1999). There were 120 arrays used in this experiment. Each array consisted of two video-still targets and a 10-face line-up. Subjects were tested individually in a session of approximately an hour. They were asked to learn two unfamiliar faces presented simultaneously (one beside the other) or sequentially (one after the other) until they felt confident that could recognise the faces later. After a 2 second gap, they were asked to identify one of the two learned faces in target-present or target-absent line-ups. The sequential/simultaneous presentation was manipulated within subjects, and blocked, with order of blocks counter-balanced across the experiment. A schematic representation of the procedure is shown in Figure 5.2.

There were 20 simultaneous trials, in which left/right position of the target was counterbalanced. In the sequential condition, there were 40 trials; in half of which the targets appeared first, and in the other half the targets appeared second. These were presented to subjects inter-mixed in a random order. The targets were counter-balanced between the two serial positions across the experiment. In the simultaneous and sequential conditions, half the trials were target-present, and half target-absent, and subjects were made aware of this before the experiment. As with previous experiments, the presence of targets was counter-balanced across the experiment.

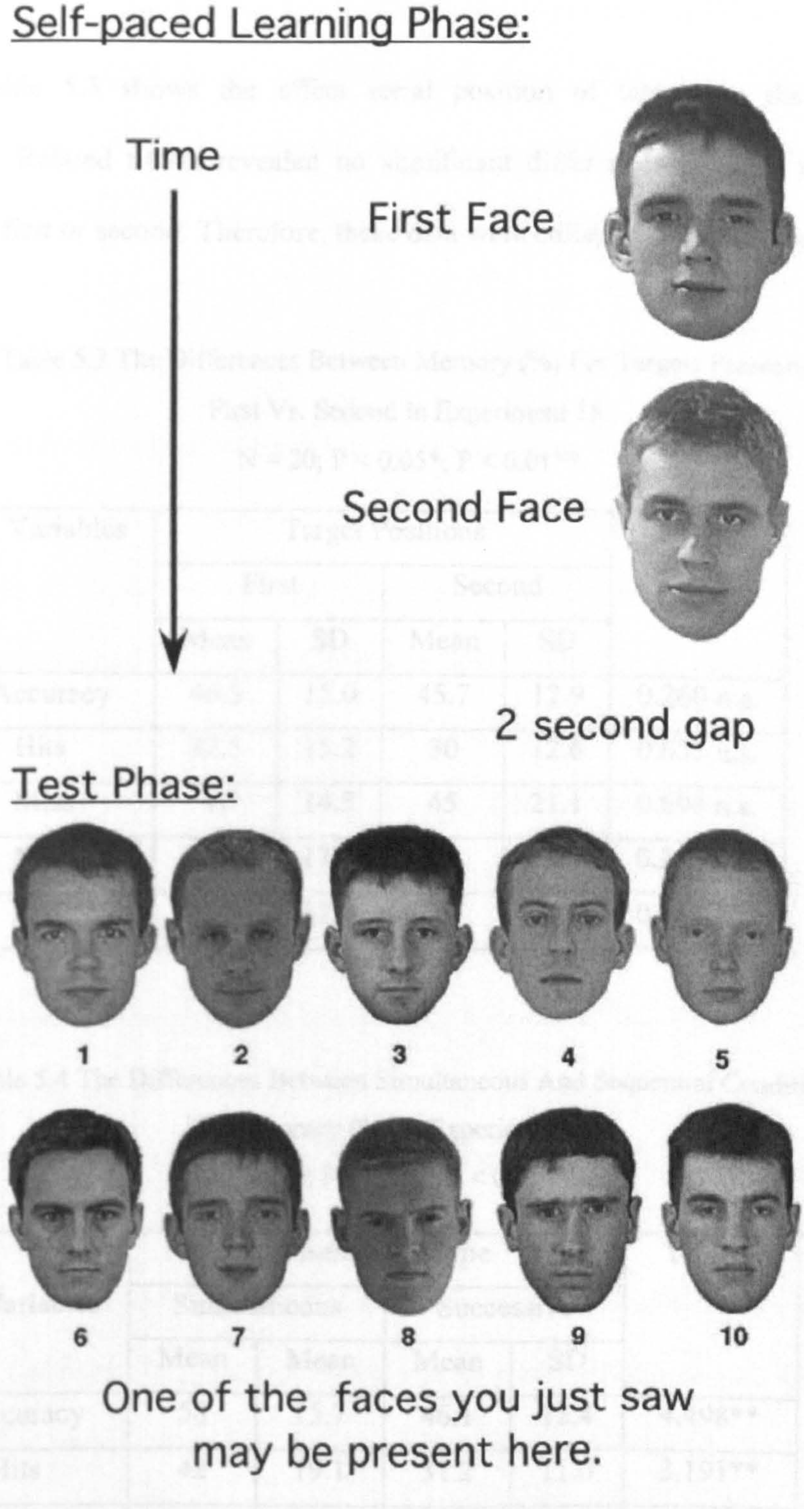


Figure 5.2 A schematic representation of the procedure used in the sequential condition in Experiment 18. The correct match is face number 7.

Results

Table 5.3 shows the effect serial position of targets in the sequential condition. Related t-tests revealed no significant differences between target faces presented first or second. Therefore, these data were collapsed into one condition.

Table 5.3 The Differences Between Memory (%) For Targets Presented First Vs. Second In Experiment 18.

N = 20; P < 0.05*; P < 0.01**.

Variables	Target Positions				t-Tests
	First		Second		
	Mean	SD	Mean	SD	
Accuracy	46.5	15.0	45.7	12.9	0.260 n.s.
Hits	32.5	15.2	30	12.6	0.653 n.s.
Miss	41	14.5	45	21.1	0.698 n.s.
Misid	26.5	17.8	25	19.3	0.286 n.s.
FPS	39.5	17.9	39	19	0.137 n.s.

Table 5.4 The Differences Between Simultaneous And Sequential Conditions In Accuracy (%) In Experiment 18.

N = 20; P < 0.05*; P < 0.01**.

Variables	Presentation Type				t-Tests
	Simultaneous		Successive		
	Mean	Mean	Mean	SD	
Accuracy	58	15.7	46.1	12.4	4.498**
Hits	42	19.1	31.2	11.0	3.191**
Miss	38	22.4	43	12.8	1.209 n.s.
Misid	20	17.5	25.8	14.4	1.607 n.s.
FPS	26	22.6	39.2	16.5	3.345**

Table 5.4 shows mean performance levels in the simultaneous and sequential conditions. Related t-tests showed significant differences in the overall accuracy, hits, and FPS, with an advantage for simultaneous condition. However, there was no significant difference for misses and misidentifications.

Discussion

Identification of a target when presented simultaneously with a second face was very poor (a hit rate of 42% for target present trials), replicating the results of Experiment 17. However, this fell to a very low 31% when the two faces were presented sequentially, rather than simultaneously. Furthermore, there was no effect of target position on the sequential trials: hit rate was equally poor whether the target appeared first or second. This finding suggests that the second face did not "over-write" the first face during learning phase, i.e. there appears to be no advantage for the face that subjects have seen most recently. Therefore, change blindness of identity cannot be explained by overwriting hypothesis (see Chapter 1), rather it could be explained by simple poor face memory. The advantage for seeing faces simultaneously might be explained as a benefit to comparison. Subjects were able to compare between faces in the simultaneous condition, and perhaps this might help them to process some distinctive features. This mode of processing is absent in the sequential condition. The question raised now is whether this two-face disadvantage occurs while transferring information about faces to memory, or during the perceptual encoding of these faces. In other words, are both faces encoded sufficiently but this information cannot be fully stored during or following encoding, or are both faces encoded insufficiently in first place? This question was investigated in the next experiment.

Experiment 19

Although Experiments 17 and 18 demonstrated a disadvantage for remembering two faces, as compared to one, the locus of this effect remains unclear. In particular, it is not clear whether the difficulty of the task lies with accessing a memory for seen faces, or whether the faces are coded poorly in the first place. Note that subjects were allowed to encode the faces as much time as they need, and were not given any particular strategy for doing so. However, in experiments 1 – 13, poor *matching* performance was observed on these same types of stimuli. It is therefore possible that a significant difficulty in remembering previously unfamiliar faces lies in the encoding stage, rather than in memory recall. Given the large literature attempting to enhance the recovery of accurate memories from eyewitnesses, a difficulty with initial encoding may suggest that one part of the problem is under-researched.

The purpose of this experiment was to investigate the basis for the two-face disadvantage by examining the effect in a matching task. The intention is to allow subjects to encode the faces optimally, but to minimise memory demands. If the difficulty in recognising a face in the context of a second face is primarily memorial, then one would expect the effect to be eliminated (or at least attenuated) in a matching task. On the other hand, if the effect is primarily with the encoding of the faces, then one would expect a similar pattern of effects in a matching task to those already observed in immediate memory tasks (Experiments 17 and 18).

Method

Participants

Twenty-two subjects participated in this experiment. All of them were students at the University of Glasgow (16 female and 6 male), and age ranged from 17 to 21. They were given a small payment or course credit for participation. All had normal or corrected to normal vision. None had taken part in Experiments 17 and 18.

Stimuli and procedures

Stimuli for this experiment were generated from the same set of photographs as for Experiments 17 and 18, but the companions were selected more carefully to be similar to one of the faces in the line-up, but different from the targets (see Figure 5.3). Target position (left/right) in the two-face arrays was counter-balanced across trials; half targets were presented to the left and half were presented to the right.

Subjects were tested individually in a session of approximately 30 minutes. They were presented with 80 line-up stimuli, half of which had a single target face, and half of which had two target faces. As in Experiments 17 and 18, faces were rotated around conditions such that, across the experiment, targets appeared equally often in single or two-face arrays. Within each condition, half targets were present and half were absent, with presence counter-balanced across the experiment.

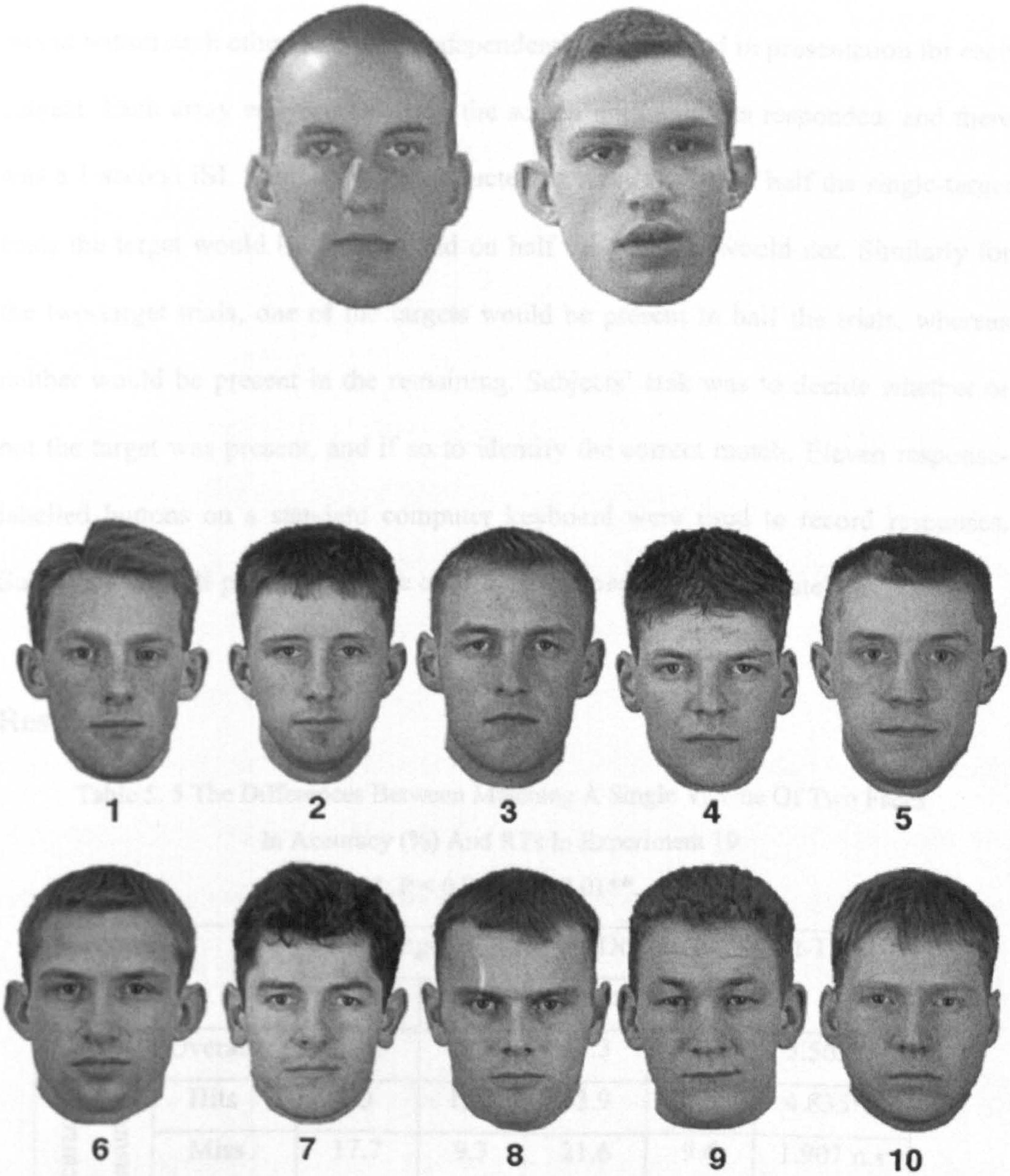


Figure 5.3 An example of stimuli used in the two-face condition in Experiment 19. The correct match is face number 6.

A Macintosh computer was used to present the stimuli and to record responses using Superlab Pro software. The single and two-face arrays were inter-mixed within each other, and were independently randomised in presentation for each subject. Each array was presented on the screen until subjects responded, and there was a 1 second ISI. Subjects were instructed (correctly) that on half the single-target trials the target would be present, and on half the trials he would not. Similarly for the two-target trials, one of the targets would be present in half the trials, whereas neither would be present in the remaining. Subjects' task was to decide whether or not the target was present, and if so to identify the correct match. Eleven response-labelled buttons on a standard computer keyboard were used to record responses. Subjects were self-paced, and were encouraged to perform as accurately as possible.

Results

Table 5. 5 The Differences Between Matching A Single Vs One Of Two Faces In Accuracy (%) And RTs In Experiment 19.

N = 22; P < 0.05*; P < 0.01**.

Variables		Single		Double		t-Tests
		Mean	SDs	Mean	SDs	
Accuracy Measures	Overall	68.2	12.2	57.3	18.6	3.563**
	Hits	70	13.2	53.9	16.7	4.835**
	Miss	17.7	9.3	21.6	9.6	1.907 n.s
	Misid	12.3	9.7	24.5	19.4	3.663**
	FPS	33.6	15.3	39.3	21.8	1.608 n.s
RTs	Hits	6285	1877	9178	3500	5.242**
	CR	10545	3555	15111	6547	5.758**

Tables 5.5 shows mean level of accuracy and RTs for matching a single vs. one of two faces. Related t-tests revealed significant differences in the overall accuracy, hits and misidentifications, with an advantage for the single condition. There was no significant difference for misses or FPS. In addition, Subjects' performance was significantly shorter for single than for two-face arrays in both target-present and target-absent trials.

Discussion

The findings of this experiment were very consistent with the results of Experiment 17. Matching one of two faces was significantly poorer than matching a single face, specifically when targets were present. Hit rates fell from 70% when the target was presented alone to 54% when he was presented with a companion. As in Experiment 17, the number of targets had no significant effect on FPS. Therefore, *both* memory and matching performance are significantly attenuated by the addition of a second face, suggesting that the basis of the two-face disadvantage might not primarily lie in memory, but instead has its locus at encoding. This finding provides further support to the argument that only one face could be processed at one time (Bindemann et al., in press; Boutet & Chaudhuri, 2001; Palermo & Rhodes, 2002; Jenkins et al., 2003). From an applied perspective, this suggests that the difficulty of encoding unfamiliar faces might turn out to be a more significant factor in poor eyewitness memory than has previously been acknowledged (see Chapter 1). The next experiment aimed to replicate this two-target disadvantage by a non-face object-matching task.

Experiment 20

Experiment 19 suggests that the two-face disadvantage of Experiments 17 and 18 might not be primarily memorial. In stead, the disadvantage might occur during encoding visual information from faces in the first place. However, it is not clear whether this effect is face-specific or it might generally associate the encoding of visual information. To investigate this question subjects were presented with non-face object matching tasks with the same format as the face matching tasks used in Experiment 19. If this capacity limit is face-specific, then one would expect that the two-target disadvantages would be eliminated in matching two-target objects compared to one. On the other hand, if encoding visual information is generally limited, then one would expect that matching two objects would be worse than matching a single object.

Method

Participants

Twenty paid volunteers participated in this experiment (12 female and 8 male). All were students at the University of Glasgow, and age ranged from 19 to 26 years. All had normal or corrected to normal vision.

Stimuli and procedure

Stimuli for this experiment were generated from The MFFT test, which has already been used in Experiments 1 and 14 as an object-matching test. In the original version of the test, targets were always present (see Experiment 1). However, a modified version was also used, in which half targets were present and half were absent (Experiment 14). FP rates in this modified version were very high (66 %), and caused a large reduction in overall accuracy (52%) compared to the hits (70%). Here, the MFFT test was modified again to fit the two-target condition, but unlike Experiment 14, targets were always present to avoid a similarly high level of FPS.

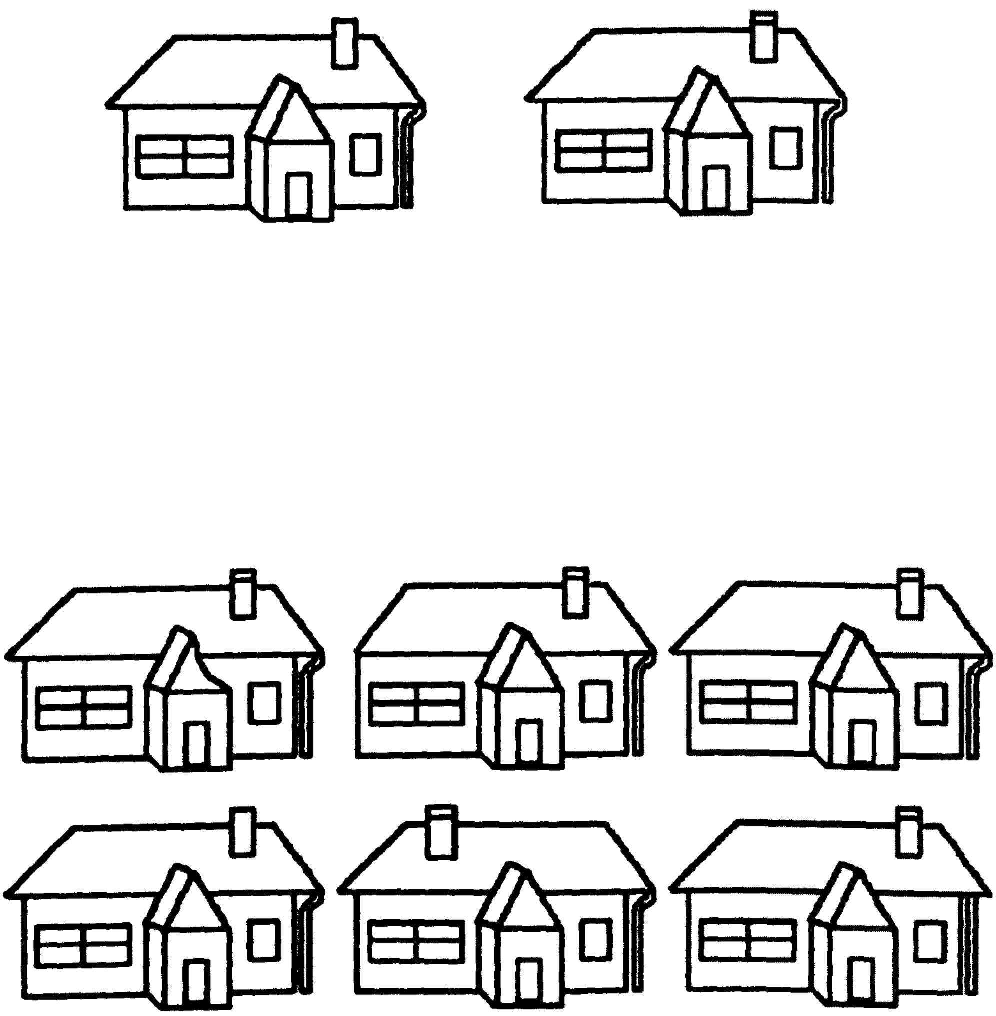


Figure 5.4 An example of two-target arrays used in Experiment 20.
The correct match is object numbered 4.

Subjects were presented with 48 arrays, half of which had a single target, and half of which had two target objects. In two-object arrays, left/right position was counter-balanced across the experiment. The distractors (the second target) were, in fact, one of the line-up foils, but after changing a specific feature using graphics software (see Figure 5.4). A Macintosh computer was used to present the stimuli and to record responses using Superlab Pro software. The single and two-object arrays were inter-mixed, and were randomly presented across subjects. Each array was presented on the screen until subjects responded, and there was a 1 second ISI. Subjects' task was to pick up the correct match by pressing one of six response-labelled buttons on a standard computer. Subjects were self-paced, and were encouraged to perform as accurately as possible.

Results

Table 5.7 shows the effects of target position (left/right) in the two-object condition. Related t-tests revealed better hits and shorter RTs for the left than for the right items.

Table 5.7 The effects of target position on matching objects In Experiment 20.

$N = 20$; $P < 0.05$*; $P < 0.01$**.

Variables	Left		Right		t-Tests
	Mean	SD	Mean	SD	
Hits (%)	66.2	15.4	52.9	17.4	3.559**
RTs	17594	6513	19086	6574	2.175*

Table 5.8 shows mean levels of matching performance for the single and two-object arrays. Related mean t-tests showed higher hits and shorter RTs for single-compared to two-target conditions.

Table 5.8 The Differences Between Matching Single Vs. One Of Two Objects In Experiment 20.

N = 20; $P < 0.05$*; $P < 0.01$**.

Variables	Single		Two objects		t-Tests
	Mean	SDs	Mean	SDs	
Hits (%)	67.5	10.3	59.6	14.1	3.999**
RTs	15723	5371	18340	6361	4.767**

Discussion

A left advantage was observed in the two-target arrays. Matching was more accurate and shorter when targets were presented to left than to right. This suggests that subjects might scan the display from left to right. I will return to this observation below. More interestingly, subjects' performance was significantly more accurate and shorter in single-target than in two-target arrays. This converges with the results of Experiment 19 that matching a single face was significantly better than matching one of two faces. Therefore, it appears that encoding visual information in general has a capacity limit. The next and final experiment examined the way of improving the disadvantage of matching two unfamiliar faces.

Experiment 21

This experiment examined whether the difficulty of encoding two faces could be reduced by a simple presentational manipulation. If it is particularly hard to encode two unfamiliar faces, this difficulty might be partly relieved by presenting subjects with a match, which is visually less cluttered. Therefore, the effects of presenting targets near together (as in Experiment 19) or far apart were examined.

Method

Participants

Twenty-five University of Glasgow students participated in this experiment (16 female and 9 male), each was paid a small sum for their participation. Ages ranged from 18 to 25. All subjects had normal or corrected to normal vision. None had taken part in Experiment 19.

Stimuli and procedure

Stimuli were constructed in the same manner, and from the same database, as for Experiment 19. Subjects were presented with 80 arrays, in each of which there were two target faces. In half the arrays, the target faces were presented 1 cm apart (as in Figure 5.3) and in the remaining arrays, they were separated by 8 cm (see Figure 5.5). Targets were rotated between the near and far presentation conditions across the experiment. Therefore, each target face was equally often seen in near and far conditions. In addition, the left/right positions of targets were counter-balanced across the trials to allow direct analysis of left/right position.

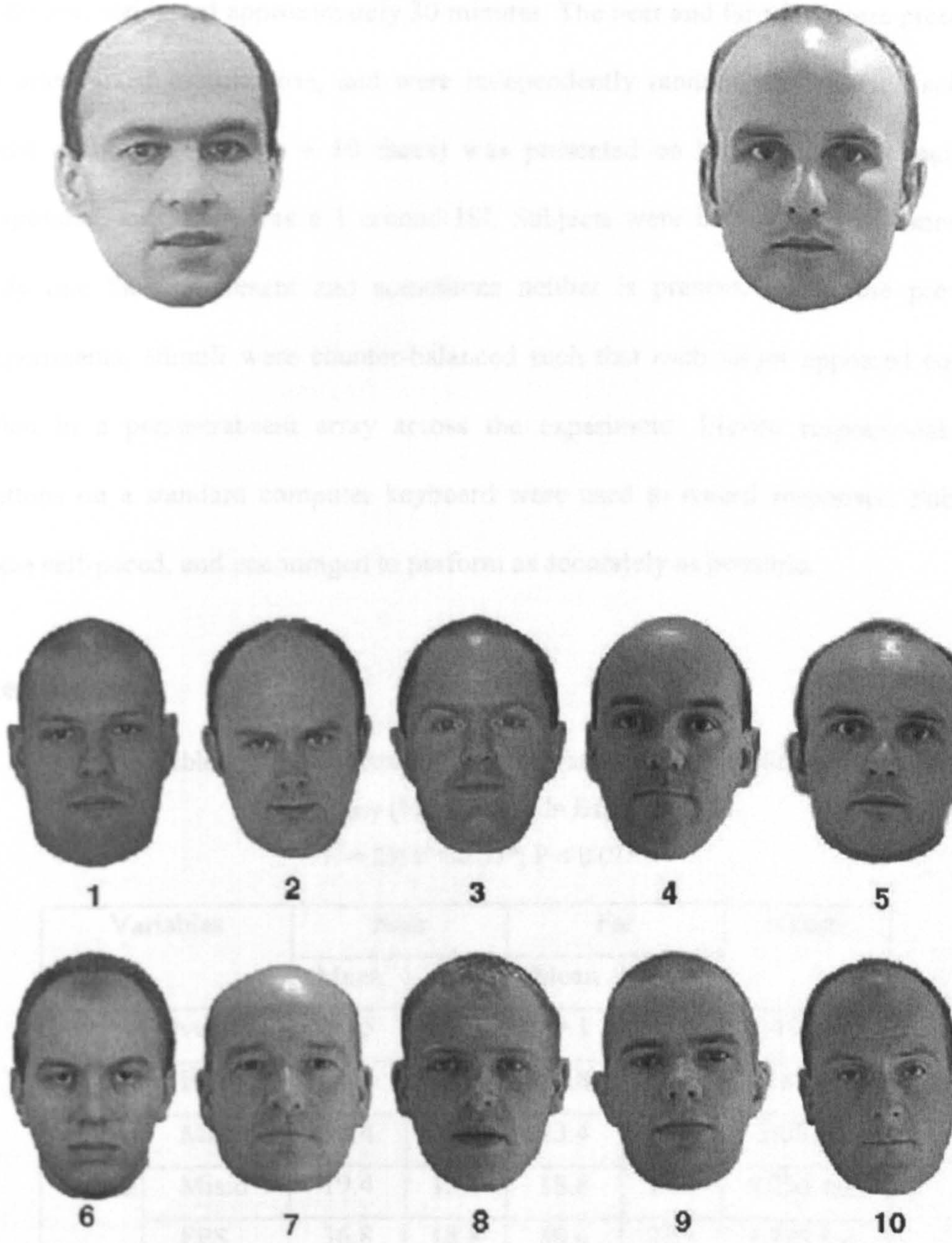


Figure 5.5 An example of stimuli used the far presentation condition in Experiment 21. The correct match is face numbered 5.

The experiment was run on a G3 Macintosh computer using Superlab Pro software, and lasted approximately 30 minutes. The near and far trials were presented in inter-mixed presentation, and were independently randomised for each subject. Each array (two targets + 10 faces) was presented on the screen until subjects responded, and there was a 1 second ISI. Subjects were instructed that sometimes only one face is present and sometimes neither is present. As in the previous experiments, stimuli were counter-balanced such that each target appeared equally often in a present/absent array across the experiment. Eleven response-labelled buttons on a standard computer keyboard were used to record responses. Subjects were self-paced, and encouraged to perform as accurately as possible.

Results

Table 5.9 The Differences Between Far And Near Conditions In Accuracy (%) And RTs In Experiment 21.

$N = 25$; $P < 0.05$*; $P < 0.01$**.

Variables		Near		Far		t-Tests
		Mean	SDs	Mean	SDs	
Accuracy Measures	Overall	56.5	10.8	59.1	13.5	1.493 n.s.
	Hits	50.2	15.8	57.8	14.6	2.870**
	Miss	30.4	18.7	23.4	15.1	3.031**
	Misid	19.4	13.1	18.8	14.1	0.285 n.s.
	FPS	36.8	18.8	39.6	22.3	1.221 n.s.
RTs	Hits	10277	2977	11154	6081	0.980 n.s.
	CR	16545	7496	16536	8036	0.014 n.s.

Table 5.9 shows mean levels of matching performance for far/near pairs of stimuli. Related t-tests revealed higher hits and lower misses for far, as opposed to near pairs of stimuli. There was no significant difference in the overall accuracy, misidentifications and FPS. Furthermore, there were no reliable differences in RTs for far and near targets.

Table 5.10 Descriptive Statistics For Matching left/right Targets In Near/Far Conditions In Experiment 21.

Variables		Left		Right	
		Mean	SDs	Mean	SDs
Hits	Near	55.6	18.9	44.8	17.6
	Far	64.8	17.8	50.8	19.1
RTs	Near	10100	3689	10454	3893
	Far	10394	6541	11914	6071

2 (left/right) by 2 (far/near) analyses of variance (ANOVAs) were conducted to examine the effects of target position in matching faces in near and far condition. For hits, there was significant main effect for the spatial distance [$F(1, 24) = 8.240$, $p < 0.01$), and for target position [$F(1, 24) = 25.584$, $p < 0.01$). However, there was no interaction between distance and position [$F(1, 24) = 0.233$, $p > 0.05$). For RTs, there was no main effect for spatial distance [$F(1, 24) = 0.960$, $p > 0.05$) or for target position [$F(1, 24) = 2.100$, $p > 0.05$), though clearly there was strong trend in the means indicating that left items were recognised shorter than right ones in the far condition (a difference of 1520 msec). Table 5.10 shows mean levels of hits and RTs for left and right targets in near and far conditions.

Discussion

In this experiment subjects were asked to match one of two target faces presented either close together or far apart. The effects of spatial distance between targets and the left/right positions were examined. Performance in "near" trials replicated Experiment 19. Subjects could correctly identify only 50% of matches on target-present trials. However, this turn out to be qualified by left/right position of the target. Subjects were much better in matching a target presented on the left, than one presented on the right (an analysis not possible in Experiment 19). The effect of spacing was also important. Subjects performed more accurately in the "far" than in the "near" items, specifically targets were present. However, this effect too, is qualified by left/right position, with a large advantage for targets on the left.

The left advantage, for two-face target stimuli, replicates the results of Experiment 20 using non-face stimuli. Together, this advantage might reflect a left-to right scanning strategy. Although there was no reliable differences for RTs, there was strong trend that left items were recognised shorter than right ones in far, but not in near conditions. This may further support this left-to right scanning hypothesis. However, it is important for future eye movement studies to test this possibility.

The over-riding result from this experiment is that multiple faces appear to be able to exert an influence on each other, to the extent that a nearby distractor can attenuate a subject's ability to match a target face, supporting the possibility that faces might capture attention (Ro et al., 2001; Vuilleumier, 2000). This provides further suggestive evidence that the two-face disadvantage has its locus in the encoding of unfamiliar faces, rather than in memory.

General Discussion

The main aim of the present experiments was to investigate the effects of multiple faces on the task of identifying a single target. This was done very simply by presenting a target face either alone or accompanied by a second face. The results show a consistent and rather severe detriment in subjects' ability to identify a target in the presence of a second face. This effect shows up in both immediate memory (Experiments 17 and 18) and in matching (Experiments 19 and 21), and became much worse when the two-target faces were presented sequentially, rather than simultaneously (Experiment 18). The effect was also observed using an object-matching task (Experiment 20). Furthermore, although the spatial position of the face targets has a large effect on hits (near/far and left/right), the order in which targets are presented was not observed to make a significant difference to performance (Experiment 18).

The observation of a two-face disadvantage for matching tasks, suggests that the effect is not wholly due to memory constraints. Instead, the effect appears to increase the difficulty of encoding unfamiliar faces. This problem has perhaps been underestimated in the literature on eyewitness memory. The well-known difficulty in remembering faces might result, at least in part (see Chapter 1), on a difficulty in encoding them in the first place. If this is true, then the present results suggest that encoding more than one unfamiliar face at once may add to this difficulty. Of course, the experiments reported here relate only to immediate memory, and would have to be extended to longer-term recognition in order to relate them directly to the large literature on eyewitness testimony. However, the low rates of memory here would almost certainly reduce still further in this situation, and no qualitative change in these results would be anticipated.

There may be a clue to the locus of this two-face disadvantage in the details of the results across experiments. It is interesting to note that the direct comparison of one versus two targets only produced differences in target-present trials, and not in target-absent trials. In Experiments 17 (memory) and 19 (matching) the FPS were equivalent for single- and two-face targets. FP rates were generally rather high (over 20% in memory, and over 30% in matching), however they were not affected by the addition of a simultaneously available second target. On the other hand, moving from simultaneous to sequential presentation of targets produced a very large increase in FPS (Experiment 18). This is interesting in that it suggests that subjects have a general bias to pick a face, and that this is unaffected by the range of targets currently available on which they have to make this decision. However, presentation of targets in sequence appears to lower the criterion for picking a match. If this is true, it is an important constraint on identification evidence, as it suggests behaviour, which is procedure-driven rather than data-driven.

The results of the present experiments have a number of important implications, for both theoretical and applied issues in face recognition research. Theoretically, the results provide further insights into the apparent capacity limits for face processing. Some recent research has proposed that only one face may be processed at once (Boutet & Chaudhuri, 2001; Palermo & Rhodes, 2002; Jenkins, Lavie & Driver, 2003). Using a target-distractor interference paradigm, Bindemann et al. (in press) found that distractor names\flags interfered with the classification of target faces, and that target names\flags were subject to interference from distractor faces. Importantly however, target faces did not interfere with distractor faces. This confirms the hypothesis that only one face can be processed at a time. However, the paradigm employed by Bindemann et al. (in press) is very different to the procedure used in this chapter. Bindemann et al. used familiar faces, which were presented very briefly (200 msec), whereas the present experiments utilised unfamiliar faces, which were presented under no time limit. Indeed, any contrast between these studies might be pronounced even further when familiar faces are presented for longer durations than 200 msec. Thus, it seems unlikely that two familiar faces would be misidentified when they are presented at least for 500 msec.

The implications of these findings for forensic practice are perhaps even more important. Many crimes are committed by more than one perpetrator. Hundreds of studies have investigated the sources of eyewitness identification error (e.g. see Cutler & Penrod, 1995; Lindsay & Pozzulo, 1999; Narby et al., 1996; Wells, 1993; Wells, et al., 1999; Westcott & Brace 2002 for reviews). At present however, there is only one study that has examined the effect of *the number of perpetrators* on identification accuracy. Clifford and Hollin (1981) found that as the number of perpetrators increased, identification accuracy decreased, particularly in non-violent crimes, which greatly supports the findings reported in this chapter.

Chapter 6

Processing Unfamiliar Faces:

Summary And Conclusions

The research carried out in this thesis investigated the processing of unfamiliar faces using a variety of encoding and immediate memory tasks. The introductory chapter argued that familiar and unfamiliar face processing are dissociable. The strongest evidence for this argument comes from the double dissociation between familiar and unfamiliar face recognition. On one hand, some brain-damaged patients have a severe impairment in recognising unfamiliar faces, but perform normally in recognising familiar faces. On the other hand, some patients are significantly impaired in recognising familiar faces, but retain the ability to recognise unfamiliar faces (Benton, 1980; Malone et al., 1982; Tranel et al., 1988; Warrington & James, 1967; Young et al., 1993). Further evidence for this dissociation concerns the accuracy of familiar and unfamiliar face recognition. People are remarkably poor at recognising unfamiliar faces, even under seemingly optimal conditions (e.g. Bruce et al., 1999). In contrast, people are still extremely accurate at recognising familiar faces under highly demanding conditions (Burton et al., 1999) and after long retention intervals (Bahrick et al., 1975). In addition, there is some limited evidence for this dissociation including an internal feature advantage in familiar face processing (Bonner & Burton, 2004; Ellis et al., 1979; Young et al., 1985), differences in interhemispheric cooperation (Mohr et al., 2002), and increases of activation in some brain regions (Leveroni, et al., 2000) for familiar but not for unfamiliar faces.

This thesis supports the contrast between recognition accuracy for familiar and unfamiliar faces, and emphasizes the role of individual differences (Chapter 2) and capacity limitations (Chapter 5) in the encoding of unfamiliar faces. In addition, I have introduced two novel sources of evidence for the dissociation between familiar and unfamiliar face processing. One of these concerns the relationship between the processing of upright and inverted familiar and unfamiliar faces (Chapter 3). The second source concerns the relationship between hits and false positives (Chapter 4).

The first step for examining unfamiliar face processing, like any process, is to have an accurate assessment by a reliable measure. The concept of reliability refers to "*the consistency of scores obtained by the same persons when they are re-examined with the same test on different occasions, or with different sets of equivalent items, or under other variable examining conditions*" (Anastasi & Urbina, 1997, p. 84). Using Bruce et al's (1999) 1 in 10 face-matching task, subjects' performance on two different sets of equivalent items was both quantitatively and qualitatively very similar to each other (Experiment 11). Similarly, neither quantitative nor qualitative differences were found when subjects were re-examined by the same match/mismatch task after approximately one week (Experiment 3). Thus, face matching was shown to be a reliable task, by which one could assess how accurately people recognise unfamiliar faces.

In Bruce et al's (1999) face-matching task, subjects were presented with a target face, taken by a high quality video camera, and 10 face images taken by a high quality studio camera, one of which might be the target. Both targets and the 10 faces were presented simultaneously, with no time constraints. In addition, all images were taken on the same day and under the same conditions, such that any differences in age, health, hairstyle, and weight were eliminated. Under these rather optimal conditions, subjects were surprisingly very poor at matching unfamiliar faces, so that error rates of 30% occurred equally often for target-present and target-absent arrays.

This difficulty of matching unfamiliar faces was replicated here by 10 experiments (representing a total 346 subjects) using variations of Bruce et al's (1999) task. On average, hit rates of 76.4% and FP rates of 27.4% were recorded. This low level of performance persisted when the task was reduced to an ABX task, in which a target face was compared with two other faces, one of which could be another photo of the target person (Experiment 12), or even to a match/mismatch task, in which two images of faces were presented, and subjects had to decide whether or not they were of the same person (Experiments 3, 7, and 13). In marked contrast to this low level of unfamiliar face recognition, subjects were extremely accurate in recognising famous (Experiment 8) and familiarised faces (Experiments 9a and 15b), a result which converges with the findings of Burton et al. (1999).

An immediate memory task was introduced using Bruce's arrays. Subjects were presented with the targets and 10 faces sequentially, separated by a short gap (Experiments 5, 8, 10, 17). Subjects' performance on this task (as expected) was significantly poorer than on face matching, but only when targets were present (Experiments 8 and 10). This finding suggests that the difficulty of memorising unfamiliar faces is not the cause for FPS. In stead, subjects might have a bias to pick a match even when the targets and foils are seen simultaneously. Interestingly, there were strong positive associations between matching and immediate memory (Experiments 8 and 10), suggesting that encoding and memorising unfamiliar faces involve quantitatively, but not qualitatively, different processes. This contrasts with the results of Haxby et al's (1996) study, in which encoding and recognition were found to be dissociable. However, this contrast might be attributed to the differences between memory components in the recognition memory paradigm used in Haxby et al's (1996) study and the immediate memory paradigm used here, and also between encoding during learning and encoding during matching. In addition, the high associations between matching and memory seem to be mediated by the stimuli as well. This is because faces that were easy to match were also easy to remember (Experiment 10).

Although unfamiliar face recognition is generally poor, there are quite considerable variations between individuals. Using a recognition memory paradigm, Woodhead and Baddeley (1981) found that recognition discrimination *d'* scores ranged from −0.5 to 6.8. Similarly, there were large individual differences in matching unfamiliar faces, which ranged (for example) from 50% to 96% in Experiment 1.

The aim of Chapter 1 was to predict these individual differences using a range of general visual recognition and specific face processing tasks. Experiment 1 found that some tests could predict performance on target-present trials including Visual

STM, Perceptual Speed Finding A's Test, and confidence, whereas some tests could predict performance on target-absent trials including Perceptual Speed Identical Pictures Test. Notably, the perceptual speed test was previously found to predict performance on Benton face-matching test (Schretlen et al., 2001). However, the best predictor here was matching objects, which predicted performance in *both* target-present and target-absent trials. Similarly, recognition of old and new faces in recognition memory for face images predicted matching performance on target-present and target-absent trials, respectively. In addition, matching strategies had a significant effect on both accuracy and confidence of face matching, with pop-out processes associated with more hits and higher confidence than elimination process strategy. These results were in agreement with previous eyewitness identification studies, which found that these strategies could significantly differentiate between accurate and inaccurate identifications (Dunning & Stern, 1994; Kneller et al., 2001). On the other hand, there was no relationship between field dependence and face matching, converging with some memory experiments (Courtois & Mueller, 1982; Ryan & Schooler, 1998).

In order to further explore potential predictors for face matching, Experiment 2 investigated the relationship between facial encoding within and across identities by examining the impact of face change detection on matching unfamiliar faces. Subjects were presented with a face change detection task, in which same or different pairs of unfamiliar face images were presented. Different pairs consisted of an original image and a featurally (e.g. exchanging the eyes by those of a different person) or configurally (e.g. altering the spacing between the eyes) changed image of the same person. As with O'Donnell and Bruce's (2001) study, face change detection was generally poor, with remarkable difficulties for detecting eye changes specifically. However, detecting changes to the eyes was the best predictor for face matching, confirming the importance of the eyes for face identification (Schyns et al., 2002; Vinette et al., 2004). In addition, face matching was moderately predicted by detecting changes to the hair and mouth, but not to the chin. Interestingly, there was no relationship between face change detection and FPS, suggesting that the ability to encode changes within face identities is *unrelated* to the ability to encode changes between identities.

Experiment 2 showed also a novel and possibly more important finding. Namely, there were strong positive associations between the processing of featural and configural information. Featural and configural information is thought to be dissociable (e.g. see Bartlett et al., 2003 for a review; and Chapter 1 for more discussion about this topic), such that some researchers suggest that configural information is the most important component for upright face processing (e.g. Bartlett & Searcy, 1993; Friere et al., 2000), whereas others suggest that featural information could be processed and represented independently (e.g. Macho & Leder, 1998; Rakover & Teucher, 1997). The present finding supports the holistic theory (Tanaka and Farah, 1993), and confirms Tanaka and Sengco's (1997) conclusion that features and their configurations have inter-dependence contributions to face recognition.

Experiments 1 and 2 show two potentially interesting findings. Namely, there were high positive associations between matching unfamiliar faces and objects and between the processing of featural and configural information. These findings suggest positive correlations between upright and inverted unfamiliar faces. This is because inverted faces might be processed similarly to objects (de Gelder & Rouw, 2000; Farah et al., 1995; Haxby et al., 1999; Moscovitch et al., 1997). In addition, it is thought upright face processing depends on configural information, whereas processing inverted faces relies on featural information (e.g. Freire et al., 2000; Searcy & Bartlett, 1996). In the face memory literature, very few studies investigate the association between upright and inverted unfamiliar face processing, and the results are very inconsistent, to the extent that all three possibilities of correlations - negative (Yin, 1969), positive (Flin, 1985), and no correlation (Flin, 1985; Phillips & Rawles, 1979) – have been reported.

Chapter 3 examined the relationships between recognition of upright and inverted familiar and unfamiliar faces. Inversion had a detrimental effect on matching unfamiliar faces, when only the target faces (Experiment 4) or whole arrays (Experiment 6) were presented upside down. However, the face inversion effect was bigger in the latter than the former condition. Interestingly, this effect persisted when the 1 in 10 face-matching arrays was reduced to match/mismatch pairs (Experiment 7). Notably, this is the first instance of the face inversion effect with a perceptual face identification task, supporting Rossion and Gauthier's (2002) conclusion that the face inversion effect occurs during face encoding.

There were high positive associations between the processing of upright and inverted unfamiliar faces, whether it was measured by tasks of matching (Experiments 4 and 6) or immediate memory (Experiment 5). This effect was also observed when the 1 in 10 face-matching task was reduced to a match/mismatch task (Experiment 7). In contrast, there was no correlation between upright and inverted familiar face processing using a semantic classification task (Experiment 8). In addition, there was no relationship between the processing of upright unfamiliar faces and the recognition of upright famous (Experiment 8) or familiarised (Experiment 9a) faces. Rather, there were high positive associations between the recognition of upright unfamiliar faces and the processing of inverted famous (Experiment 8) and familiarised (Experiment 9b) faces. These data were interpreted as evidence that upright and inverted unfamiliar face processing are quantitatively but not qualitatively different processes, supporting Sekular et al's (2004) conclusion that inversion leads to quantitative but not qualitative changes in unfamiliar face processing.

The most popular explanation for the face inversion effect, as discussed in Chapter 1, is that inversion impairs configural information processing (Farah et al., 1995; Freire et al., 2000; Leder and Bruce, 2000; Rhodes et al., 1993; Searcy and Bartlett, 1996; Tanaka and Farah, 1993; Tanaka and Sengco, 1997; Young et al., 1987). Consequently, the associations between upright and inverted unfamiliar face processing suggest that configural information might not be important for unfamiliar face processing. This position converges with Hancock et al's (2000) conclusion that unfamiliar faces are treated as simple visual patterns, and matched on this basis without any domain-specific expertise. This might be important for future studies aiming to improve unfamiliar face matching. Thus, teaching subjects how to encode faces holistically might improve their matching performance. In contrast, the dissociation between upright and inverted familiar face processing suggests that different processes are at play. However, familiar faces are processed similarly to upright unfamiliar faces *only* when they become inverted. Therefore, the processes underlying the recognition of upright unfamiliar faces appear to be similar to those underlying the recognition of inverted familiar and unfamiliar faces, but seem to be very different from those underlying the recognition of upright familiar faces.

Chapter 4 provided further evidence for the dissociation between upright familiar and unfamiliar face processing, and the association between upright unfamiliar and inverted familiar face processing. In the face memory literature, it is well documented that hits and FPS do not correlate with each other (Bruce et al., 1994; Hancock et al., 1996; Lewis & Johnston, 1997; Vokey & Read, 1992). This is a surprising finding because if some faces are easily identified as old (in the sense that they have been seen before) when they are old, then they should be easily identified as new when they have not been encountered before. Instead, the dissociation between hits and FPS suggests that faces that are easy to remember are not those that are easy to reject. In other words, this dissociation suggests that the ability to recognise a face when old is unrelated to the ability to reject a face when new. Notably, this dissociation cannot be explained by the mirror effect because this effect refers to a negative correlation between hits and FPS across two classes of item, one of which should be easier than the other. For example, memory for disguised faces mirrors memory for non-disguised ones (Hockley et al., 1999). The effect does not necessarily suggest a negative correlation between hits and FPS within one class of items such as non-disguised faces. Rather, the dissociation between hits and FPS was explained by Vokey and Read's (1992) theory that typicality of faces could be broken into two orthogonal components: Context-free familiarity and memorability (Bruce et al., 1994). However, this explanation was challenged by replicating the dissociation between hits and FPS by a face-matching task (Bruce et al., 1999). Here, the by-people and by-item analyses consistently replicated this dissociation using both matching and immediate memory tasks (Experiment 10). Moreover, there was a close to zero correlation between matching a face when present and rejecting the *same* face when absent (Experiment 11). For example, 80% of subjects correctly identified the target presented in Figure 4.1, but only 33% of the same subjects correctly rejected the same target when he was absent in Figure 4.2. Even when the 1 in 10 face-matching task was reduced to an ABX (Experiment 12) or a match/mismatch (Experiment 13) task, this dissociation persisted in both by-people and by-item analyses. The same effect was also observed using a non-face object-matching task (Experiment 14). Therefore, this dissociation does not appear to be face-specific, but might characterise more general visual processing.

Nonetheless, familiarisation was able to produce the expected negative correlation between hits and FPS using the 1 in 10 face-matching task in both by-people (Experiments 15a and 15b) and by-item (Experiment 15b) analyses. Familiarisation therefore was able to re*concile* subjects' ability to match a face when present and to reject that face when absent. Importantly however, this effect disappeared when familiarised faces were presented upside down (Experiment 16). Thus, the negative correlation between hits and FPS could be observed *only* for upright familiar faces.

These data strongly support the conclusions made in Chapter 3. Taking the dissociation between hits and FPS in unfamiliar face recognition (Experiments 10 – 13) with the association between them in familiar face recognition (Experiments 15a and 15b) *requires* a dissociation between familiar and unfamiliar face processing (see Experiments 8 and 9a). In addition, inversion *converted* the association between hits and FPS in familiar face processing to a dissociation, suggesting that inverted familiar faces appear to be processed similarly to upright unfamiliar face processing (see Experiments 8 and 9b).

The dissociation between hits and FPS in matching unfamiliar faces provides further evidence for the difficulty of encoding unfamiliar faces. Recognising a target when present involves different processes to rejecting the same target when absent. The problems of encoding unfamiliar faces relate to the work examining the role of attention in face processing. On the one hand, some studies suggest that faces capture attention (e.g. Ro et al., 2001; Vuilleumier, 2000), and also retain attention (Bindemann, Burton, Hooge, Jenkins & De Haan, in press). On the other hand, there is some good evidence that only one face could be processed at one time (Bindemann et al., in press a; Boutet & Chaudhuri, 2001; Jenkins et al., 2003; Palermo & Rhodes, 2002). This conclusion can be made from the inability of subjects to process two familiar faces when they were presented briefly (200 msec) as in Bindemann et al's (in press a) study, or from the failure to match two unfamiliar faces presented for a short time (≤1.5 seconds) while studying a central target as in Palermo and Rhodes's (2002) study. However, to date no evidence exists for capacity limitations in unfamiliar face processing without time constraints. This was examined in Chapter 5.

The first question addressed in this chapter was how accurately people could recognise one of two unfamiliar faces. In Experiment 17, subjects learned a target face seen alone or with a companion until they felt confident that they could recognise the face(s). After a 2 second gap, they were asked to identify the target face from either target-present or target-absent line-ups. The presence of a second face considerably impaired recognition of the target, confirming the results of Clifford and Hollin (1981) that increasing the number of perpetrators significantly reduced identification accuracy. However, this effect was confined only to target-present trials. Interestingly, no effect was observed for FPS, suggesting that subjects had a bias to pick a face, irrespective of the number of targets.

Experiment 18 examined how presentation might affect this two-face disadvantage. Now, subjects studied two unfamiliar faces presented either simultaneously or sequentially. Once again, there was no time limit for learning faces, and there was a very short gap between learning and test. However, subjects' performance was generally poor. There was no difference between target faces being presented first or second in the sequential condition, suggesting that the second face did not *over-write* the first one. Rather, memory for each was significantly worse than memory for faces seen simultaneously. These findings are very important for the eyewitness identification field. It may be useful for future studies to replicate these effects in long-term memory, and to investigate the effects of larger numbers of targets on witness accuracy. A research programme to investigate these processes will also need to look at the precise effects of target position.

The two-face disadvantage was quite pronounced in Experiments 17 and 18. However, the locus of this disadvantage was still not clear. In particularly, it was not clear whether this effect is primarily memorial or occurs during the encoding phase. To investigate this question, Experiment 19 tested this disadvantage with a matching task. The results were very similar to those of Experiment 17. The presence of a second face significantly impaired hits, but not FPS. This suggests that this effect occurs during encoding unfamiliar faces in the first place, rather than in a later recall phase. And in turn, this suggests that unfamiliar face encoding has a limited capacity. Experiment 20 replicated this effect by a non-face object-matching task, suggesting that the limited capacity of encoding is not face-specific. Instead, there is a general capacity limit for encoding visual information from complex patterns such as unfamiliar faces and non-face objects.

The final experiment found that presenting faces in a visually less cluttered display significantly relieved the difficulty of encoding two faces, specifically when targets were present. Therefore, faces in close proximity appeared to influence each other, which provides further suggestive evidence that the two-face disadvantage occurs during the encoding of unfamiliar faces.

Across a series of 21 experiments that were carried out in this thesis to examine the processing of unfamiliar faces, a number of important conclusions can be made. First, recognition of unfamiliar faces is highly error prone, and this difficulty occurs during encoding information from faces prior to processing it into memory. Second, there are large individual differences in encoding unfamiliar faces. Third, there is high consistency for encoding unfamiliar faces within individuals. Fourth, encoding changes within face identities is unrelated to encoding changes between identities. Fifth, there is inter-dependency for featural and configural information in encoding unfamiliar faces. Sixth, encoding and memorising unfamiliar faces differ quantitatively but not qualitatively. Seventh, encoding unfamiliar faces has a remarkably limited capacity, even under no time constraints. Eighth, recognition of faces when present dissociates from rejecting the same faces when absent, but familiarisation is able to reconcile them. Ninth, there are quantitative, but not qualitative, differences between upright and inverted unfamiliar faces. On the other hand, there are both quantitative and qualitative differences between upright and inverted familiar faces. Last and more importantly, there is a dissociation between upright familiar and unfamiliar face processing, but there is an association between upright unfamiliar and inverted familiar face processing.

Some of these conclusions have very important implications to the forensic practice. First, matching CCTV images to images of suspects is highly error prone, unless the person who performs this matching is familiar with the culprit. Second, eyewitnesses who incorrectly identify an innocent person from a culprit-absent line-up may nevertheless be able to identify the actual culprit from a target-present line-up. Last, the number of perpetrators has a severely detrimental effect on identification accuracy, which gets much worse when the perpetrators are seen sequentially.

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