Virtual Reality for Fear of Falling in Older People

Luke Barracliffe

BSc (Hons), MSc, PgCert

Submitted in partial fulfilment of the requirements for the Degree of Doctorate in Clinical Psychology (D.Clin.Psy)

Institute of Health and Wellbeing

College of Medical, Veterinary and Life Sciences

University *of* Glasgow

September 2021

Contents

List of Tables **4**

List of Figures **4**

Acknowledgements **5**

Foreword **6**

Chapter 1 Systematic Review **7**

Exploring the use of Virtual Reality for Fear of Falling in Older Adults

Abstract **8**

Introduction **10**

Methods **13**

Results **16**

Discussion **37**

Conclusion **44**

References **46**

Chapter 2 Major Research Project **53**

Augmenting psychological treatment for fear of falling using Virtual Reality: A feasibility study in older adults

Plain English Summary **54**

Abstract **56**

Introduction **58**

Method **62**

Results **71**

Discussion **87**

Conclusion **92**

References **93**

Appendices Systematic Review (Chapter 1)

Appendix 1.1 - Manuscript submission guidelines **102**

Appendix 1.2 - Quality assessment tool **113**

Major Research Project (Chapter 2)

Appendix 2.1 - Study protocol **118**

Appendix 2.2 - Email to Psychology service **136**

Appendix 2.3 – Expert & service-user feedback **139**

Appendix 2.4 - Mental health measures **143**

Appendix 2.5 – Intervention materials **148**

Appendix 2.6 – Interview schedule **170**

Appendix 2.7 - NHS research ethics letter **172**

Appendix 2.8 - NHS board approval letter **178**

Appendix 2.9 - Thematic analysis log **180**

Appendix 2.10 - Manuscript submission guidelines **182**

List of Tables

Chapter 1 Systematic Review

Table 1 - Database search terms **15**

Table 2 – Study characteristics **19**

Table 3 – Quality assessment tool **25**

Chapter 2 Major Research Project

Table 1 – VR research stages **61**

Table 2 - Demographics **73**

Table 3 – Mental health measures **74**

Table 4- Themes & sub-themes **76**

List of Figures

Chapter 1 Systematic Review

Figure 1 – PRISMA flow diagram **18**

Chapter 2 Major Research Project

Figure 1 – VR main menu image **68**

Figure 2 – VR garden task image **68**

Figure 3 – VR living room task image **69**

Acknowledgements

My thanks to Professor Hamish McLeod throughout this process for his expert guidance. I'd also like to thank those who participated in this study for their valuable time and data. Another thank you to the recruiting Clinical Psychologists from the Older People's Psychology Service, Dr Salma Iqbal and Dr Ashley Gibson, for their huge efforts. A thank you to my Computer Science colleagues, Lynda Faller, Tiancheng Dong and Professor Stephen Brewster, for their programming of the intervention. Thanks to Kevin Murray for his support as an independent reviewer and to all my colleagues and friends on the DClinPsy course; it has been a fun and fascinating journey. I look forward to flourishing friendships with many of you. I'd like to voice my appreciation for many of my supervisors who have helped me grow in confidence as a clinician. A huge thank you to my family who have been my biggest and closest support throughout this journey, despite being in London. My trips home will always be comforting and refreshing to me. I'd also like to thank myself, for coming out the other side with such an enormous achievement – I look forward to starting my new job and life very soon!

Luke Barracliffe

Foreword

The original study involved testing the Virtual Reality Fear of Falling intervention in-person with older people, allowing use of measures in addition to those eventually used, such a sense of immersion and presence. Due to the COVID-19 pandemic, which began part way through this study's development, this became unfeasible. This was due to government lockdown restrictions and as this research involved at-risk populations. The primary researcher made drastic changes and adaptations, rendering it entirely remote. This had implications for recruitment, materials, costs and aims. This also slowed the ethics process.

Due to these necessary adaptations, this thesis is being submitted under 'Contingency Plan 2'

CHAPTER 1: Systematic Review

Exploring the use of Virtual Reality in Fear of Falling in Older Adults:

A Systematic Review

Luke Barracliffe[1*]

[1]Mental Health and Wellbeing, Institute of Health and Wellbeing, University of Glasgow

***Address for Correspondence:**
University of Glasgow
Mental Health and Wellbeing
Gartnavel Royal Hospital
1st Floor, Administration Building
1055 Great Western Road
Glasgow
G12 0XH

Submitted in part fulfilment of the requirements for the Degree of Doctorate in Clinical Psychology (D.Clin.Psy)

Target Journal: 'Journal of Computers in Human Behavior'

Word Count: 10791 (including references).

Abstract

Background:

Falls in older adults reduce quality of life for victims and are expensive to health services. Falls risk is increased by Fear of Falling (FoF). Virtual reality (VR) exposure treatments can improve FoF and potentially save labour and costs. Past reviews have primarily focused on video games and less immersive VR.

Aims:

Examine the ways in which VR is used in relation to FoF in older people, review how outcomes relevant to FoF are measured, explore acceptability and report any barriers to VR implementation.

Methods:

Four databases were searched for studies which met inclusion criteria. Data from the studies were extracted, their quality assessed and results synthesised.

Results:

Seven studies were included. There was large variation in VR content, exposure length and sample characteristics. Evidence is limited regarding longevity of effects. Method of FoF measurement was varied, often being a secondary outcome to balance- though VR was well accepted with generally good adherence.

Conclusion:

VR via HMDs is accepted by older adults and beneficial for FoF in the short term. Given the need for reduced labour costs, VR could be a step closer to successful FoF treatment.

Keywords: Virtual Reality; Fear; Falling; Review; Anxiety.

1. Introduction & Theory

1.1 Background

The purpose of this review is to summarise and critically analyse the evidence on the use of Virtual Reality (VR) for Fear of Falling (FoF) in older adults. An established definition of FoF is a reduced confidence in balance abilities (Maki et al., 1991) resulting in avoidance of activities that people can still physically perform (Tinetti & Powell, 1993). It can develop independently of previous falls (Public Health England [PHE], 2017). A significant number of older adults (≥65 years) experience falls and the risk increases with age (National Institute for Health and Care Excellence [NICE], 2013). Inevitably, this incurs great cost to UK public health services, including in Scotland (Craig et al., 2013; McGinley et al., 2020; PHE, 2017). Annually, emergency hospital admissions cost the NHS up to £2-billion and social care following fall-related fractures cost £1-billion (NICE, 2018; PHE, 2017); associated annual costs in Scotland are over £470-million (Craig et al., 2013). This is reflected internationally, with yearly costs in California USA alone being over £3-billion (Haddad et al., 2019). Consequences for individuals can include reduced social interaction, lower quality of life (QoL) and even premature death (Arfken et al., 1994; Fuller, 2000; Jung et al., 2009).

Some exercise-based interventions have attempted to target the balance aspect of FoF, with low to moderate benefits (Levy et al., 2016; Rand et al., 2011). Meta-analytic data suggest these may be effective in improving FoF, however mean effect-sizes were small (*Cohen's d* = 0.2) and most of the studies reviewed found treatment was ineffective (Jung et al., 2009). Such interventions also neglect the cognitive elements of FoF; since FoF can be considered an anxiety disorder involving complex psychological processes, it makes sense to address this in interventions too (Levy et al., 2016; Young & Mark-Williams, 2015).

Additionally, there is also a need for reduced costs and labour in such psychological interventions, which can be assisted by semi-automated technology; this could mean one clinician could provide therapy for multiple people engaging in the automated technology for example, thus saving labour costs (Freeman et al., 2018).

Some studies have used traditional video games to address FoF (Jorgensen et al., 2013; Pietrzak et al., 2014; Seamon et al., 2017). Video games for the purpose of such treatment are known as 'serious games', which are a type of video game with purposes beyond just entertainment, such as treatment and education. Commercial systems can be utilised for serious gaming, including the Nintendo Wii. Some studies incorporated commercially available fitness-based serious games, including dancing, to treat FoF (Rodrigues et al., 2018). However, their results mimic those of the exercise-based studies. Specifically, a review found little evidence that balance-training serious games prevent falls or reduce FoF; they reported that many games are distracting to older people, given they were not designed to target FoF (Pietrzak et al., 2014).

Psychological exposure via Virtual Reality (VR) is a more modern approach to addressing FoF which could meet the need to reduce labour costs, as well as targeting cognitive aspects of FoF. It is also relatively affordable considering it can be used long-term, with the recent 'Oculus Quest 2' VR system retailing at £200-300. VR is an interactive computer simulation in which users' actions are sensed and fed back to one or multiple senses (e.g. visual or haptic); they then become immersed in the virtual environment (Mihelj et al., 2014). It usually involves users wearing goggles or a helmet ('Head Mounted Device' [HMD]) through which they view virtual worlds, which tracks where they look. They also use hand-held controllers which track their hand-location, allowing them to interact with virtual objects. VR therapy for FoF could occur in a clinical or home setting and would have a clinician supervising one or multiple users, who would be gradually exposed to their feared FoF situations until they habituate,

and their fears reduce. Unlike real-world exposure, it has lower physical risk and higher controllability of situations (Fromberger et al., 2018). Recent research suggests that VR via Head Mounted Displays (HMDs), which users wear as goggles, can successfully induce FoF in different populations, including those without existing FoF (Gui, 2021) and those with lower or higher levels of FoF. This demonstrates that VR is suitable for exposure work (Martens et al., 2017).

Though VR is also more immersive than serious games, some forms of VR, including HMDs, are more immersive than others. Formats such as interactive projector screens give a particularly immersive experience when treating FoF (Eloy et al., 2018). This is an emerging area, with technology developing rapidly, including recent wireless HMDs (e.g. Oculus Quest 2) to facilitate both ease of use and immersion.

1.2 Rationale for this review

Past systematic reviews related to this topic have mainly focused on serious games in general, less immersive forms of VR or the modification of non-psychological elements, such as balance and mobility (Corregidor-Sánchez et al., 2021; Dennett & Taylor, 2015; Kruisbrink et al., 2020; Neri et al., 2017). Neri et al.'s (2017) review reported that VR games were superior to conventional exercise interventions for FoF. They also reported poor methodological quality in most studies, noting particularly that nearly 90% of studies did not include follow-up periods (Neri et al., 2017). Other evidence suggests few significant benefits for use of non-VR serious games over physiotherapy at improving balance confidence (Dennett & Taylor, 2015). However, some of Neri et al.'s (2017) results included regular games, such as the Nintendo Wii balance board, which are categorised as "VR" (Singh et al., 2012). These are not fully immersive forms of VR, such as those using HMDs, but are often labelled as VR in the literature and therefore included in reviews on VR (Corregidor-Sánchez et al., 2021; Kruisbrink et al., 2020; Neri et al., 2017).

The present review focuses on less examined areas, including studies which use VR with fully immersive HMDs and are applied specifically to FoF in older adults, rather than physical balance. Older adults can be accepting of VR HMDs (Lin et al., 2018), however, the technology is generally more novel to them, with younger adults giving higher useability ratings for HMDs than older adults - possibly reflecting generational differences in attitudes towards technology (Plechatá et al., 2019). Aims include examining evidence on user-engagement and acceptability in this older population, given that previous reviews have not focused on this.

1.3 Aims

- To examine the ways in which VR is used in relation to FoF.
- To review how outcomes relevant to FoF are measured.
- To summarise the findings and any treatment effects.
- To explore the acceptability of treatments and user-engagement levels.
- To report any barriers to implementation of VR for FoF.

2. Methods

This review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021). Data extraction and evidence synthesis was conducted in line with Popay et al.'s (2006) guidance on conducting narrative synthesis in systematic reviews.

2.1 Inclusion Criteria

Interventions using VR with HMDs were included, including male and/ or female participants with an average age of ≥60 years. Studies had to include psychological measures related to FoF, including those measuring FoF directly and indirectly. Such indirect measures of FoF can adequately assess state anxiety in response to a specific event, in this case, exposure to VR scenarios inducing FoF. Equally, they can measure confidence in abilities related to FoF, including balancing. Any experimental-design studies were included (i.e. when researchers introduce an intervention and study the outcome effects); these could include controlled trials and quasi-experimental studies.

2.3 Search Strategy

The online databases searched were MEDLINE, Embase, PsycINFO and Web of Science Core Collections. The searches spanned all dates the databases held papers for, with no limitation on publication date. (**Table 2**).

Table 1: Search terms used for databases

Target	Medline (Ovid)	Embase (Ovid)	PsycINFO (EBSCO)	Web of Science Core Collection
Population	*Searched manually*			
Problem	((fear* or phobia* or afraid or anxiet*) ADJ3 (fall* or balanc*)).tw.	((fear* or phobia* or afraid or anxiet*) ADJ3 (fall*or balanc*)).tw.	TI (((fear* or phobia* or afraid or anxiet*) N3 (fall*or balanc*))) OR AB (((fear* or phobia* or afraid or anxiet*) N3 (fall*or balanc*)))	TOPIC: ((fear* or phobia* or afraid or anxiet*) NEAR/3 (fall*or balanc*))
Intervention	*Mapped subjects:* • **Virtual reality** • **Augmented reality** • **Video games *(Psychology subheading)*** • **Simulation training** Serious ADJ2 gam*.tw. (virtual or augment*) ADJ2 realit*.tw. *[Combined all above with OR]*	*Mapped subjects:* • **Virtual reality [Explode]** • **Virtual reality exposure therapy** • **Augmented reality** • **Video games** Serious ADJ2 gam*.tw. (virtual or augment*) ADJ2 realit*.tw.	*Mapped subjects:* • **Virtual reality** • **Virtual reality exposure therapy** • **Augmented reality** • **Computer games** Serious N2 gam* TI (virtual or augment*) N2 realit* OR AB (virtual or augment*) N2 realit*	Serious NEAR/2 gam* (virtual or augment*) NEAR/2 realit* “Immersive virtual reality” [keyword]

Further & Hand Searches

Guidance on conducting robust systematic reviews suggests performing forward and backwards searches to identify relevant work cited by suitable articles (Webster & Watson, 2002; Xiao & Watson, 2019), and reviewing past systematic reviews (Kitchenham & Charters, 2007). Over 600 studies were screened with four identified as suitable; these were already captured in the original search. From this original search, systematic reviews or meta-analyses studying interventions for FoF were also reviewed. One eligible study was identified which had been previously captured in the original search. Relevant reviews found via backwards and forwards searches of accepted papers were also examined. Five were identified as suitable, all of which were captured in the original search; therefore, no additional suitable studies were identified.

2.4 Quality Assessment

The final studies were assessed using the Joanna Briggs Institute (JBI) - Checklist for Quasi-Experimental Studies, which examines quality and risk of bias, for which studies are ultimately appraised as 'include' or 'exclude' across nine items. A second independent researcher (a Trainee Clinical Psychologist) also quality-assessed all studies to confirm inter-rater reliability in scoring. As recommended by the JBI manual, a pre-determined cut-off was decided between researchers, specifically that two-thirds of items be met for a study to be included in this review (Aromataris & Munn, 2020); meaning if over three out of nine criteria were not met or unclear, the study would be excluded. This was considered suitable to assess relevant studies in this niche emerging area of research. There was excellent agreement between researchers across all items (k = 0.86; weighted k = 0.9), resulting in confirmation that all studies were of good enough quality to include. (See **Table 3**).

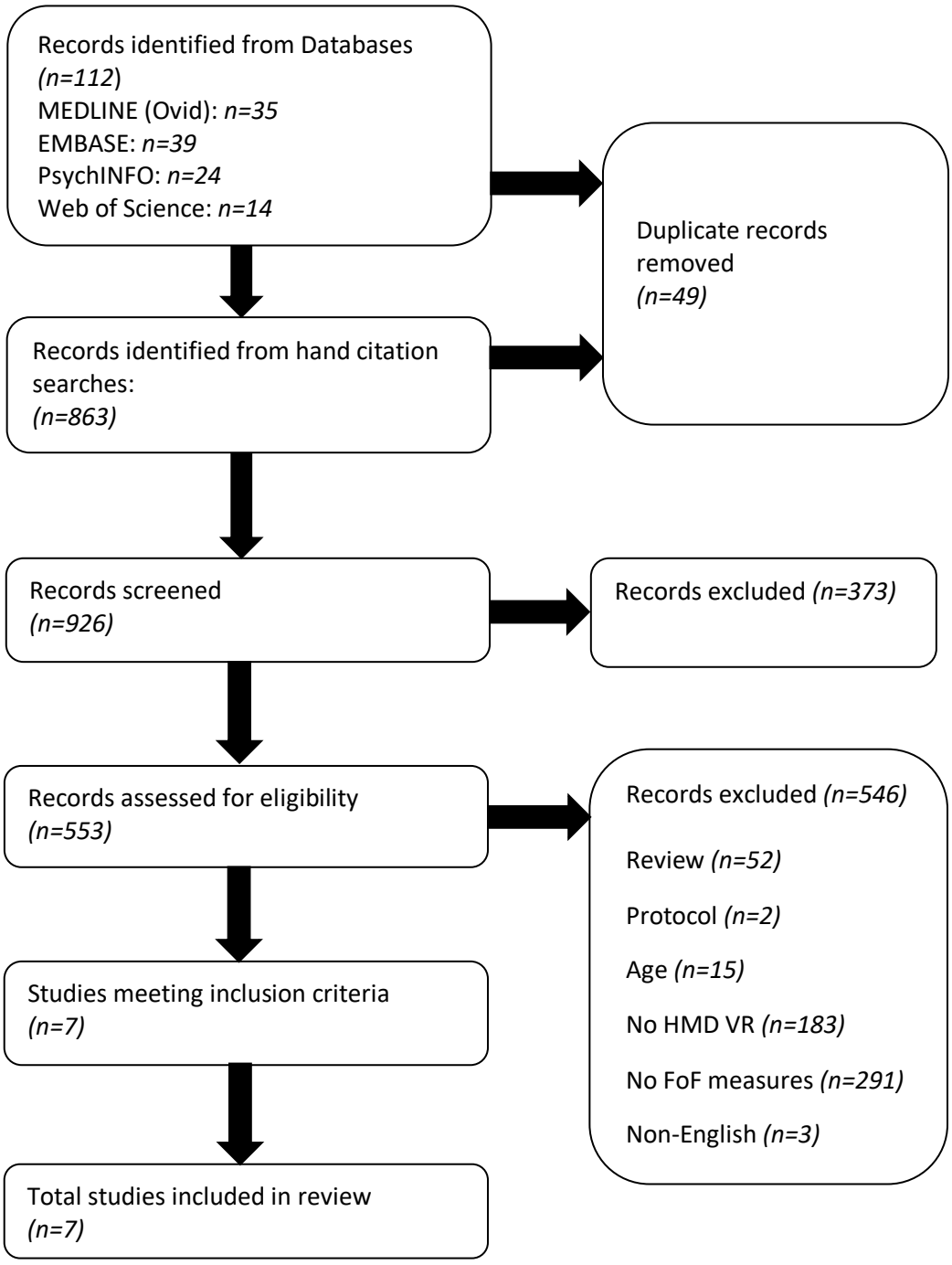
3. Results

3.1 Outcome of Search Process

Seven studies were found to be eligible for this review by the primary researcher. The same second independent researcher replicated this search and screened the results, with duplicates removed, to ascertain inter-rater reliability of inclusion/ exclusion decisions. The second researcher agreed on the same final studies except for one, which they initially excluded, for the reason that they believed it did not measure FoF adequately (*Cohen's kappa* = 0.9*)*. Researchers reached an agreement via discussion, choosing to ultimately include the study, as it adequately measured FoF indirectly.

3.2 Final studies

Figure 1: PRISMA Flow Diagram



Page et al. (2021).

Table 2: Characteristics of included studies

Authors	*N*	Mean age (years) (SD) & Sex (% female)	Study design	Target condition	Treatment	Comparison	Length & frequency	FoF-related measurement & time-points	Main Analysis	Relevant results
Daga et al., 2017	61 (35 treatment; 26 control).	69 (±11.2). 52%.	Cross-sectional. Baseline only measures.	Glaucoma patients.	VR: Presentation of static and dynamic visual stimuli, such as a moving tunnel, whilst participants were stationary.	VR. Healthy controls.	Three exposures of 2 minutes 15 seconds each, in one session.	University of Illinois at Chicago Fear of Falling Measure (16-item). Baseline only.	Tests of difference (*t*-test, Mann-Whitney). Linear regressions.	Significantly greater FoF in glaucoma group vs. controls (P = .04). Postural reactivity in response VR significantly associated with FoF in glaucoma group (P = .009; R^2 = 18.8%). A multivariable model including age, gender, postural reactivity, number of falls in past year, and physical activity score, predicted specific increase in FoF units as postural

										movements increased (P = .001; R^2 = 48.8%) in glaucoma group. No effect sizes or degrees of freedom reported.
Duque et al., 2013	60 (30 treatment; 30 control). [Data error- also reports sample size as 70].	77 (±9). 62%.	Quasi-experimental. Pre and post measures.	Patients from Falls and Fractures Clinic.	VR: Visual-vestibular rehabilitation and postural training exercises/ games.	VR. Patients from Falls and Fractures Clinic.	20-minute sessions, twice a week for six weeks; 12 total.	Survey of Activities and Fear of Falling in the Elderly (SAFFE). Baseline and nine months.	Tests of difference (*t*-test, ANOVA).	At 9 months: Significant reduction in falls in VR vs. controls group (P = <.01). Significantly lower FoF in VR vs. controls (P = <.05). Significantly improved balance parameters in VR group vs. baseline (P = .01). No effect sizes reported.

Ehgoetz Martens et al., 2017	42 (21 treatment; 21 control).	69 (±6). 38%.	Cross-sectional. Baseline only measures.	Parkinson's disease patients (high vs. low anxiety).	VR: High vs. low threat of falling, virtual environments, including walking on an elevated plank.	VR. Healthy controls.	10 exposures of 30 seconds each, in one session.	'Self-assessment Manikins' & State Anxiety Likert scale. Immediately post each exposure.	Tests of difference (*t*-test, ANOVAs).	Greater anxiety in high vs. low threat FoF situations by group ($F(2,39) = 8.32$, $p = .001$) and condition ($F(1,39) = 11.92$, $p = .001$). Significantly higher anxiety in both conditions for high anxiety group vs. other groups (P = <.05). Suggest that anxiety in Parkinson's increases cognitive processing, influencing balance control; particularly in highly anxious people. No effect size reported.

Giotakos et al., 2007	68 treatment.	77 (±5). 54%.	Quasi-experimental. Pre and post measures.	Patients with hip fracture history and FoF.	VR: 'Virtual reality exposure scenario' (VRET), involving walkways, obstacles, movement training and shopping task with a treadmill.	No control group. Baseline vs. post-intervention.	Three ten-minute weekly sessions and booster session at 6 months.	Falls Efficacy Scale-International (FES-I). Activities-specific Balance Confidence scale (ABC). Baseline, immediately-post intervention, six months and a year.	Tests of difference (MANOVA).	97% had significantly lower FoF at 12 months vs. high FoF at baseline (P = <.001). Lower balance scores were predicted by FoF (P = <.05). FoF, or related anxiety following hip fracture, may be 'significantly mitigated' by VRET scenario. No effect size reported.
Griffin et al., 2011	26 treatment.	64 (±6.7). 15%.	Quasi-experimental. Pre and post measures.	Parkinson's disease patients.	VR: Walking task simulating real world challenges, incorporating FoF triggers, including obstacles vs. open ground.	No control group. Baseline vs. post-intervention.	Six exposures total without time limit, in one day.	FoF Visual Analogue Scale (VAS). Immediately after each exposure.	Tests of difference (ANOVA.	Significantly greater FoF in VR conditions with obstacles vs. open ground ($F(1,18) = 11.7$, $p = .003$). Low overall FoF in all conditions. No significant interaction of condition and terrain

										(*F*(2.24,40.3) = 1.26, p > .2). No effect size reported.
Levy et al., 2016	16 (9 treatment; 7 control).	71 (±15.7). 63%.	Quasi-experimental. Pre and post measures.	Participants with FoF.	VR: navigating virtual environments of increasing difficulty (e.g. steps, obstacles), whilst sat in swivel chair.	Waiting list controls, with FoF.	12 weekly sessions of 40 minutes each.	University of Illinois at Chicago Fear of Falling Measure (19-item). Within a week both pre- and post-intervention.	Tests of difference (Mann-Whitney, Fisher's exact).	Significantly greater decrease in VR's FoF vs. controls post-intervention (P = .007). Treatment group (M = 6.44, SD = 3.17) and controls (M = 6, SD = 1.15) were impaired socially due FoF according to Sheehan Disability Scale. Suggest that VR therapy, associated with serious gaming, appears feasible for treating FoF. No effect size reported.

Phu et al., 2019	195 (63 treatment one; 82 treatment two; 50 control).	Median= 78 (interquartile range= 72-83). 67%.	Quasi-experimental. Pre and post measures.	Patients with balance deficits or falls history.	Treatment one- VR: Postural training and rehabilitation games, such as reaching for objects. Treatment two: Group-based Otago Exercise Programme (OEP) for falls prevention.	Controls were participants who declined interventions.	20-minute sessions, twice a week for six weeks; 12 total.	FES-I. Baseline and immediately post-intervention.	Tests of difference (Fisher's exact).	Significant reduction in FoF post-intervention vs. baseline in VR (P = .004) and exercise (P = .013) groups; largest FoF reduction of 16% in exercise group vs. 11% in VR, though no significant difference between these. No significant change in control group. No effect sizes reported.

Table 3: Quality assessment tool

The Joanna Briggs Checklist for Quasi-Experimental Studies (non-randomised experimental studies)

Study	1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	2. Were the participants included in any comparisons similar?	3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	4. Was there a control group?	5. Were there multiple measurements of the outcome both pre and post the intervention/ exposure?	6. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analysed?	7. Were the outcomes of participants included in any comparisons measured in the same way?	8. Were outcomes measured in a reliable way?	9. Was appropriate statistical analysis used?	**Overall appraisal**
Daga et al., 2017	N/a (use of regression, not cause and effect)	Yes	Yes	Yes	N/a (exploring relationships not effects)	N/a (no follow-up measures after intervention)	Yes	Yes	Yes (appropriate test used- but no effect sizes or degrees of freedom reported)	**Include**

Duque et al., 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes (but same physiotherapist conducted all measures)	Yes (appropriate test used- but no effect sizes reported)	**Include**
Ehgoetz Martens et al., 2017	Yes	No (high FoF group had significantly greater depression than other groups)	Yes	Yes	Yes	Yes	Yes	Unclear (no mention who conducted STAI)	Yes (appropriate test used- but no effect sizes reported)	**Include**
Giotakos et al., 2007	Yes	N/a (repeated measures)	N/a (same group)	No	Yes	Unclear (all participants completed FES-I- no mention if everyone completed ABC at follow-up)	Yes	Unclear (questionnaires 'self-administered'- does not say who conducted this or if they were trained)	Yes (appropriate test used- but no effect sizes reported)	**Include**
Griffin et al., 2011	Yes	N/a	N/a	No	Yes	Yes	Yes	Unclear	Yes	**Include**

		(repeated measures)	(same group)					(no inter-rater measures for video gait observations)	(appropriate test used- but no effect sizes reported)	
Levy et al., 2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear (no mention of who conducted measures)	Yes (appropriate test used- but no effect sizes reported)	**Include**
Phu et al., 2019	Yes	Yes	Unclear (recruited from various hospitals/ GPs)	Yes	Yes	Yes	Yes	Yes	Yes (appropriate test used- but no effect sizes reported)	**Include**

Possible outcomes: Yes, No, Unclear, N/A. Studies had to meet at least two-thirds of criteria to be included. Criteria which were not met or were unclear are highlighted in red. Criteria which were met overall, but with caveats or additional points, are highlighted in yellow.

4. Review of Study Findings

The studies included a range of sample sizes (M = 68, SD = 55, Range = 16-195), with one study reporting conflicting information on this as a data-entry error (Duque et al., 2013). Participants were 72 years old on average (SD = 4.9), with an average of 50% females across all samples. Other sample demographics varied considerably, with two studies including participants with Parkinson's disease (Ehgoetz Martens et al., 2017; Griffin et al., 2011), one using glaucoma patients (Daga et al., 2017) and the remaining four recruiting those with a history of falls, balance deficits and/ or FoF. Two of the latter studies also specified a history of fractures from falling (Duque et al., 2013; Giotakos et al., 2007). All studies used tests of difference when analysing FoF, including *t*-tests and ANOVAs, with one conducting linear regression (Daga et al., 2017). Only one study (Daga et al., 2017) reported data on ethnicity, with 54% Caucasian, 34% African American, and 12% Asian or 'Other'. Five of the studies (71%) also had control groups, with the remaining using pre- and post-intervention measures of one group (Giotakos et al., 2007; Griffin et al., 2011). Although this review focuses on FoF as a psychological outcome, other non-psychological measures were used in the studies, including balance, posture, grip strength and 'freezing of gait', which is a temporary perceived inability to step forward (Nutt et al., 2011).

The following review of the studies is categorised into the main review aims, as outlined above.

4.1 How VR is used in relation to FoF

Not all studies used VR to primarily treat FoF, with it often being a related factor or secondary outcome. This reflects the use of VR in FoF via HMDs being an emerging area. Methods of VR's application were also variable, with total

number of sessions across studies varying from one to 12 (M = 9, SD = 4.1). The length of these individual sessions also spanned from 30 seconds (s) to 40 minutes (m) (M = 15.5m, SD = 15m), with total exposure time of all sessions varying from 5m to 8 hours (h) (M = 2.8h, SD = 2.9h). Just two studies clearly used VR to directly treat FoF, the first of which used treadmills and virtual walking environments, with obstacles requiring postural adjustments (Giotakos et al., 2007; Levy et al., 2016). They particularly highlighted cognitive aims to increase self-efficacy beliefs around falling, which not all studies did. The second study was the only one to use seated VR and incorporate serious games on the PlayStation Eyetoy, with graded exposure tasks including navigating narrow corridors (Levy et al., 2016). A further two studies used VR interventions for primarily balance rehabilitation. Duque et al. (2013) and Phu et al. (2019) used visual and postural training tasks of increasing difficulty, involving leaning. The tasks were also tailored to the person in Phu et al.'s (2019) study. Taking a graded exposure approach, task difficulty or time of exposure increased with progression. Graded exposure was present in most studies in some form, though one study only used two grading categories: 'high' and 'low' FoF situations (Ehgoetz Martens et al., 2017).

Four of the studies included those with falling histories or FoF (Duque et al., 2013; Levy et al., 2016; Phu et al., 2019), with the remaining three focusing on Parkinson's Disease and glaucoma, for whom FoF can be exacerbated. This suggests VR could be applied across health conditions common in older people. One study used VR primarily to measure the effects of visual cues on gait in Parkinson's, with FoF measured post-exposure (Griffin et al., 2011). Ehgoetz Martens et al. (2017) examined effects of anxiety, induced by VR situations, on balance control in Parkinson's, as a loss of balance predicts falls (Adkin et al., 2002). Daga et al. (2017) similarly investigated relationships between FoF in Glaucoma participants and postural reactivity. Overall, despite all utilising VR via HMDs, the interventions differed in multiple ways, including content and exposure-length; there was no 'typical' VR FoF intervention. Some involved participants remaining stationary or sitting (Daga et al., 2017; Levy et

al., 2016), whilst others required they move on treadmills (Giotakos et al., 2007). The stimuli they experienced through HMDs was likewise diverse, although most utilised games simulating real world challenges that their demographic might face. For instance, one study engaged participants in walking tasks along narrow walkways in high and low threat situations, specifically being lower to or higher from the ground (Ehgoetz Martens et al., 2017), whilst another required participants to step over boundaries on the floor (Griffin et al., 2011).

4.2 How outcomes relevant to FoF are measured

All studies used measures relating to FoF and direct or indirect measures were included due to the emerging nature of this area. Six of the studies used one measure and one study used two. All were self-report questionnaires, unlike more objective physical balance measures such as force platforms (Daga et al., 2017). The measures used were as diverse as the VR application, with seven measures utilised in total, the Falls Efficacy Scale-International (FES-I) (Yardley et al., 2005) being used twice and all others once.

The FES-I, comprised 16 items examining everyday activities which might induce FoF, including cleaning or shopping, scored on a 10-point scale of falling 'concern'. It is a widely used, high-quality measure and is sensitive to change in clinical interventions (Moore & Ellis, 2007). Phu et al. (2019) and Giotakos et al. (2007) used this, with the latter also using the Activities-specific Balance Confidence scale (ABC) (Powell & Myers, 1995). This is a 16-item questionnaire rating confidence in ability to keep balanced in certain situations as a percentage, with '100%' being totally confident; again, items cover everyday tasks like cleaning. Levy et al. (2016) used a version of the University of Illinois at Chicago Fear of Falling Measure (FFM), which assessed FoF on a four-point scale of 'worry' across 19 activities, including getting out of bed. Daga et al. (2017) was the only study meeting inclusion criteria which measured FoF

at baseline only. They used an updated 16-item version of the FFM, comparing scores with postural metrics gained via VR and force platforms. This questionnaire is measured on a three-point scale of 'worry' and covers similar situations, including walking outside. This latter version of the FFM was created after a detailed analysis determined that users could not discriminate certain categories on the scale, therefore reducing the Likert from four to three-points (Moore & Ellis, 2007; Velozo & Peterson, 2001); it is not explained why Levy et al. (2016) did not use this updated version of the measure. Duque et al. (2013) utilised the Survey of Activities and Fear of Falling in the Elderly (SAFFE), which has 11 items on four-point Likert scales of FoF, covering activity restriction and QoL.

Most of these measures had been validated and had reportedly high test-retest reliability, including the ABC (intraclass correlation coefficient [ICC] = 0.93), the FES-I (ICC = 0.96) and the SAFFE (ICC = 0.91) (Liu & Ng, 2019; Shah et al., 2017; Yardley et al., 2005). More limited support was found for the 19-item FFM, with their scale being poorly supported empirically before being updated (Velozo & Peterson, 2001). There were also no reliability statistics for both versions of this measure, though Moore and Ellis (2007) posit that a strength of the FFM is that the items were developed by older people, unlike the other measures. Overall, there was significant variation, though all questionnaires covered feasible situations older people might face. The remaining two studies used simpler measures. Ehgoetz Martens et al. (2017) indirectly measured FoF via a 9-point Likert scale of State anxiety imposed onto 'Self-assessment Manikins' (SAMs), which are pictures of faces displaying various distress levels; this was measured immediately post-exposure to FoF situations. SAMs are a validated approach in the measurement of state anxiety, although they have poor to reasonable reliability for this (ICC = 0.55-0.78) (Nazari et al., 2012). Griffin et al. (2011) used a 10-point Visual Analogue Scale (VAS) directly measuring FoF after each VR exposure session. No explanation was given for why they chose VAS when more detailed measures exist, though it was likely faster to implement due to fewer items. Validity and reliability are reportedly

poor to reasonable for the VAS in measuring FoF (ICC = 0.49-0.64) (Scheffer et al., 2010). Overall, follow-up periods were also short, ranging from no follow-up, to 12 months. One study had a follow-up at six and 12 months (Giotakos et al., 2007) and another at nine months (Duque et al., 2013). One was measured at baseline only (Daga et al., 2017), with the remaining conducted immediately following VR exposure (Ehgoetz Martens et al., 2017; Griffin et al., 2011; Phu et al., 2019), other than Levy et al. (2016), who followed-up within a week post-exposure. The JBI quality assessment also found that not all follow-ups were clearly reported, with Giotakos et al. (2007) not clarifying if all participants completed the ABC.

4.3 Findings and Treatment effects

The findings varied greatly due to differences in study design, population and specific FoF measures, with some being primary or secondary outcomes. Due to their diversity, the studies are first described individually below and then synthesised.

Using VR alongside serious games to directly treat FoF, Levy et al. (2016) reported significantly lower FoF scores in the VR intervention group versus controls, though no effect size is reported. They concluded that VR associated with serious games can be successfully utilised in FoF treatment, noting that the approaches are complementary. However, they randomised participants via drawing lots, making this study quasi-randomised. Giotakos et al. (2007) likewise measured FoF as a primary outcome, alongside balance confidence. They reported a high ‘success rate’, with 66 out of 68 participants experiencing significant FoF reductions, from ‘high’ to ‘low’ FoF, at 12 months. Balance confidence also increased over time from baseline (M = 48%), to six (M = 68%) and 12 months (M = 88%). Again, no effect-sizes or significance statistics are reported for this, making it challenging to interpret. Based on their results, they

suggest VR is an effective platform for the development of FoF treatments, though the basis for this is questionable.

Phu et al. (2019) concurred with this view and had the largest sample of 195, with three groups: VR, exercise and control. The JBI flagged that, unlike the other studies, it was unclear whether these groups received similar care outside the intervention variable, partly as they were recruited from various hospitals and GPs. This might have introduced unknown biases into the results. The primary outcome was physical balance, though there was a significant reduction in FoF in both VR and exercise groups immediately post-intervention, versus baseline. Controls showed no significant FoF change over these six-weeks. FoF was significantly lower in the VR group versus controls, though no significant difference between interventions groups was reported and no effect sizes were reported either. As with some of the studies, there was also no longer-term follow-up, meaning it is unknown if any benefits were sustained. Additionally, this study did not randomise participants, indicating potential bias. Overall, they advocated for the use of VR as being an effective alternative in FoF treatment, at least in the short term.

Primarily exploring balance outcomes, Duque et al. (2013) found significant reductions in FoF and falls frequency in the VR group versus controls at 9-months, again, no effect sizes were reported for this. As noted in the JBI, they reported one physiotherapist as conducting multiple measures of posture, which could have benefitted from a secondary rater; this physiotherapist also conducted the FoF questionnaire. However, the clinicians who conducted the VR training were different from those conducting the assessments, reducing risk of bias somewhat. Reporting also could have been clearer in other areas, with the randomisation method for group allocation not being identified.

Daga et al. (2017) investigated relationships between FoF and posture in glaucoma patients via VR, versus healthy controls. They reported significantly greater FoF in glaucoma patients at baseline. Postural reactivity in response to VR, such as leaning, was significantly associated with FoF in glaucoma participants, but not in controls. Their linear regression univariate model predicted specific increase in FoF units as postural movements forward and backwards increased ($P = .009$; $R^2 = 18.8\%$); a limitation however, is that they did not report the degrees of freedom or effect size. Another improvement they acknowledged would be to include multiple FoF measures in their regressions, rather than just one, to strengthen their findings.

Griffin et al. (2011) evaluated the effects of VR visual cues on the gait of those with Parkinson's, with intention to improve their walking. FoF was a secondary measure to freezing of gait. There were low levels of FoF across VR conditions, including those with obstacles, though there was significantly greater FoF in the presence of obstacles versus without. Although their ANOVA was otherwise reported in full, no effect size was reported for this. Specific VR conditions, including floor lines to cue walking, also did not significantly influence FoF. They conclude that some VR cues, specifically transverse lines, can be effectively used to improve walking, whilst keeping FoF levels manageable. A limitation of their use of VAS to measure FoF is the need for clear vision and precise writing ability when answering, unlike other measures which could be read by someone else if necessary. Ability to use a pen could be especially impaired in those with Parkinson's. As previously noted, their decision to use VAS over other more detailed FoF measures is not explained.

The final study likewise used participants with Parkinson's (Ehgoetz Martens et al., 2017), using Likert scales indirectly measuring FoF via state anxiety, immediately following VR exposure. There were two conditions, high and low FoF threat, with three groups: those with high FoF, low FoF and controls. Participants were assigned to these groups based on their baseline anxiety

score, with those scoring above a threshold assigned to the high FoF group. All participants reported significantly greater anxiety when exposed to the high threat VR condition, versus the low threat condition. The high FoF group reported significantly higher anxiety across both low and high threat conditions, versus both controls and those in the low FoF group. Again, no effect sizes were reported for the findings of the ANOVAs. In the high threat condition, only the high FoF group reported increasing anxiety as trials progressed, whilst the low FoF group, and controls, had steady anxiety levels throughout the exposure. Despite being immediately post-exposure, the Likert anxiety measure was not specific to FoF, measuring it only indirectly. Also, due to an inability to match groups on all mental health traits, the high FoF group had significantly greater depression than other groups, as highlighted in the JBI, which could confound results.

Overall, the studies generally concluded that VR might be useful in treating FoF, including in samples with health conditions, and this seemed related to improvements in balance. VR obstacles also appeared to induce FoF and those with higher existing anxiety found that VR induced more FoF, versus those with lower baseline FoF. The studies did use and report appropriate analyses, as identified through the JBI. All used tests of difference, including *t*-tests, Fisher's exact, Mann-Whitney, ANOVAs and MANOVAs; only one study examined relationships, specifically between postural reactivity and FoF using Linear regression (Daga et al., 2017). However, there were significant quality issues which challenge the validity of these results. Reporting of their FoF analyses was overall fairly brief, partly as other non-FoF outcomes were focused on such as gait and grip-strength (Phu et al., 2019). Despite reporting significant results, none of the studies reported the effect size of their findings. It is crucial that *p* values are accompanied by effect sizes to provide full context (Sullivan & Feinn, 2012), which was not the case.

The JBI also emphasised issues concerning how reliably the FoF questionnaires were conducted. For instance, Ehgoetz Martens et al. (2017), Giotakos et al. (2007) and Levy et al. (2016) do not clarify who conducted the measures nor whether they were trained in this. Additionally, shorter follow-up periods also mean the evidence is limited regarding longevity of any effects, though these effects cannot clearly be established in the first place, given the lack of effect sizes. Another issue is that these results are challenging to compare and synthesise, due to the lack of consistency in FoF measurement. Though five studies used controls, true randomisation was also not reported in the studies, introducing bias into the findings. Nonetheless, group randomisation was not a prerequisite for inclusion in this review.

4.4 Treatment Acceptability and User-engagement Levels

The studies generally did not explicitly report participants' qualitative acceptance of VR interventions, though other factors including drop-out rates and their reasons, can be explored. Overall, VR seemed to be well accepted, with high adherence. Phu et al. (2019) reported adherence rates of 72% in the VR group, akin to the non-VR exercise group at 71%. Griffin et al. (2011) also reported a high adherence rate of 85%, with one participant withdrawing due to "discomfort", which was not elaborated on. Duque et al. (2013) reported 97% adherence, with drop-out due to "logistics problems" in attending sessions, not due to aversion to VR itself; again, this reason was not explained. Remaining studies did not explicitly refer to drop-out rates, but all participants completed the VR interventions and were included in their analyses, suggesting good treatment adherence (Daga et al., 2017; Ehgoetz Martens et al., 2017; Giotakos et al., 2007; Levy et al., 2016).

Phu et al. (2019) mentioned that their VR stimulus could be individually customised according to participants' ability to tolerate it, such as changing the intensity of postural training games as people habituated. Moreover, Phu et al.

(2019) reported that this customisable content and one-on-one nature of the intervention enhanced peoples' engagement. Duque et al. (2013) also progressively increased the complexity of VR training games as participants reported higher confidence; they concluded that their intervention was "well-accepted" by participants. Griffin et al. (2011) also emphasised the necessity for HMDs to be unobtrusive, comfortable and to not contribute to FoF or reduced balance confidence.

4.5 Barriers to Implementation

As described, user-engagement levels were reportedly good across studies. Drop out reasons were not always reported nor explained, but included discomfort, inability to physically complete tasks and logistical issues attending (Duque et al., 2013; Griffin et al., 2011). These barriers were both related and unrelated to the VR interventions, though few others were explicitly discussed. Promisingly, VR-induced side-effects for instance were not reported in any study. Phu et al. (2019) explained that barriers personal to participants such as tiredness and low motivation could contribute to low adherence, particularly in VR interventions which combine physical activity. Duque et al. (2013) concurred, reporting that real-world implementation of such exercise-related interventions could be challenging, as they require physical endurance which some older adults might not have. Levy et al. (2016) demonstrated that VR treatments for FoF could be conducted with participants sitting down however, reducing physical fatigue.

5. Discussion

There was large variation between studies on numerous factors, including the sample population, FoF-related measures, study design, sample size and specific VR intervention. This inevitably makes comparing and synthesising findings more challenging. However, some issues are relevant across all VR

studies, for instance, it is difficult to blind participants to a VR versus non-VR treatment in such studies. ‘Treatment as usual’ for FoF also varied, for example in one study it involved: an invitation to join an exercise group, medication reviews, healthcare professional home visits, hearing and visual assessments, nutritional or vitamin supplements and psychoeducation on falls prevention (Duque et al., 2013). Not all studies had controls with this variety of support, again, making comparison challenging and reflecting the different health service contexts the research took place in.

5.1 How VR is used in relation to FoF

There was no typical VR intervention for FoF, moreover, only a minority of studies actually used VR to directly treat FoF (Giotakos et al., 2007; Levy et al., 2016). Most measured FoF as a secondary outcome and focused on objective balance rehabilitation, which could be due researchers’ desire to rely less on time-consuming self-report questionnaires (Perez-Jara et al., 2010). Some concentrated on the mitigation of symptoms relating to specific conditions, including freezing of gait in Parkinson’s disease (Griffin et al., 2011). This highlights the prevalence of FoF in disorders like Parkinson’s and Glaucoma, as well as in older people generally. Some involved participants remaining stationary or sitting (Daga et al., 2017; Levy et al., 2016), whilst other interventions conversely used treadmills (Giotakos et al., 2007). VR was also not purely used, with Levy et al. (2016) including non-VR serious games, further convoluting cross-study comparisons of HMD usage in VR. The actual stimuli via HMDs likewise differed, although most opted for content simulating real-world challenges that their demographic might face, presented in a graded manner, including reaching, leaning or navigating objects. The HMD technology also varied, including V8 head-mounted displays (Levy et al., 2016) or KEO - Proview XL-50 (Giotakos et al., 2007). These varied by weight, head straps, screen type and size, emphasising the variety of VR available. Although only three studies reported adherence (Duque et al., 2013; Griffin et al., 2011; Phu et al., 2019), it was good when reported, suggesting these various HMDs were mainly tolerable to older people, as in past research (Lin et al., 2018). The

varied exposure length and session numbers reflects VR's potential versatility in application, though no session was wider than a week apart. Despite this, the generally incomplete reporting of findings outside of *p* values means the optimal exposure format for most effectively treating FoF remains unclear.

5.2 How outcomes relevant to FoF are measured

The methods of FoF measurement varied greatly, all being self-report. Most studies used just one measure, with seven different measures being used across all studies. The FES-I was the only questionnaire used twice. Only one study measured FoF indirectly, which is less precise than direct measurement. In any case, FoF is challenging to measure according to past review evidence, with much research using just one question to assess it; this needs to be improved to ensure adequate FoF assessment (Perez-Jara et al., 2010). The JBI also highlighted that reporting on who conducted these measures, and if they were adequately trained, should be clarified in these studies to reduce bias and enhance transparency (Ehgoetz Martens et al., 2017; Giotakos et al., 2007; Levy et al., 2016). Scales commonly used in other research include the ABC and FES-I (Moore & Ellis, 2007), both of which were present once and twice respectively (Phu et al., 2019; Giotakos et al., 2007). These longer, detailed scales are more suitable for measuring responses to FoF interventions but are often not utilised due to the time required (Perez-Jara et al., 2010). Most studies in the present review used measures in addition to FoF, such as balance, meaning shorter scales might have fitted better into their design, particularly if participants were also engaging in intensive VR. Nonetheless, improvements could still be made; Levy et al. (2016) for example did not use the updated 16-item version of the FFM, which has been found to have better validity than the previous version (Velozo & Peterson, 2001), as used by Daga et al. (2017). Ehgoetz Martens et al. (2017) also opted to use SAMs with imposed Likert scales, which have relatively low reliability and validity versus other specific FoF measures (Nazari et al., 2012). In all cases, the choice of FoF measure was not fully explained, reducing both replicability and transparency in the research process.

A possible reason for the differing FoF measures used is the lack of consensus on a definition (Jung, 2008). It has been suggested that the subjective nature of FoF measurement can be helped by also measuring activity restriction, an objective FoF consequence (Perez-Jara et al., 2010). Since FoF was often measured secondary to other objective balance measures, this raises the question around whether researchers should focus on self-report outcomes like FoF, or more objective measures. A combination of both might reflect users' experience best (Perez-Jara et al., 2010), which was conducted in multiple studies, including via force platforms, and were found to be correlated (Daga et al., 2017). This relative strength of combined measurements could have been better highlighted if they had improved their reporting of statistics, including effect sizes. Despite these studies representing an emerging niche in FoF treatment, coherency and comparability in research is still essential, including of outcome measures and reporting of results.

Moreover, follow-up periods for FoF were mostly conducted immediately following VR exposure; longer follow-ups would improve the research quality and give better indication of maintained benefits. As found in the JBI, follow-ups could have been better reported, with Giotakos et al. (2007) not clearly reporting whether all participants completed the ABC at follow-up for instance. Before further research examines longer follow-up periods, the reporting of results must be improved to establish the size of the effects of VR on FoF in the first place. It is crucial that studies report effect sizes, and degrees of freedom where necessary, to enhance the quality of the evidence-base in this area (Sullivan & Feinn, 2012).

5.3 Findings and Treatment effects

The studies resulted in unique findings given their diverse aims, design, sample population and FoF measures. For instance, the diverse samples highlight FoF differences across health conditions, including higher FoF in glaucoma patients versus controls (Daga et al., 2017). Despite this, there were many significant quality issues in the findings. Most utilised experimental designs with control groups and reported findings initially appeared positive. Multiple studies described significant reductions in FoF following VR intervention, versus controls (Duque et al., 2013; Levy et al., 2016; Phu et al., 2019) or their own baseline (Giotakos et al., 2007). Other notable results included greater FoF in the presence of virtual obstacles compared to without (Griffin et al., 2011) and prediction via regression of increases in FoF, as postural imbalance increased (Daga et al., 2017). One study also found that low threat VR FoF situations induce high anxiety in more anxious older people (Ehgoetz Martens et al., 2017). As outlined previously, the validity of all these findings is questionable given the standard of reporting in the results sections, with none reporting effect sizes. Therefore, the magnitude of these significant effects is unknown. Although some samples were large, most were also relatively modest, further challenging the generalisability their findings. As discussed, follow-up lengths were generally short-term, meaning longer-term benefits of FoF interventions are yet to be explored further. Multiple studies explicitly concluded that VR via HMDs is an effective and promising platform for FoF intervention (Levy et al., 2016; Giotakos et al., 2007; Phu et al., 2019), even if used alongside serious games (Levy et al., 2016). Although review evidence supports this, finding that VR interventions are superior at improving FoF than traditional treatments, including balance exercises (Neri et al., 2017); these conclusions are not yet adequately supported by the quality of the reported results in the present studies.

5.4 Treatment acceptability and user-engagement levels

Adherence rates were good for studies which reported them, ranging from 72-97% in VR groups (Duque et al., 2013; Griffin et al., 2011; Phu et al., 2019). However, not all studies reported this, which is necessary to ensure quality and

transparent research. Although other drop-out rates were not explicitly mentioned, all participants completed interventions for the other studies (Daga et al., 2017; Ehgoetz Martens et al., 2017; Giotakos et al., 2007; Levy et al., 2016). A general benefit of VR is that virtual environments are adaptable to individuals' needs and this customisation could logically result in better adherence and acceptance of interventions. Some studies allowed customisable content according to participants' progress, which reportedly increased engagement and acceptance levels (Duque et al., 2013; Phu et al., 2019). These good retention rates are reflected in other research; one study found that retention of technology-based FoF interventions, including serious games, exceeded regular exercises at three-months (Kwok & Pua, 2016). A review also reported high engagement levels in technology-based balance and exercise interventions in older adults (Valenzuela et al., 2018).

One study emphasised the importance of HMDs being unobtrusive and themselves not increasing FoF (Griffin et al., 2011). Research suggests that intention to use VR HMDs is positively predicted by perceived usefulness, enjoyment and usability (Mascret et al., 2020). More recent introductions of lighter wireless HMDs logically aid this perceived usability and unobtrusiveness, such as the Oculus Quest 2.

5.5 Barriers to implementation

Participant discomfort, inability to physically engage and logistical issues in attending were the only adherence barriers reported (Duque et al., 2013; Griffin et al., 2011); these could have been more fully explained to ensure future studies can address them. Home-based VR treatment might remedy any issues attending for instance. As outlined, HMD-related discomfort can also be minimised through use of wireless HMDs. HMDs are also relatively affordable, making cost an increasingly minimal barrier, especially considering they can be used many times. They also require fewer clinicians to supervise multiple users

engaging in semi-automated VR interventions, thus potentially saving labour costs (Freeman et al., 2018).

Physical exhaustion can be another barrier for older adults in physically active interventions (Forkan et al., 2006; Rhodes et al., 1999). Promisingly, this was not reported in the study samples, albeit some involved sitting (Levy et al., 2016). Although sitting VR interventions might reduce the barrier of physical fatigue, they could simultaneously reduce opportunities to strengthen balance-related muscles. Differences in the use of additional force platforms or hand-held controllers could also hinder the implementation of VR in older adults. For instance, those with arthritis might have issues holding controllers, though this was not reported as a barrier in the studies.

Furthermore, as Duque et al. (2013) notes, blinding in VR studies is often unfeasible, which could be interpreted as a barrier to producing the strongest evidence base for VR for FoF. Similarly, although many FoF measures have been developed, most studies only used one, with few studies using the same measures. Some even opted for outdated measures or those with poorer reliability (Ehgoetz Martens et al., 2017; Levy et al., 2016), a significant barrier to evaluating the effectiveness of VR when reviewing the evidence. Daga et al. (2017) also highlighted this need to further validate findings using multiple FoF measures before further implementation of VR in real-world settings.

5.6 Limitations

This review has some limitations; firstly, the sample populations included were heterogenous in factors other than ‘older’ age, making it challenging to synthesise and make generalisations on this topic. For example, comorbidities included Parkinson’s disease and glaucoma. A meta-analysis was also not possible given the varying study designs and outcomes. Although the quality

assessment matched the study designs well and the approach recommended by the authors was followed (Aromataris & Munn, 2020), it had no objective cut-off score, being determined instead by the reviewers.

5.7 Areas for Future Research and Clinical Practice

There is a pressing need for further consensus on a definition for FoF (Jung, 2008), which would potentially remedy the use of many different measures across studies, making comparisons difficult. The use of multiple reliable FoF measures in studies would also strengthen findings, though issues including time limitations might contribute to such decisions (Perez-Jara et al., 2010). Activity restriction could be measured as a more objective adjunct to FoF to address the subjective nature of FoF measurement (Perez-Jara et al., 2010). Overall, a key area of improvement is the reporting of results, as emphasised in the JBI, as none of the studies outlined the effect sizes of any significant differences, leaving the evidence-base currently weak regarding VR for FoF. Specifically who conducted the measures, and their training, should also always be reported. Follow-up periods were mostly immediately following VR exposure and longer follow-ups would provide better indication of maintained benefits. The studies were also quasi-randomised and greater true randomisation would reduce potential bias.

6. Conclusion

The diverse content and focus of the VR interventions in these studies inevitably reflects the emerging nature of this area. When directly addressing FoF, most studies used tasks simulating real world challenges older people might face in-vivo. Many FoF measures with varying reliability were used and this reflected the lack of consensus on a FoF definition; this somewhat convolutes and weakens the evidence-base. Though the results would suggest

that VR treatment via HMDs is beneficial for FoF in the short-term, the quality of reporting was not adequate to merit this conclusion yet. Better reporting of effect-sizes, larger sample sizes, detailed multiple FoF measures and longer follow-ups are necessary. VR for FoF was generally well accepted by older adults across various conditions, including sensory disorders and age-related balance decline, though adherence-levels should be more consistently reported. Few implementation barriers were also reported, other than participant discomfort by a minority. Past research suggests that VR therapy is already as effective at improving anxiety as in-vivo therapy (Carl et al., 2019). Given the additional need for reduced labour costs in such psychological interventions (Freeman et al., 2018), these semi-automated VR treatments may also have potential in the treatment of FoF and therefore it is worth continuing to strengthen this evidence-base to better determine this.

7. References

Adkin, A. L., Frank, J. S., Carpenter, M. G., & Peysar, G. W. (2002). Fear of falling modifies anticipatory postural control. *Experimental brain research*, *143*(2), 160-170.

Arfken, C. L., Lach, H. W., Birge, S. J., & Miller, J. P. (1994). The prevalence and correlates of fear of falling in elderly persons living in the community. *American journal of public health*, *84*(4), 565-570.

Aromataris, E. & Munn, Z. (Editors). (2002). JBI Manual for Evidence Synthesis. JBI, 2020. Retrieved https://synthesismanual.jbi.global. https://doi.org/10.46658/JBIMES-20-01

Corregidor-Sánchez, A. I., Segura-Fragoso, A., Rodríguez-Hernández, M., Jiménez-Rojas, C., Polonio-López, B., & Criado-Álvarez, J. J. (2021). Effectiveness of virtual reality technology on functional mobility of older adults: systematic review and meta-analysis. *Age and Ageing, 50(2),* 370-379.

Craig, J., Murray, A., Mitchell, S., Clark, S., Saunders, L., & Burleigh, L. (2013). The high cost to health and social care of managing falls in older adults living in the community in Scotland. *Scottish medical journal*, *58*(4), 198-203.

Daga, F. B., Diniz-Filho, A., Boer, E. R., Gracitelli, C. P., Abe, R. Y., & Medeiros, F. A. (2017). Fear of falling and postural reactivity in patients with glaucoma. *PloS one*, *12*(12), e0187220.

Dennett, A. M., & Taylor, N. F. (2015). Machines that go “ping” may improve balance but may not improve mobility or reduce risk of falls: A systematic review. *Journal of rehabilitation medicine, 47*(1), 18-30.

Duque, G., Boersma, D., Loza-Diaz, G., Hassan, S., Suarez, H., Geisinger, D., ... & Demontiero, O. (2013). Effects of balance training using a virtual-reality system in older fallers. *Clinical interventions in aging*, *8*,(1) 257.

Ehgoetz Martens, K. A., Lefaivre, S. C., Beck, E. N., Chow, R., Pieruccini-Faria, F., Ellard, C. G., & Almeida, Q. J. (2017). Anxiety provokes balance deficits that are selectively dopa-responsive in Parkinson's disease. *Neuroscience*, *340*(1), 436-444.

Eloy, S., Ourique, L., Woessner, U., Kieferle, J., & Schotte, W. (2018, September). *How present am I: three virtual reality facilities testing the fear of falling*. In 36th eCAADe Conference, (717-726). Lodz, Poland.

Forkan, R., Pumper, B., Smyth, N., Wirkkala, H., Ciol, M. A., & Shumway-Cook, A. (2006). Exercise adherence following physical therapy intervention in older adults with impaired balance. *Physical therapy*, *86*(3), 401-410.

Freeman, D., Haselton, P., Freeman, J., Spanlang, B., Kishore, S., Albery, E., … Nickless, A. (2018). Automated psychological therapy using immersive virtual reality for treatment of fear of heights: A single-blind, parallel-group, randomised controlled trial. *Lancet Psychiatry, 5(8)*, 625-632.

Fromberger, P., Jordan, K., & Müller, J. L. (2018). Virtual reality applications for diagnosis, risk assessment and therapy of child abusers. *Behavioral Sciences & the Law, 36*(2), 235-244.

Fuller, G. F. (2000). Falls in the elderly. *American family physician*, *61*(7), 2159.

Giotakos, O., Tsirgogianni, K., & Tarnanas, I. (2007, September). *A virtual reality exposure therapy (VRET) scenario for the reduction of fear of falling and balance rehabilitation training of elder adults with hip fracture history*. In 2007 Virtual Rehabilitation (155-158). IEEE.

Griffin, H. J., Greenlaw, R., Limousin, P., Bhatia, K., Quinn, N. P., & Jahanshahi, M. (2011). The effect of real and virtual visual cues on walking in Parkinson's disease. *Journal of neurology*, *258*(6), 991-1000.

Gui, C. (2021). *Quantifying Fear of Falling by Utilizing Objective Body Sway and Muscle Contraction Measures.* [Master's thesis]. University of Nebraska.

Haddad, Y. K., Bergen, G., & Florence, C. (2019). Estimating the economic burden related to older adult falls by state. *Journal of public health management and practice: JPHMP*, *25*(2), E17.

Joana Briggs Institute. (2017). The Joanna Briggs Institute Critical Appraisal Tools for Use in JBI Systematic Reviews-Checklist for Quasi-Experimenal Studies (Non-Randomised Experimental Studies). Retrieved http://joannabriggs.org/assets/docs/critical-appraisal-tools/JBI_Quasi-Experimental_Appraisal_

Jorgensen, M. G., Laessoe, U., Hendriksen, C., Nielsen, O. B. F., & Aagaard, P. (2013). Efficacy of Nintendo Wii training on mechanical leg muscle function and postural balance in community-dwelling older adults: a randomized controlled trial. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, *68*(7), 845-852.

Jung, D. (2008). Fear of falling in older adults: comprehensive review. *Asian nursing research, 2*(4), 214-222.

Jung, D., Lee, J., & Lee, S. M. (2009). A meta-analysis of fear of falling treatment programs for the elderly. *Western journal of nursing research*, *31*(1), 6-16.

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Keele and Durham University.

Kruisbrink, M., Delbaere, K., Kempen, G. I., Crutzen, R., Ambergen, T., Cheung, K. L., ... & Zijlstra, G. A. (2020). Intervention characteristics associated with a reduction in fear of falling among community-dwelling older people: a systematic review and meta-analysis of randomized controlled trials. *The Gerontologist*, doi: 10.1093/geront/gnaa021.

Kwok, B. C., & Pua, Y. H. (2016). Effects of WiiActive exercises on fear of falling and functional outcomes in community-dwelling older adults: a randomised control trial. *Age and ageing*, *45*(5), 621-627.

Levy, F., Leboucher, P., Rautureau, G., Komano, O., Millet, B., & Jouvent, R. (2016). Fear of falling: efficacy of virtual reality associated with serious games in elderly people. *Neuropsychiatric disease and treatment*, *12*(1), 877-881.

Lin, C. X., Lee, C., Lally, D., & Coughlin, J. F. (2018). *Impact of virtual reality (VR) experience on older adults' well-being.* In International Conference on Human Aspects of IT for the Aged Population. Springer.

Liu, T. W., & Ng, S. S. (2019). The reliability and validity of the Survey of Activities and Fear of Falling in the Elderly for assessing fear and activity avoidance among stroke survivors. *PloS one*, 14(4), e0214796.

Mascret, N., Delbes, L., Voron, A., Temprado, J. J., & Montagne, G. (2020). Acceptance of a virtual reality headset designed for fall prevention in older adults: questionnaire study. *Journal of medical internet research*, *22*(12), e20691.

McGinley, P., Ansari, E., Sandhu, H., & Dixon, T. (2020). The cost burden of falls in people with glaucoma in National Health Service Hospital Trusts in the UK. *Journal of medical economics*, *23*(1), 106-112.

Moore, D. S., & Ellis, R. (2008). Measurement of fall-related psychological constructs among independent-living older adults: a review of the research literature. *Aging and mental health*, *12*(6), 684-699.

National Institute for Health and Care Excellence. (2013). Falls in older people: Assessing risk and prevention. Retrieved www.nice.org.uk/guidance/cg161

National Institute for Health and Care Excellence. (2018). NICE impact falls and fragility fractures. Retrieved https://www.bgs.org.uk/sites/default/files/content/resources/files/2018-08-29/NICE-Impact-falls-and-fragility-fractures.pdf

Nazari, M. A., Nabizadeh, C. G., Vahedi, S., & ROSTAMI, M. (2012). Validity and reliability of self-assessment manikin. *Research in Psychological Health, 6*(1), 52-61.

Neri, S. G., Cardoso, J. R., Cruz, L., Lima, R. M., De Oliveira, R. J., Iversen, M. D., & Carregaro, R. L. (2017). Do virtual reality games improve mobility skills and balance measurements in community-dwelling older adults? Systematic review and meta-analysis. *Clinical Rehabilitation*, *31*(10), 1292-1304.

Nutt, J. G., Bloem, B. R., Giladi, N., Hallett, M., Horak, F. B., & Nieuwboer, A. (2011). Freezing of gait: moving forward on a mysterious clinical phenomenon. *The Lancet Neurology*, *10*(8), 734-744.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffman, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hrobjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P. & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 2021; 372:n71

Perez-Jara, J., Walker, D., Heslop, P., & Robinson, S. (2010). Measuring fear of falling and its effect on quality of life and activity. *Reviews in Clinical Gerontology, 20*(4), 277.

Phu, S., Vogrin, S., Al Saedi, A., & Duque, G. (2019). Balance training using virtual reality improves balance and physical performance in older adults at high risk of falls. *Clinical interventions in aging*, *14*(1), 1567.

Pietrzak, E., Cotea, C., & Pullman, S. (2014). Using commercial video games for falls prevention in older adults: the way for the future?. *Journal of geriatric physical therapy*, *37*(4), 166-177.

Plechatá, A., Sahula, V., Fayette, D., & Fajnerová, I. (2019). Age-related differences with immersive and non-immersive virtual reality in memory assessment. *Frontiers in psychology*, *10*, 1330, doi: 10.3389/fpsyg.2019.01330.

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., ... & Duffy, S. (2006). *Guidance on the conduct of narrative synthesis in systematic reviews.* In *ESRC methods programme* (1-92). Lancaster, UK.

Powell, L. E., & Myers, A. M. (1995). The activities-specific balance confidence (ABC) scale. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *50*(1), 28-34.

Public Health England. (2017). Falls and fracture consensus statement- Supporting commissioning for prevention. Retrieved https://www.england.nhs.uk/south/wp-content/uploads/sites/6/2017/03/falls-fracture.pdf

Rand, D., Miller, W. C., Yiu, J., & Eng, J. J. (2011). Interventions for addressing low balance confidence in older adults: a systematic review and meta-analysis. *Age and ageing*, *40*(3), 297-306.

Rhodes, R. E., Martin, A. D., Taunton, J. E., Rhodes, E. C., Donnelly, M., & Elliot, J. (1999). Factors associated with exercise adherence among older adults. *Sports medicine*, *28*(6), 397-411.

Rodrigues, E. V., Gallo, L. H., Guimarães, A. T. B., Melo Filho, J., Luna, B. C., & Gomes, A. R. S. (2018). Effects of dance exergaming on depressive symptoms, fear of falling, and musculoskeletal function in fallers and non-fallers community-dwelling older women. *Rejuvenation research*, *21*(6), 518-526.

Scheffer, A. C., Schuurmans, M. J., VanDijk, N., Van Der Hooft, T., & De Rooij, S. E. (2010). Reliability and validity of the visual analogue scale for fear of falling in older persons. *Journal of the American Geriatrics Society*, *58*(11), 2228-2230.

Seamon, B., DeFranco, M., & Thigpen, M. (2017). Use of the Xbox Kinect virtual gaming system to improve gait, postural control and cognitive awareness in an individual with Progressive Supranuclear Palsy. *Disability and rehabilitation, 39*(7), 721-726.

Shah, G., Oates, A. R., Arora, T., Lanovaz, J. L., & Musselman, K. E. (2017). Measuring balance confidence after spinal cord injury: the reliability and validity of the Activities-specific Balance Confidence Scale. *The journal of spinal cord medicine, 40*(6), 768-776.

Singh, D. K., Rajaratnam, B. S., Palaniswamy, V., Pearson, H., Raman, V. P., & Bong, P. S. (2012). Participating in a virtual reality balance exercise program can reduce risk and fear of falls. *Maturitas, 73*(3), 239-243.

Sullivan, G. M., & Feinn, R. (2012). Using effect size—or why the P value is not enough. *Journal of graduate medical education*, *4*(3), 279-282.

Tinetti, M. E., & Powell, L. (1993). Fear of falling and low self-efficacy: A cause of dependence in elderly persons. *Journal of Gerontology, 48*(1), 35–38.

Valenzuela, T., Okubo, Y., Woodbury, A., Lord, S. R., & Delbaere, K. (2018). Adherence to technology-based exercise programs in older adults: a systematic review. *Journal of Geriatric Physical Therapy*, *41*(1), 49-61.

Velozo, C. A., & Peterson, E. W. (2001). Developing meaningful fear of falling measures for community dwelling elderly. *American journal of physical medicine & rehabilitation*, *80*(9), 662-673.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly, 1*(1), 13-23.

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research, 39*(1), 93-112.

Yardley, L., Beyer, N., Hauer, K., Kempen, G., Piot-Ziegler, C., & Todd, C. (2005). Development and initial validation of the Falls Efficacy Scale-International (FES-I). *Age and ageing, 34*(6), 614-619.

CHAPTER 2: Major Research Project

Augmenting psychological treatment for fear of falling using Virtual Reality: A feasibility study in older adults

Luke Barracliffe[1*]

[1]Mental Health and Wellbeing, Institute of Health and Wellbeing, University of Glasgow

***Address for Correspondence:**
University of Glasgow
Mental Health and Wellbeing
Gartnavel Royal Hospital
1st Floor, Administration Building
1055 Great Western Road
Glasgow
G12 0XH
l.barracliffe.1@research.gla.ac.uk

Submitted in part fulfilment of the requirements for the Degree of Doctorate in Clinical Psychology (D.Clin.Psy)

Word Count: 9366 (Including references, excluding plain language summary)

Plain English Summary

Title

Augmenting psychological treatment for fear of falling using Virtual Reality: A feasibility study in older adults

Background

Falls in older adults are expensive to the NHS and reduce quality of life. A third of older adults (≥65 years) fall annually, increasing with age. Fear of falling (FoF) is a reduced confidence in balancing abilities, usually associated with reduced daily activities and exercise. This can develop whether people have had past falls or not and can increase falling risk through impaired balance abilities. This heightened anxiety negatively affects attention relating to movement. Given the role of these psychological processes, Virtual reality (VR) exposure treatments can potentially improve FoF and reduce clinician labour. Moreover, few VR treatments have been designed co-productively.

Aims

To evaluate older people's perceived acceptability, tolerability and feasibility of a VR FoF exposure intervention. To determine if these patients are willing to participate in actual VR.

Methods

Older people with current or previous FoF from NHS Glasgow Psychology services received visual and written information on a VR intervention, involving

exposure to feared scenarios. This was designed alongside Clinical Psychology experts, service-users and Computer science colleagues. Participants engaged in semi-structured telephone interviews, providing feedback, including perceived tolerability, feasibility and acceptability. These were analysed via qualitative thematic analysis. They also completed mental health measures on anxiety, mood and FoF.

Main findings & Conclusions

Ten sub-themes were found within four overarching themes. Additional comments emphasised fall experiences, physical health, motivation and effects of COVID-19 on exercise. Results suggested older people are mainly positive and willing to engage in VR for FoF. Most could envisage it in usual treatment. Implications for intervention development included increased reassurance from clinicians, clear explanation of technology, more VR tasks outside the home and adaptations for health conditions. Recruiting participants via clinicians was effective. Future research should improve VR content and test in-vivo with larger samples; effort should be made to include more diversity, including males, non-white ethnicities and lower socioeconomic backgrounds, to better reflect older people's views.

Abstract

Background:

Falls in older adults are expensive to the NHS and reduce quality of life for victims. Fear of falling (FoF) also increases the risk of falls. Virtual reality (VR) supported exposure treatments could potentially save labour and costs and can improve FoF, though few VR treatments have been co-productively designed.

Aims:

To evaluate perceived acceptability, tolerability and feasibility of a co-productively designed VR FoF exposure intervention in older adults. To also determine if patients are willing to participate in this intervention.

Methods:

Older people (≥65 years) with existing or previous FoF were recruited from NHS Psychology services. They received information on the intervention, involving exposure to feared scenarios. Participants engaged in semi-structured telephone interviews, providing feedback, including on perceived tolerability and acceptability. Measures of anxiety and low mood were also gathered. Interviews were analysed qualitatively via Braun & Clarke's (2006) thematic analysis.

Results:

There were 10 sub-themes within overarching themes. Additional comments emphasised fall experiences, physical health, motivation and effects of COVID-19 on exercise. Most reported high anxiety and FoF.

Conclusion:

Results suggested older people are mainly positive and willing to engage in VR for FoF. Most could envisage it as usual treatment. Implications include increased reassurance being required from clinicians and clear explanations of technology, more VR tasks outside the home and adaptations for health conditions.

Keywords: Virtual Reality; Fear; Falling; Psychology; Anxiety.

1. Introduction & Theory

1.1 Background

Approximately one third of over 65-year-olds fall annually (National Institute for Health and Care Excellence [NICE], 2013), with half of those 80 years or older at risk of falling (NICE, 2013). Falls can result in serious injuries, particularly fractures. They cost the NHS up to billions of pounds yearly for outpatients and inpatients, including in Scotland (Craig et al., 2013; McGinley et al., 2020; Public Health England [PHE], 2017; NICE, 2018), with emergency hospital admissions costing £2-billion (NICE, 2018) and social care following fractures costing £1-billion (PHE, 2017). Falls related to specific conditions, including glaucoma, have additionally been identified as costing millions (McGinley et al., 2020). This is also the case internationally, with California's annual cost alone being over £3-billion (Haddad et al., 2019).

Despite this, most people following falls are not seen by healthcare services (Graham & Firth, 1992), with 80% of non-injurious falls unreported to healthcare staff (Age Concern, 1997). This is concerning considering past falls can predict future falls (NICE, 2013). Risk factors are intrinsic or environmental (Todd & Skelton, 2004). Unsuitable lighting, walking aids or floor surfaces extrinsically increase falling risk (Dean & Ross, 1993; Lord et al., 2000). Intrinsic physical and mental health factors include arthritis, depression and stroke (NICE, 2013); multimorbidity further heightens risk (NICE, 2018)

1.2 Fear of Falling

Falls reduce quality of life (QoL), with effects including activity avoidance, frailty and reduced socialising (PHE, 2017; Arfken et al., 1994). With an ageing population, falls prevention is increasingly important to reduce NHS costs and

enhance wellbeing (McLean et al., 2015). Fear of falling (FoF) equally impacts QoL, limiting living activities (Suzuki et al., 2002). FoF is reduced confidence in balance abilities, often associated with reduced daily activities and exercise (Maki et al.,1991; Martin et al., 2005). It can develop whether people have fallen previously or not (PHE, 2017), and can increase falling risk via impaired balance ability (Li et al., 2003).

Young and Williams (2015) described psychological mechanisms behind this, drawing from Attentional Control Theory (Eysenck et al., 2007). These include increased anxiety, negatively altering attentional movement-related processes. Hence, people become preoccupied with threatening stimuli, irrelevant to movement tasks. They become distracted by anxious thoughts about falling, leaving inadequate attentional resources remaining to safely guide movement. This anxiety also reduces ability to retain visuospatial information in working memory, for example, where obstacles are (Young & Williams, 2015). Moreover, people stiffen their body to avoid falling, compromising ability during postural tasks with high working memory demands, like navigating uneven pavements (Young & Williams, 2015).

1.3 Interventions: Virtual Reality

Given the role of psychological processes, Cognitive Behavioural Therapy (CBT) elements have been successfully used, improving FoF, depression and QoL, with reasonable effect sizes for reducing FoF versus controls (*Cohen's d = 0.4*) (Parry et al., 2016; Liu et al., 2018). There is necessity for efficient replicability, improved costs and labour in psychological interventions (Freeman et al., 2018), as also found in the systematic review in Chapter one. Evidence suggests that interventions reducing falls in older adults can be cost-effective when there are reductions in medical care costs (McLean et al., 2015). Virtual Reality (VR) is increasingly used in psychological exposure interventions, addressing this. VR is defined as an interactive computer simulation whereby

users' physical actions are sensed and fed back to their senses (e.g. visual or haptic), so they become immersed in virtual worlds (Mihelj et al., 2014). It often involves users wearing goggles or a helmet ('Head Mounted Device' [HMD]) through which they view this world, which tracks where they are looking. They also use hand-held controllers which tracks where their hands are, allowing them to interact with virtual objects. Its advantages include ecological realism, low physical risk, experiencing situations impossible in reality and low logistical efforts once set up (Fromberger et al., 2018). Additionally, there is a need for reduced labour and costs in these psychological interventions; semi-automated technology like VR can help this. For example, one clinician could provide therapy for multiple people engaging in automated VR technology, thereby saving labour costs (Freeman et al., 2018).

A meta-analysis found VR exposure therapy as effective at improving anxiety disorders as in-vivo therapy, with a large effect size ($g = 0.9$) (Carl et al., 2019). Studies have demonstrated benefit for anxiety disorders using automated VR-treatment, conducive to replicable low-labour therapy (Freeman et al., 2018). VR FoF exposure therapy interventions have had success in reducing anxiety, demonstrating older adults tolerate associated HMDs (Levy et al., 2016). VR interventions are particularly successful when including both exposure to challenge FoF beliefs and interaction in environments to internalise new beliefs (Levy et al., 2016).

1.4 Co-production

Co-production of mental health interventions has been used less than in physical health (Larkin et al., 2015). It is increasingly considered crucial in developing psychological VR interventions. A seminal paper described three stages for VR healthcare studies to follow for best 'end-user' outcomes (Birckhead et al., 2019) **(Table 1)**; end-users in this case are older people with FoF.

Table 1: VR healthcare research stages

Stage	Focus
VR1 ↓	Developing content to “promote empathy, team collaboration, and continuous user feedback”.
VR2 ↓	Exploring “early testing… feasibility, acceptability, tolerability, and initial clinical efficacy.”
VR3	Randomised controlled trials (RCTs).

(Birckhead et al., 2019).

‘Acceptability’ is patients’ willingness to use interventions, ‘Feasibility’ is the extent it can be effectively utilised in care and ‘Tolerability’ involves evaluating adverse effects, physical or emotional. Some CBT-based FoF treatments have co-designed interventions using patient interviews (Parry et al., 2016). However, few VR-based interventions have co-produced interventions, including RCT studies of FoF and phobias (Carl et al., 2019; Levy et al., 2016). Nonetheless, older people with FoF tolerate HMDs and experience improved anxiety (Levy et al., 2016).

This study combined Birckhead et al.’s (2019) VR1 and VR2 stages, remotely evaluating a FoF VR intervention, regarding participants’ perceived tolerability, feasibility and acceptability. Semi-structured interviews gathered rich qualitative data. A similar study assessed older people’s acceptance of a FoF VR exercise intervention via questionnaires (Mascret et al., 2020). However, this was less focused on psychological exposure and did not use interviews. This research step comes before participants test the intervention in-person, allowing further changes to be made to meet end-users’ needs. It was designed in line with the Medical Research Council’s (MRC) development process for complex interventions, helping develop interventions efficiently, minimising wasted efforts

(Craig et al., 2019). VR is not currently used to treat FoF in NHS settings, making this novel and beginning iterative processes of developing cost and labour-saving interventions in collaborative patient-centred ways.

1.5 Aims

To evaluate perceived acceptability, tolerability and feasibility of a VR intervention in older adults, designed to target psychological process related to FoF. Specifically:

- To determine perceived tolerability and acceptability of VR as a FoF treatment, gaining qualitative feedback
- To determine if FoF patients are willing to participate in a VR intervention

2. Methods

2.1 Participants

Older adults (≥65 years) who currently or have historically experienced FoF as diagnosed by Clinical Psychologists.

2.2 Inclusion Criteria

Currently or previously treated within NHSGGC older adult Psychology services and have/had FoF.

2.3 Exclusion Criteria

Never treated within older adult NHSGGC services or who have never had FoF. Any disorder undermining capacity to provide informed consent as determined by Clinical Psychologists.

2.4 Design

The design was qualitative, involving individual semi-structured telephone interviews about the intervention, analysed thematically. Participants did not engage in VR but received visual and written materials about it via post. Quantitative mental health measures were also collected and presented descriptively.

The recruiting Consultant Clinical Psychologist was consulted throughout intervention design. They proposed features based on clinical experience to be included, ensuring it was based on psychological theory. A FoF service-user of NHS Older Adult Psychology was also consulted on their experience and needs, prior to intervention design. Feedback was communicated to Computer Science colleagues at the University of Glasgow, who programmed the VR intervention, and elements were improved iteratively over multiple meetings. Ultimately there were two versions of the intervention, the second version being presented to participants. They were designed by Computer Science students, supervised by a Professor of Computer Science. The present primary researcher and their supervisor also contributed to intervention-development in these meetings. For instance, by shaping written instructions for participants around psychological exposure theory and proposing specific tasks and environments. The primary researcher also physically tried the full intervention to assess final quality and provide ongoing feedback to Computer Science colleagues. **(Appendix 2.3)**.

2.5 Sample Size Justification

There is no definite answer to the ideal number of participants in qualitative research, being dependent on many practical issues (Baker & Edwards, 2012). Research examining older people's perspectives on FoF via interviews varied greatly in sample size, from under 10 to nearly 100 (McMahon et al., 2011). Generally, those with smaller samples collected "richer" data. The National Institute for Health Research (NIHR, 2017) suggested sample calculations are unnecessary for most qualitative research but indicate samples must be adequate to reach theme "saturation" and represent the target population. A co-production study gaining qualitative feedback for a VR psychosis intervention used 20 participants, via convenience sampling (Realpe et al., 2019). Guidelines on "small" thematic analyses suggest under 10 participants is feasible (Braun & Clarke, 2013). Data from the NHSGGC older adult psychology service suggested 14 referrals were directly FoF-related over the past year (March 2019-20). This somewhat limited the sample pool; such practical issues also inevitably affect sample sizes (Baker & Edwards, 2012). In addition to the short time-period available and early stages of this research, convenience sampling was used aiming to recruit five participants. This was adequate to determine preliminary data on feasibility, acceptability and tolerability. It was also deemed adequate to elicit relevant themes, based on past guidance (Baker & Edwards, 2012). Recruiters tracked numbers of patients approached versus those who participated.

3. Procedure

3.1 Recruitment

Two Clinical Psychologists based in Glasgow's NHS Older Adult Psychology service, one of whom was a Consultant, identified patients meeting inclusion criteria from their past/ present caseloads. These recruiters then contacted potential participants, gaining consent for the primary researcher to send

Participant Information Sheets (PIS) and then call to gain informed consent to participate.

3.2 Research Procedure

Written and visual materials on the intervention were posted to participants and a telephone call was scheduled. This comprised individual semi-structured interviews gaining qualitative data on perceived acceptability, feasibility and tolerability. Interviews occurred around a week after participants received the materials, to give them time to peruse them.

The call included firstly gathering demographic information, then conducting three mental health measures and finally the semi-structured interview on their views of the FoF intervention. Once completed, data were analysed qualitatively as described below.

3.3 Measures

Three validated self-report mental health measures were conducted within the interview call, including: Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001); General Anxiety Disorder-7 (GAD-7) (Spitzer et al., 2006); Falls Self-Efficacy Scale (FES-I) (Tinetti et al., 1990) **(appendix 2.4)**. These were gathered to help characterise the sample's mental health. All are regularly used as outcome measures in Glasgow Older Adult Psychology services, as recruiting Clinical Psychologists advised.

PHQ-9

This short self-report questionnaire asses low mood, comprising nine questions scored on a four-point scale, including items on tiredness, concentration and hopelessness. Users answer based on symptoms over the past fortnight. It is

validated for screening depression in various populations, including older people (Gilbody et al., 2007). It is very reliable over the phone and in-person (intraclass correlation coefficient [ICC] = 0.9) (Pinto-Meza et al., 2005).

GAD-7

This brief self-report questionnaire assesses anxiety. It comprises seven items scored on a four-point scale, including worry, restlessness and irritability. Again, users answer based on symptoms over the past fortnight. It is reliable (ICC = 0.89) (Löwe et al., 2008) and validated, including for older people, with moderate to high sensitivity and specificity for anxiety disorders (Kroenke et al., 2007; Swinson, 2006).

FES-I

This self-report measure of FoF comprises 16 items, scored on a four-point scale. Users rate their falling concern in various situations, including stairs, dressing or navigating crowds. If they do not or cannot do the activity, they answer based on how they would feel if they did do it. In older people, it has good reliability (ICC = 0.96) (Yardley et al., 2005) and validity (Hauer et al., 2010).

3.4 Intervention Materials

Written and visual materials firstly described the aim of the intervention and then explain what VR is, including photos of equipment and how it is used. It outlined potential VR-induced symptoms and effects (VRISE), including motion-sickness. It then outlined the intervention, with images of menu screens **(Figure 1)**, environments and how users interact with these. The tasks are set in various environments, including a kitchen, bedroom, living room and garden **(Figure 2).**

The tasks are graded from easier to harder, based on behaviours those with FoF might commonly find challenging, including bending down and navigating cluttered or darker environments. Images of users engaging in these tasks are depicted. One example is walking across a garden path to reach the post-box. Another is walking across a living room, around furniture, to retrieve a television remote **(Figure 3)**. The virtual therapist or 'avatar' is also introduced, guiding users through the therapy with verbal prompts. Participants read about the anxiety Likert scales, completed before and after exposure to environments. This tracks users' self-reported FoF and thereby their recovery.

The 'tilt alarm' feature is also described, alerting users if they physically tilt too far forward whilst walking. This gives them opportunity to correct their posture and improve their balance. This was suggested by the consulting Clinical Psychologists to target this maladaptive FoF feature. Research also suggests that dynamic balance, during movement, may be related to FoF and falls (Maki, 1997). The alarm itself consisted of neutral beeping and users can turn off the feature by turning the volume down. (**Appendix 2.5**).

Figure 1: Example of main menu screen.

Figure 2: Example of garden task.

Figure 3: Example of living room task.

3.5 Semi-structured interview questions

Telephone interview questions were based on recommendations for exploring user-experience of VR via semi-structured interviews and on past research using these same methods (Birckhead et al., 2019; Jung et al., 2017). Interviews started with exploring participants' General impressions, moving onto questions covering: Acceptability (e.g. "Are the tasks relevant to you?", "Would you be willing to try this intervention?"), Feasibility (e.g. "Can you see this being part of regular treatment for FoF?") and Tolerability (e.g. "What is your view on the VR induced symptoms and effects?"). 'Acceptability' in this case is defined as the degree to which participants consider the intervention to be appropriate (Sekhon et al., 2017). 'Feasibility' is how relevant and sustainable it is, including how participants perceive it as 'treatment as usual' for FoF, given they have undergone regular psychological therapy for FoF. 'Tolerability' is whether participants believe they can comfortably tolerate or endure the intervention.

As participants did not receive the intervention, but read and viewed information on it, their responses were based on anticipated cognitive and emotional responses. There was no interview time-limit and participants had opportunity to ask questions or freely comment on the materials. **(Appendix 2.6)**.

3.6 Ethical Approval

Ethics were approved by NHS Greater Glasgow and Clyde board of Research and Innovation in February 2021 (reference number: GN20MH679; Integrated Research Application System reference number: 287360). **(Appendices 2.7-8)**.

3.7 Data Analysis

Mental health measures were reported descriptively, adhering to recommendations on reporting studies concerning feasibility (Arain et al., 2010). Semi-structured interviews were audio-recorded, transcribed and analysed qualitatively via Braun & Clarke's (2006) thematic analysis. This was chosen as it is a flexible analysis which can be used with many qualitative questions, without having to prescribe to theoretical assumptions (Braun & Clarke, 2006), making it suitable for this exploratory research. The six steps were followed by the primary researcher, including: 1. Familiarisation with data, 2. Coding, 3. Generating initial themes, 4. Reviewing themes, 5. Defining/ naming themes, 6. Writing up. A deductive-inductive procedure was used; both approaches can be part of thematic analysis (Braun & Clarke, 2006). This involved both top-down and data-driven coding, therefore combining deduction and induction. This 'reflexive' approach is encouraged by recent thematic analysis research (Braun & Clarke, 2019b). This hybrid approach has also been used successfully in similar qualitative studies (Barracliffe et al., 2018; Fereday & Muir-Cochrane, 2006).

The initial step involved deductively identifying topics of interest, based on existing knowledge. This was achieved by separating participants' interview answers by theme of the interview questions, such as issues of VR tolerability, including side-effects. As described, these questions were designed a priori based on previous research using similar methods and on recommendations for exploring VR user-experience via interviews (Birckhead et al., 2019; Jung et al., 2017). The next step was inductive, with further themes within these deductive categories emerging from the data, specifically, participants' interview answers.

At step four, themes were discussed with a second independent researcher (a Trainee Clinical Psychologist) to explore the data further (Moore et al., 2015) **(Appendix 2.9)**. As Braun and Clarke's (2006) approach advocates against use of inter-rater reliability measures for thematic analysis, this was conducted only to invigorate thinking and increase data-immersion (Braun & Clarke, 2019b). This works within their ethos that there is no single 'right way' to code data, positing that coding is an *"active and reflexive process that inevitably and inescapably bears the mark of the researcher"*; thus removing the need for independent multiple coders in thematic analysis (Braun & Clarke, 2019a).

4. Results

4.1 Recruitment & demographics

The recruiting Psychologists approached 11 eligible people to potentially participate. Nine of these 11 (82%) consented to be contacted by the primary researcher and two declined. Of those then contacted by the primary researcher, two more declined, one did not respond and one was unable to receive materials required for interview, though they consented to participate. Nonetheless, they provided demographic information and completed mental health measures.

A total of five participants completed both the mental health measures and interview. Overall, six out of 11 (55%) of those initially approached consented to engage.

Table 2 presents demographic characteristics. All six participants were retired females, with an average age of 74 years (SD = 5.2). Participant '5' is the person who was unable to complete the interview, as described previously. All were from similar ethnic backgrounds, white Scottish, and had 'low-skilled' type jobs pre-retirement. Most left school in their mid to late teens. Scottish Index of Multiple Deprivation (SIMD) data were collected from participants' current postcodes. This relative measure of deprivation across Scotland is based on employment, health, education and other factors. Four participants (67%) were in the least deprived decile and two (33%) lived in more deprived areas.

Table 2: Demographic characteristics

Participant	Age	Gender	Ethnic Identity	SIMD Category	Past Occupation	Education-level
1	65-70	Female	White Scottish	10% least deprived	Administrator	Secondary school- Until 16 years
2	75-80	Female	White	10% least deprived	Administrator. Driver	Higher education- College
3	75-80	Female	Scottish	10% most deprived	Administrator	Secondary school- Until 15 years
4	65-70	Female	Scottish	10% least deprived	Administrator. Shop assistant	Higher education- College
5	75-80	Female	Scottish	30% most deprived	Charity worker	Unsure
6	75-80	Female	Scottish-Jewish	10% least deprived	Salesperson	Secondary school- Until 15 years

Scottish Index of Multiple Deprivation (SIMD) percentages of most to least deprived areas for participants' current addresses.

4.2 Measures

Table 3 outlines mental health scores. All participants completed all questionnaires. Scores ranged from 'Normal' to 'Severe anxiety' on the GAD-7, with the average indicating 'Moderate anxiety' (M = 11, SD = 6.1, Range = 1–19). The commonest was 'Severe anxiety' (50%). Mood measure, PHQ-9, scores ranged from 'Normal' to 'Severe low mood' (M = 10, SD = 5.8, Range = 4-20), with the commonest scores indicating 'Mild' (33%) or 'Moderately-severe' (33%) low mood. One statement participants rate is "Thoughts that you would

be better off dead or of hurting yourself". No participants reported thoughts of this nature, nor plans or intent to act on them. FES-I scores for FoF were generally high; the average score specified 'High' falling concern (M = 38, SD = 7.3, Range = 23-45). Scores indicating 'High' falling concern were the commonest (83%).

Table 3: Mental health measures

Participant	GAD-7 Score /21	GAD-7 Interpretation	PHQ-9 Score /27	PHQ-9 Interpretation	FES-I Score /64	FES-I Interpretation
1	6	Moderate Anxiety	5	Mild Low Mood	41	High Falling Concern
2	9	Moderate Anxiety	5	Mild Low Mood	41	High Falling Concern
3	19	Severe Anxiety	20	Severe Low Mood	45	High Falling Concern
4	15	Severe Anxiety	12	Moderately-Severe Low Mood	36	High Falling Concern
5	15	Severe Anxiety	13	Moderately-severe Low Mood	43	High Falling Concern
6	1	Normal Anxiety	4	Normal Mood	23	Moderate Falling Concern
Mean	**11**	**Moderately-severe Anxiety**	**10**	**Normal**	**38**	**High Falling Concern**
Median	**12**	**Moderately-severe Anxiety**	**9**	**Normal**	**41**	**High Falling Concern**

Cut-off points:- GAD-7: 0-5= Normal anxiety, 6-10= Moderate, 11-15= Moderately-severe, 15-21= Severe. PHQ-9: 0-5= Normal mood, 6-10= Moderate, 11-15= Moderately-severe, 16-27= Severe. FES-I: 16-19= Low falling concern, 20-27= Moderate, 28-64= High.

4.3 Thematic Analysis

Semi-structured interviews, excluding time taken for mental health measures and demographics collection, ranged from 8 minutes (m) 4 seconds (s) to 20m 59s (M= 14m25s, Median= 15m52s, SD= 4m45s). As outlined, questions comprised four overarching themes in line with research aims, including: General impressions, Acceptability, Feasibility and Tolerability. Within participants' answers to these were 10 sub-themes **(Table 4)**, alongside example quotations. Some sub-themes appeared across multiple question themes.

Table 4: Themes and sub-themes

Question Theme	Sub-theme (no. participants expressing theme)	Example Quotations
General Impressions	**Certainty & safeness (5)**	"I know you'd be in a safe environment. That you wouldn't fall or be hurt. You'd put your trust in that therapy." (P2) "...it's all helpful and useful for someone who needs help." (P4)
	Technological understanding & experiences (4)	"...you might need to be a little aware of the technology and be alert and understanding about it." (P1) "We had been at my daughter's one evening and we try trying them (VR) out and we were on a rollercoaster." (P5)
	Physical ability & health (4)	"…my hands don't work very well. The Parkinson's takes over when I try to do things. Sometimes you can't do what you'd like to do because they're not steady enough." (P3)
	Engagement & trust (5)	"I know you'd be able to see from my expression and any noise I made that I wasn't happy." (P2)

	"It will take them time I think for people to get adjusted to it. But it may well help..." (P5)
Fall experiences **(4)**	"Sometimes if I try and look up from my feet, I fall backwards rather than forwards. I try to push myself up, as I can't pull myself up." (P3) "…recently in January with the ice. I've had a hard fall. It's just outside my backdoor steps. It was at 11pm at night. Husband was in his bed- I could have laid there all night." (P1)
Task relevance, choice & difficulty **(5)**	"To me they were common sense, everyday tasks that you would. See opening the cupboard, it's something you would do every day. And walking out your front door. Tasks they would all encounter" (P2) "Very much so. Particularly the walking and the avoiding obstacles on the ground… picking up a mobile phone." (P5) "I didn't think the obstacles were too difficult to do." (P5) "Yes I think so [that tasks are graded appropriately]. The walking and then with the obstacles later on." (P1)

Acceptability	**Task relevance, choice & difficulty** **(5)**	"Initially I thought it was a wonderful idea but now I think maybe people experiencing these different challenges would have been better having a set of stairs in the real world…" (P5) "How much it would help someone in the real world I don't know." (P5)
	Technological understanding & experiences **(4)**	"I'm not very steady at all when I do things like that…. If I'm using the controllers, I'd be saying to myself, I'm not holding onto something here" (P3) "I like my laptop, I'm into my… technology. And I've tried the virtual reality before" (P5)
	FoF improvement **(3)**	"Just to see the delight of having something that works" (P3) "Yes. Because it's only going to help me" (P2)
	Certainty & safeness **(5)**	"No, no I don't think so (no uncertainty about trying)" (P1) "I would try it" (P3)
	Physical ability & health **(4)**	"… (depends) whether you were physically or mentally mobile." (P1) "I can only do these things at a certain pace, for so long. And then I start to feel myself go off" (P3)

	Other health treatments **(2)**	"I'm doing hypnosis, so it's helping. I've got to do the hypnosis. I've got so many homeworks to do, I've got it from them and you and from my OT and from all these people. I say I don't have time" (P4)
Feasibility	**Fall experiences** **(4)**	"Yes I think it would (meet needs), but recently I've been getting better. I've improved a lot since I fell and fractured my shoulder. But I am very wary on ladders or stools." (P1)
	Task relevance, choice & difficulty **(5)**	"Yes, (could also include) stairs. If your balance isn't good and you're manoeuvring stairs, in and outside." (P1) " going down a hill…That's just my fear of hills. You're doing this for a wide range of people who've fallen- maybe not all of them have a fear of hills." (P2)
	VR as treatment as usual (TAU) **(5)**	"Yes I think it would be a good idea. It gives people a chance to do it virtually rather than from a physio point of view" (P1) "Yes I definitely think it should be introduced into the NHS to help people." (P2)
Tolerability	**Side-effects** **(5)**	"…when that headsets on, you're very unbalanced. I was when I put it on. Very unbalanced." (P5)

		"Yes I think it would (put me off). Because I've just got rid of vertigo." (P4) "Might make people feel too closed in when you have something on your head like that. So people sort of panic a bit. I think that can cause you to feel worse than what you would normally." (P3)
	Engagement & trust **(5)**	"I'd put my faith and trust in the clinician…" (P2)
	Task relevance, choice & difficulty **(5)**	"I think doing it from the easy part and working up to harder most difficult part- I think that would be good. By the time you got onto the difficult part you'd be more able." (P1)

With example quotations from participants (P).

Certainty & safeness

This theme covered certainty about the treatment, feeling assured and safe. It was frequently conveyed by all participants in short definite answers. For instance, having an impression of:

> *"Excellent. Very very good."* (P2)

Or regarding VR realism:

> *"Oh yes. They did (look realistic). Oh yes. They did."* (P5).

Other statements described usefulness of the treatment for tackling FoF and safety they felt with it being led by clinicians, reducing uncertainty:

> *"…you'd be in a safe environment"* (P2).

Technological understanding & experiences

This was defined as answers referring to past experiences with, or understanding of, technology and VR. One patient tried VR before and others referred to generational differences:

> *"…young people are used to putting these things (VR headsets) on, older people may be more suspicious."* (P5).

There was a sense that participants had to be more aware when interacting with technology. One participant used incorrect terms for instance, describing the HMD as a *"camera"* (P5). Another did not fully understand the tilt alarm concept after explanation, initially referring to personal alarm buttons:

> *"I've got an alarm on my wrist. When you press the button and the person comes out. I find it useful."* (P4)

Physical ability & health

This covered references to physical health, often injuries or conditions, and ability to physically engage. Notably, some were in wheelchairs or fatigued just talking during interviews. One reported Parkinson's Disease being an issue if using VR controllers. Another asked:

> *"Do you have an option to sit down?"* (P2)

This was apparently relating to physical ability and FoF. This sub-theme reflects most older people having health conditions and multimorbidity, which increases falling risk (NICE, 2018).

Engagement & trust

This encompassed participants' willingness to engage, which was related to their trust in the treatment. This differed from 'Certainty & safeness' as these statements were less certain and assured- often tentative expressions around engagement. Some believed it would take time to engage and acclimatise. Others mentioned having no choice but to trust clinicians. Participants often mentioned inherent disposition and motivation of end-users as being an engagement factor:

> *"Depends on the person. Some people are positive and some are negative..."* (P3).

Fall experiences

This theme comprised explicit experiences of past falls, sometimes related to subsequent FoF; experiences were described in detail when raised. This included one participant reporting two frightening fall events, including on ice and when putting the rubbish out. Another mentioned multiple falls as a younger adult. Resulting injuries were also discussed:

"When I fractured my shoulder, it was in the kitchen. I tripped over my dog." (P1).

Task relevance, choice & difficulty

This covered relevance of VR treatment to everyday life, including visual realism and the nature of completing tasks, including choice and difficulty. All participants related well to visual aspects, finding rooms and tasks relevant and recognisable. They reported variety and sense of choice. Tasks were also similar to their own daily chores, described as:

"common sense, everyday tasks… they would all encounter" (P5).

One participant noted that tasks were not too challenging, whilst another found the cluttered garden unnerving. It was also pertinently stated that there were no tasks in public:

"…people go to shopping malls and what have they got from one level to the next (on) an escalator" (P5).

Others also explained that hills and steps would be useful additions, as FoF triggers. Overall, participants understood psychological exposure theory behind the tasks:

"By the time you got onto the difficult part you'd be more able" (P1).

FoF improvement

This theme comprised answers discussing FoF improvement, relating to potential treatment effects. Most were positive about the treatment reducing FoF, feeling it would be good to at least try. One person pragmatically stated:

"I would have had to have tried it to really be able to say, yes this going to work for me. Everybody's different." (P5).

Some mentioned they wished it were available when they had their psychological treatment. The underlying view was that something is better than nothing:

"it's only going to help me" (P2)

Some were even more positive in their language:

"…delight of having something that works" (P3).

Other health treatments

A minority mentioned other FoF treatments, but were clear in their comparison to VR treatment. Hypnosis and Occupational Therapy for FoF was discussed by one. She framed these as barriers for engaging, due to time constraints:

"I've got so many homeworks to do" (P4).

Another participant outlined VR as an alternative to physical exercises for FoF. Past psychological support was expressed as useful, though most still valued VR treatment as an approach which could further help them.

VR as treatment as usual (TAU)

This covered statements about VR FoF treatment being TAU, including in the NHS. All participants thought it would work well as TAU, at the least feeling that:

"I don't think it would be any harm to people who need it really." (P4).

One person expressed:

"I definitely think it should be introduced into the NHS" (P2).

It was clear that many felt they would like to try it to reduce FoF, which had persisted for some despite treatment:

"I ended up going to the Psychologist. In a way it's still with me, the fears are still there. But I'm careful." (P5).

Side-effects

'Side-effects' comprised concerns around physical and mental VR-induced side-effects. One mentioned existing vertigo as an engagement barrier, fearing it would worsen. Another who had tried VR reported she felt *"very unbalanced"* (P5), whilst another who had not tried it speculated people may feel *"closed in"* (P3). It did not entirely deter participants, as they were comforted by the temporary nature of them:

"any dizziness you felt would pass" (P2)

Overall, most expressed interest despite knowledge of side-effects.

Other comments

Participants were given opportunity to make further comments without question prompts, unlike previous sub-themes. Three of the five participants did so. One participant explained:

"I do have underlying medical things going on. I don't know if some of my thoughts and feelings are connected (to the VR treatment) because of this." (P2).

This implies that her medical issues are related to her perception of the treatment. This also mirrors sub-theme “Physical ability & health”, in which participants discuss how physical issues might inhibit their VR participation.

Another participant emphasised:

> *“There’s always been falling in my life.”* (P5)

She disclosed:

> *“…my first fall downstairs when I was 16 years of age”* (P5).

> *“When I was pregnant with my first child, I fell down the stairs”* (P5).

This suggests her FoF may have developed pre-old age. She further discussed suggested inclusion of escalators, as outlined in “Task relevance, choice & difficulty”. She had fears of these, favouring lifts instead.

One participant described effects of COVID-19 on her physical activity and motivation:

> *“Before Covid- I attended an aqua Zumba class. Also I did an aerobic class... I did all these things despite my age. I was active…it’s important that people want to have the confidence to improve… rather than give up.”* (P1).

This related to the physical motivation to engage in a novel VR intervention. She added:

> *“I’ve had breast cancer this past year as well- I had two operations and had Covid for 12 days. And I had the radiotherapy. But I’m bouncing back to my normal self. I’m confident I’ll get back to normal once my classes start again”.* (P1).

Her drive to overcome health barriers, and the benefit of physical group interventions, was reflected by this. This personal motivation is important for

success in VR interventions according to participants, as noted in ‘Engagement & trust’ sub-theme:

> *“Depends on the person. Some people are positive and some are negative about things.”* (P3).

5. Discussion

5.1 Main findings

This study evaluated perceived acceptability, tolerability and feasibility of a VR intervention targeting FoF in older people. It combined Birckhead et al.’s (2019) stages of co-productive VR design, allowing changes to be made based on the present feedback, meeting end-users’ needs.

Within overarching question themes, there were 10 sub-themes including: ‘Certainty & safeness’, ‘Technological understanding & experiences’, ‘Physical ability & health’, ‘Engagement & trust’, ‘Fall experiences’, ‘Task relevance, choice & difficulty’, ‘FoF improvement’, ‘Other health treatments’, ‘VR as TAU’ and ‘Side-effects’. Other comments emphasised physical health, early-life fall experiences, motivation and effects of COVID-19 on exercise groups and mobility.

Whilst these sub-themes were identified, answers often spanned multiple sub-themes, linked by overarching question themes. This demonstrates that aspects of acceptability, feasibility and tolerability overlap, implying that similar issues are important to older adults across domains in their views of the treatment.

Previous research supports sub-themes relating to VR ‘usability’, including ‘Technological understanding & experiences’, ‘Task relevance, choice & difficulty’ and ‘VR as TAU’. One study suggested mastering hand controllers is key for ‘useable’ and autonomous VR in older people (Baker et al., 2020). One participant noted concern regarding this due to Parkinson’s Disease; alternatives have been suggested, including haptic gloves (Baker et al., 2020). Parkinson’s sufferers also experience worse FoF than controls (Nilsson et al., 2012); more disabling Parkinson’s symptoms, including shuffling, additionally correlate with worse FoF (Rahman et al., 2011).

Understanding and acclimatising to technology was important to participants, as in sub-theme ‘Technological understanding & experiences’, with only one participant using VR before. Another misunderstood the tilt alarm, referring to personal alarm buttons. Given past research suggests older adults are accepting of HMDs (Lin et al., 2018), these findings suggest they are not averse to participating, but need concerns assuaged, requiring detailed explanations. Therefore, clinicians directing VR treatments must thoroughly explain technological aspects to address this need.

Most were willing to engage and felt others would be also. This was apparent in ‘Certainty and safeness’ and ‘FoF improvement’ sub-themes. They felt that tasks in their realism, relevance to everyday life and choice, were appropriate-with suggestions for adaptations. These included options to sit down and public tasks, including escalators. Although outdoor tasks were included, the lack of public settings might reflect the psychology researchers’ assumptions that FoF patients do not frequently leave home. This is not true for all older people, with choices to go shopping for example shaped by factors in addition to FoF. These include weather, travel costs and health conditions (Bezirgani & Lachapelle, 2021). One participant noted falls in earlier life as a factor developing FoF. This was notable, as although past falls can predict future falls, these are usually older-age falls (NICE, 2013).

Barriers to perceived engagement included VR side-effects, other health treatments, time constraints and physical health. Although visual acuity issues were unreported, this is common in older people and could interfere with engagement; it has been suggested that participants are asked about this, ensuring they are suitable for VR (Brown, 2019). However, visual issues themselves, including glaucoma, contribute to both falls and FoF (Daga et al., 2017; McGinley et al., 2020); meaning VR exposure would not necessarily aid FoF in these cases anyway. Nevertheless, most expressed willingness to try, with hopes of improving FoF and were happy to trust clinicians. This is bolstered by other research on older people, who enjoyed and accepted VR (Brown, 2019; Lin et al., 2018; Mascret et al., 2020). Although analysis suggests participants viewed the intervention generally positively, they did not engage in VR. Therefore, feedback was somewhat speculative, especially as few had tried VR before; nonetheless, it is important for determining initial engagement. Previous research has also successfully used this approach, remotely assessing participants' initial acceptance of falls VR exercise interventions. They found older people with less fall-related confidence perceived VR HMDs as more useful, albeit it was questionnaire-based without interviews (Mascret et al., 2020). However, it seems that positive attitudes, apparent in the present data, strengthen associations between intention and behaviour regarding technological engagement (Bhattacherjee & Sandford, 2009). This suggests many of this sample would likely participate in VR treatment if offered.

Participants reported moderately-severe anxiety and high falling concern on average, which makes sense given everyone experienced FoF. Anxiety was captured in sub-themes, but always linked to FoF or physical abilities. Half scored moderately-severe to severe low mood, with the remaining scoring normal to mild; though they reported normal mood on average. This supports previous research which suggests anxiety and depression are often present in, and associated with, FoF in older adults (Gagnon, 2005). Moreover, treating low mood and general anxiety may be crucial to also reducing their FoF (Gagnon,

2005). These scores emphasise need for support from clinicians for overall mental health, not just FoF, if this treatment comprised TAU.

Most participants fell into the least deprived SIMD decile and previously held ‘low-skilled’ jobs. There have been suggestions that poorer neighbourhood conditions might be linked to FoF, as falls on streets are likelier to result in injury, including dilapidated pavements (Curl et al., 2020; Li et al.,2014). Discomfort with neighbourhood environment is associated with higher FoF (Lee et al., 2018). Relatedly, fears of slopes outside their home were mentioned by one participant. However, FoF was also reported by some in usually well-kept areas like shopping centres. As there were participants in greater and lesser deprived SIMD deciles, the views on VR cover multiple socioeconomic perspectives. All participants were women, which reflects that being female is associated with higher FoF than being male (Lee et al., 2018); they are therefore likelier to be referred to mental health services for this.

The context of COVID-19 impacted some participants’ physical functioning and enjoyable activities. One mentioned cessation of aerobic classes which she reported helped her confidence and motivation. Previous research supports this, finding that older people in lockdown experienced decreased exercise (Morley, 2020). Moreover, COVID-19 or similar illnesses, which some reported, can lead to increased bedrest and muscle tone loss- which increases falls risk (Morley, 2020). This contributes to the sense of hesitation in sub-themes concerning participants’ ability to physically engage in VR, without becoming fatigued. Such concerns were commoner as barriers than the prospect of facing their fears in VR. Likewise, trusting clinicians when trying the treatment, was more important than understanding the graded exposure approach itself.

5.2 Limitations & future research

This study helped elucidate older people's views on acceptability, tolerability and feasibility of a FoF VR intervention. It co-productively involved end-users, allowing adaptations in content and application to be made to meet their needs. Collaboration between Psychology researchers and Computer Science colleagues to develop this is a strength. Interdisciplinary working is key for developing efficacious VR treatments, particularly when introducing technology to older generations, which must be done with clarity and patience, as findings suggest. The modest sample size suited this exploratory study, however larger studies involving more diverse perspectives is required- including men, non-white ethnicities and lower socioeconomic statuses, particularly as technology is less affordable to them, limiting their existing experience. Aside from the data suggesting willingness to participate, the ratio of participants approached versus those who participated gives initial indication of this too. Recruitment involved those who had already engaged with Psychology services, which may have introduced potential bias, given they may report higher willingness to engage than other older people would. Larger samples, including those who have not had previous FoF therapy, would further clarify engagement. Participants also did not receive the intervention; interviews were based on anticipated responses to VR- although this approach has been used successfully in past research. Since findings suggests older people are open to participating in this treatment, next steps would be to assess the elements of acceptability, tolerability and feasibility in-vivo, using VR HMDs.

Before assessing these elements in VR intervention development (Birckhead et al., 2019), participants' concerns must first be addressed. These include increased reassurance, technological explanations and adaptations for fatigue or health conditions and safe clinician relationships. Tasks were well received and relevant to participants, although a need for tasks in public was emphasised. Findings also inform future recruitment strategies. Recruiting using clinicians participants were treated by was successful and introductory written materials helped reassure and inform people further, before engaging in VR.

6. Conclusion

Results suggest older people are generally positive and willing to engage in VR for FoF, driven by desire to overcome past fall experiences. Most envisaged it as TAU. Despite this, adaptations to VR tasks should be made, suiting participants' needs. Care must be taken when introducing technology to older generations, accounting for higher rates of physical comorbidities, which can leave them fatigued. Alternatives to controllers might be considered for conditions like Parkinson's, including haptic gloves. Participants valued task choices and the graded exposure concept. After psychological treatment, many scored high for FoF, depression and anxiety, demonstrating the need for novel solutions. It also highlights requirement for multiple or longer FoF scales for measuring nuanced treatment responses, like the Activities-specific Balance Confidence Scale (Powell & Myers, 1995), which are sometimes avoided due to time limitations (Perez-Jara et al., 2010). Acceptability has been demonstrated in this modest sample; participants were willing to trust clinicians and tolerate potential side-effects. As older people also experience comorbidities, fitting this novel treatment around existing health treatments is researchers' responsibility and the next step in feasibility.

7. References

Age Concern. (1997). *Looking for a fall. A report on falls incidence in the UK*. London: Age Concern.

Arain, M., Campbell, M. J., Cooper, C. L., & Lancaster, G. A. (2010). What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Medical Research Methodology, 10*(1), 1-7.

Arfken, C. L., Lach, H. W., Birge, S. J., & Miller, J. P. (1994). The prevalence and correlates of fear of falling in elderly persons living in the community. *American Journal of Public Health*, *84*(4), *565*–570.

Baker, S., Waycott, J., Robertson, E., Carrasco, R., Neves, B. B., Hampson, R., & Vetere, F. (2020). Evaluating the use of interactive virtual reality technology with older adults living in residential aged care. *Information Processing & Management, 57*(3), 102-105.

Baker., S., & Edwards, R. (2012). How many qualitative interviews is enough?: Expert voices and early career reflections on sampling and cases in qualitative research.
Retrieved http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf

Barracliffe, L., Yang, Y., Cameron, J., Bedi, C., & Humphris, G. (2018). Does emotional talk vary with fears of cancer recurrence trajectory? A content analysis of interactions between women with breast cancer and their therapeutic radiographers. *Journal of psychosomatic research, 106*, 41-48, doi: 10.1016/j.jpsychores.2018.01.004.

Bezirgani, A., & Lachapelle, U. (2021). Qualitative Study on Factors Influencing Aging Population's Online Grocery Shopping and Mode Choice When Grocery Shopping in Person. *Transportation Research Record*, *2675*(1), 79-92.

Bhattacherjee, A., & Sanford, C. (2009). The intention–behaviour gap in technology usage: The moderating role of attitude strength. *Behaviour & information technology*, *28*(4), 389-401.

Birckhead, B., Khalil, C., Liu, X., Conovitz, S., Rizzo, A., Danovitch, I., … Spiegel, B. (2019). Recommendations for Methodology of Virtual Reality Clinical Trials in Health Care by an International Working Group: Iterative Study. *Journal of Medical Internet Research Mental Health, 6*(1), doi: 10.2196/11973.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners.* London: Sage.

Braun, V., & Clarke, V. (2019a). Answers to frequently asked questions about thematic analysis. Thematic Analysis–A Reflexive Approach. Retrieved https://cdn.auckland.ac.nz/assets/psych/about/our-research/documents/Answers%20to%20frequently%20asked%20questions%20about%20thematic%20analysis%20April%202019.pdf

Braun, V., & Clarke, V. (2019b). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health, 11*(4), 589-597.

Brown, J. A. (2019). An exploration of virtual reality use and application among older adult populations. *Gerontology and Geriatric Medicine, 5*, doi: 10.1177/2333721419885287.

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., … Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders, 61*(1), 27-36.

Craig, J., Murray, A., Mitchell, S., Clark, S., Saunders, L., & Burleigh, L. (2013). The high cost to health and social care of managing falls in older adults

living in the community in Scotland. *Scottish medical journal*, *58*(4), 198-203.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Pettigrew, M. (2019). *Developing and evaluating complex interventions.* Swindon, UK: Medical Research Council.

Curl, A., Fitt, H., & Tomintz, M. (2020). Experiences of the built environment, falls and fear of falling outdoors among older adults: An exploratory study and future directions. *International journal of environmental research and public health*, *17*(4), 1224.

Dean, E., & Ross, J. (1993). Relationships among cane fitting, function, and falls. *Physical therapy, 73*(8), 494-504.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International journal of qualitative methods*, *5*(1), 80-92.

Freeman, D., Haselton, P., Freeman, J., Spanlang, B., Kishore, S., Albery, E., … Nickless, A. (2018). Automated psychological therapy using immersive virtual reality for treatment of fear of heights: A single-blind, parallel-group, randomised controlled trial. *Lancet Psychiatry, 5(8)*, 625-632.

Fromberger, P., Jordan, K., & Müller, J. L. (2018). Virtual reality applications for diagnosis, risk assessment and therapy of child abusers. *Behavioral Sciences & the Law, 36*(2), 235-244.

Gagnon, N., Flint, A. J., Naglie, G., & Devins, G. M. (2005). Affective correlates of fear of falling in elderly persons. *The American journal of geriatric psychiatry*, *13*(1), 7-14.

Gilbody, S., Richards, D., Brealey, S., & Hewitt, C. (2007). Screening for depression in medical settings with the Patient Health Questionnaire (PHQ): A diagnostic meta-analysis. *Journal of general internal medicine*, *22*(11), 1596-1602.

Graham, H. J., & Firth, J. (1992). Home accidents in older people: Role of primary health care team. *BMJ, 305*(1), 30-32.

Hauer, K., Yardley, L., Beyer, N., Kempen, G. I. J. M., Dias, N., Campbell, M., ... & Todd, C. (2010). Validation of the Falls Efficacy Scale and Falls Efficacy Scale International in geriatric patients with and without cognitive impairment: Results of self-report and interview-based questionnaires. *Gerontology*, *56*(2), 190-199.

Jung, T., Dieck, C., Moorhouse, N., & Dieck, D. (2017). *Tourists' experience of virtual reality applications.* In 2017 International conference on consumer electronics. IEEE.

Kroenke, K., Spitzer, R. L., &, Williams, J. B. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine, 16(9)*, 606-13.

Kroenke, K., Spitzer, R. L., Williams, J. B., Monahan, P. O., & Löwe, B. (2007). Anxiety disorders in primary care: Prevalence, impairment, comorbidity, and detection. *Annals of internal medicine*, *146*(5), 317-325.

Larkin, M., Boden, Z., & Newton, E. (2015). On the brink of genuinely collaborative care: Experience-based co-design in mental health. *Qualitative Health Research, 25*(11), 1463–1476.

Levy, F., Leboucher, P., Rautureau, G., Komano, O., Millet, B., & Jouvent, R. (2016). Fear of falling: Efficacy of virtual reality associated with serious

games in elderly people. *Neuropsychiatric Disease and Treatment, 12*(1), 877-8.

Li, F., Fisher, K. J., Harmer, P., McAuley, E., & Wilson, N. L. (2003). Fear of falling in elderly persons: Association with falls, functional ability and quality of life. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 58*(5), 283–90.

Li, W., Procter-Gray, E., Lipsitz, L. A., Leveille, S. G., Hackman, H., Biondolillo, M., & Hannan, M. T. (2014). Utilitarian walking, neighborhood environment, and risk of outdoor falls among older adults. *American journal of public health*, *104*(9), e30-e37.

Liu, T. W., Ng, G. Y., Chung, R. C., & Ng, S. S. (2018). Cognitive behavioural therapy for fear of falling and balance among older people: A systematic review and meta-analysis. *Age and Ageing, 47*(4), 520–527.

Lord, S. R., Sherrington, C., & Menz, H. B. (2000). *Falls in older people: Risk factors and strategies for prevention.* Cambridge: Cambridge University Press.

Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. Y. (2008). Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Medical care*, 266-274.

Maki, B. E. (1997). Gait changes in older adults: Predictors of falls or indicators of fear? *Journal of the American geriatrics society*, *45*(3), 313-320.

Maki, B. E., Holliday, P. J., & Topper, A. K. J. (1991). Fear of falling and postural performance in the elderly. *Journal of Gerontology, 46*(4), 123-31.

Martin, F. C., Hart, D., Spector,T., Doyle, D.V., & Harari, D. (2005). Fear of falling limiting activity in young-old women is associated with reduced functional

mobility rather than psychological factors. *Age and Ageing, 34*(3), 281–287.

Mascret, N., Delbes, L., Voron, A., Temprado, J. J., & Montagne, G. (2020). Acceptance of a virtual reality headset designed for fall prevention in older adults: Questionnaire study. *Journal of Medical Internet Research, 22*(12), e20691.

McGinley, P., Ansari, E., Sandhu, H., & Dixon, T. (2020). The cost burden of falls in people with glaucoma in National Health Service Hospital Trusts in the UK. *Journal of medical economics*, *23*(1), 106-112.

McLean, K., Day, L., & Dalton, A. (2015). Economic evaluation of a group-based exercise program for falls prevention among the older community-dwelling population. *BMC geriatrics*, *15*(1), 1-11.

McMahon, S., Talley, K. M., & Wyman, J. F. (2011). Older people's perspectives on fall risk and fall prevention programs: A literature review. *International Journal of Older People Nursing, 6(4)*, 289-98.

Mihelj, M., Novak, D., & Beguš, S. (2014). *Virtual reality technology and applications*. London: Springer.

Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., … Baird, J. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*, 350, doi: https://doi.org/10.1136/bmj.h1258.

Morley, J. E. (2020). COVID-19- The Long Road to Recovery. *The Journal of Nutrition, Health & Aging, 24(*9), 917-919.

National Institute for Health and Care Excellence. (2013). Falls in older people: Assessing risk and prevention. Retrieved www.nice.org.uk/guidance/cg161

National Institute for Health and Care Excellence. (2018). NICE impact falls and fragility fractures. Retrieved https://www.bgs.org.uk/sites/default/files/content/resources/files/2018-08-29/NICE-Impact-falls-and-fragility-fractures.pdf

National Institute for Health Research: Research Design Service East Midlands. (2017). Sample size calculation. Retrieved https://www.rds-eastmidlands.nihr.ac.uk/resources/Newsletters/RDS%20newsletter%20APRIL%202017%20v3%20FINAL%20WEB.pdf

Nilsson, M. H., Hariz, G. M., Iwarsson, S., & Hagell, P. (2012). Walking ability is a major contributor to fear of falling in people with Parkinson's disease: implications for rehabilitation. *Parkinson's disease*, 713236. https://doi.org/10.1155/2012/713236

Parry, S. W., Bamford, C., Deary, V., Finch, T. L., Gray, J., MacDonald, C., … McColl, E. M. (2016). Cognitive-behavioural therapy-based intervention to reduce fear of falling in older people: Therapy development and randomised controlled trial- the Strategies for Increasing Independence, Confidence and Energy (STRIDE) study. *Health Technology Assessment, 20*(56), 1-206.

Perez-Jara, J., Walker, D., Heslop, P., & Robinson, S. (2010). Measuring fear of falling and its effect on quality of life and activity. *Reviews in Clinical Gerontology, 20*(4), 277-287.

Pinto-Meza, A., Serrano-Blanco, A., Penarrubia, M. T., Blanco, E., & Haro, J. M. (2005). Assessing depression in primary care with the PHQ-9: Can it be carried out over the telephone? *Journal of General Internal Medicine*, *20*(8), 738-742.

Powell, L. E., & Myers, A. M. (1995). The activities-specific balance confidence (ABC) scale. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *50*(1), 28-34.

Public Health England. (2017). Falls and fracture consensus statement-

Supporting commissioning for prevention. Retrieved https://www.england.nhs.uk/south/wp-content/uploads/sites/6/2017/03/falls-fracture.pdf

Rahman, S., Griffin, H. J., Quinn, N. P., & Jahanshahi, M. (2011). On the nature of fear of falling in Parkinson's disease. *Behavioural neurology*, *24*(3), 219-228.

Realpe, A., Elahi, F., Bucci, S., Birchwood, M., Vlaev, I., Taylor, D., & Thompson, A. (2019). Co-designing a virtual world with young people to deliver social cognition therapy in early psychosis. *Early Intervention in Psychiatry, 13*(1), 1-9.

Sekhon, M., Cartwright, M., & Francis, J. J. (2017). Acceptability of healthcare interventions: An overview of reviews and development of a theoretical framework. *BMC health services research*, *17*(1), 1-13.

Spitzer, R. L., Kroenke, K., Williams, J. B., et al. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine, 166*(10), 1092-7.

Suzuki, M., Ohyama, N., Yamada, K., & Kanamori, M. (2002). The relationship between fear of falling, activities of daily living and quality of life among elderly individuals. *Nursing & health sciences*, *4*(4), 155-161.

Swinson, R. P. (2006). The GAD-7 scale was accurate for diagnosing generalised anxiety disorder. *Evidence-based medicine*, *11*(6), 184-184.

Tinetti, M., Richman, D., & Powell, L. (1990). Falls efficacy as a measure of fear of falling. *Journal of gerontology, 45*(6), 239.

Todd, C., & Skelton, D. (2004). *What are the main risk factors for falls among older people and what are the most effective interventions to prevent these falls?*. Copenhagen: WHO Regional Office for Europe (Health Evidence Network report).

Young, W. R., & Williams, A. (2015). How fear of falling can increase fall-risk in older adults: Applying psychological theory to practical observations. *Gait Posture, 41*(1), 7-12.

Systematic Review Appendices (Chapter 1)

Appendix 1.1 – 10 - Manuscript Submission Guidelines: "Journal of Computers in Human Behavior". (https://www.elsevier.com/journals/computers-in-human-behavior/0747-5632/guide-for-authors)

This write-up is transferable to the guidelines of the target journal. Some minor elements differ, for instance, their recommended 'Introduction' and 'Theory' sections are conflated, allowing readers to smoothly follow the project as a thesis.

GUIDE FOR AUTHORS

Your Paper Your Way

We now differentiate between the requirements for new and revised submissions. You may choose to submit your manuscript as a single Word or PDF file to be used in the refereeing process. Only when your paper is at the revision stage, will you be requested to put your paper in to a 'correct format' for acceptance and provide the items required for the publication of your article.
To find out more, please visit the Preparation section below.

INTRODUCTION

Computers in Human Behavior is a scholarly journal dedicated to examining the use of computers from a psychological perspective. Original theoretical works, research reports, literature reviews, software reviews, book reviews and announcements are published. The journal addresses both the use of computers in psychology, psychiatry and related disciplines as well as the psychological impact of computer use on individuals, groups and society. The former category includes articles exploring the use of computers for professional practice, training, research and theory development. The latter category includes articles dealing with the psychological effects of computers on phenomena such as human development, learning, cognition, personality, and social interactions. The journal addresses human interactions with computers, not computers per se. The computer is discussed only as a medium through which human behaviors are shaped and expressed. The primary message of most articles involves information about human behavior. Therefore, professionals with an interest in the psychological aspects of computer use, but with limited knowledge of computers, will find this journal of interest.

Types of contributions
Original theoretical works, research reports, literature reviews, software reviews, book reviews(by invitation only) and announcements.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:
• E-mail address
• Full postal address

All necessary files have been uploaded:
Manuscript:
• Include keywords
• All figures (include relevant captions)
• All tables (including titles, description, footnotes)
• Ensure all figure and table citations in the text match the files provided
• Indicate clearly if color should be used for any figures in print
Graphical Abstracts / Highlights files (where applicable)
Supplemental files (where applicable)

Further considerations
• Manuscript has been 'spell checked' and 'grammar checked'
• All references mentioned in the Reference List are cited in the text, and vice versa
• Permission has been obtained for use of copyrighted material from other sources (including the Internet)
• A competing interests statement is provided, even if the authors have no competing interests to declare
• Journal policies detailed in this guide have been reviewed
• Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Center.

BEFORE YOU BEGIN

Ethics in publishing

Please see our information on Ethics in publishing.

Studies in humans and animals

If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The manuscript should be in line with the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals and aim for the inclusion of representative human populations (sex, age and ethnicity) as per those recommendations. The terms sex and gender should be used correctly.

Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should comply with the ARRIVE guidelines and should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Institutes of Health guide for the care and use of Laboratory animals (NIH Publications No. 8023, revised 1978) and the authors should clearly indicate in the manuscript that such guidelines have been followed. The sex of animals must be indicated, and where appropriate, the influence (or association) of sex on the results of the study.

Declaration of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places: 1. A summary declaration of interest statement in the title page file (if double anonymized) or the manuscript file (if single anonymized). If there are no interests to declare then please state this: 'Declarations of interest: none'. 2. Detailed disclosures as part of a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. More information.

Submission declaration and verification

Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify originality, your article may be checked by the originality detection service Crossref Similarity Check.

Use of inclusive language

Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that refer to personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Author contributions

For transparency, we encourage authors to submit an author statement file outlining their individual contributions to the paper using the relevant CRediT roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should be formatted with the names of authors first and CRediT role(s) following. More details and an example

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has preprinted forms for use by authors in these cases.

For gold open access articles: Upon acceptance of an article, authors will be asked to complete a 'License Agreement' (more information). Permitted third party reuse of gold open access articles is determined by the author's choice of user license.

Author rights

As an author you (or your employer or institution) have certain rights to reuse your work. More information.

Elsevier supports responsible sharing

Find out how you can share your research published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated.

Open access

Please visit our Open Access page for more information.

Elsevier Researcher Academy

Researcher Academy is a free e-learning platform designed to support early and mid-career researchers throughout their research journey. The "Learn" environment at Researcher Academy offers several interactive modules, webinars, downloadable guides and resources to guide you through the process of writing for research and going through peer review. Feel free to use these free resources to improve your submission and navigate the publication process with ease.

Language (usage and editing services)

Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the English Language Editing service available from Elsevier's Author Services.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Submit your article

Please submit your article via https://www.editorialmanager.com/chb/default.aspx/

PREPARATION

Queries

For questions about the editorial process (including the status of manuscripts under review) or for technical support on submissions, please visit our Support Center.

NEW SUBMISSIONS

Submission to this journal proceeds totally online and you will be guided stepwise through the creation and uploading of your files. The system automatically converts your files to a single PDF file, which is used in the peer-review process.

As part of the Your Paper Your Way service, you may choose to submit your manuscript as a single file to be used in the refereeing process. This can be a PDF file or a Word document, in any format or lay-out that can be used by referees to evaluate your manuscript. It should contain high enough quality figures for refereeing. If you prefer to do so, you may still provide all or some of the source files at the initial submission. Please note that individual figure files larger than 10 MB must be uploaded separately.

References

There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/ book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct.

Formatting requirements

There are no strict formatting requirements but all manuscripts must contain the essential elements needed to convey your manuscript, for example Abstract, Keywords, Introduction, Materials and Methods, Results, Conclusions, Artwork and Tables with Captions.

If your article includes any Videos and/or other Supplementary material, this should be included in your initial submission for peer review purposes.

Divide the article into clearly defined sections.

Figures and tables embedded in text

Please ensure the figures and the tables included in the single file are placed next to the relevant text in the manuscript, rather than at the bottom or the top of the file. The corresponding caption should be placed directly below the figure or table.

Peer review

This journal operates a double anonymized review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor's decision is final. Editors are not involved in decisions about papers which they have written themselves or have been written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. More information on types of peer review.

Double anonymized review

This journal uses double anonymized review, which means the identities of the authors are concealed from the reviewers, and vice versa. More information is available on our website. To facilitate this, please include the following separately:

Title page (with author details): This should include the title, authors' names, affiliations, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.
Anonymized manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.

REVISED SUBMISSIONS

Use of word processing software
Regardless of the file format of the original submission, at revision you must provide us with an editable file of the entire article. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier). See also the section on Electronic artwork.
To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

LaTeX
You are recommended to use the latest Elsevier article class to prepare your manuscript and BibTeX to generate your bibliography.
Our Guidelines has full details.

Article structure

Subdivision - numbered sections
Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction
State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods
Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

Theory/calculation
A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results
Results should be clear and concise.

Discussion
This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions
The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices
If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

• ***Author names and affiliations.*** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
• ***Corresponding author.*** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
• ***Present/permanent address.*** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Abstract
A concise and factual abstract is required and should not be longer than 200 words. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Graphical abstract
Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 × 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. You can view Example Graphical Abstracts on our information site.
Authors can make use of Elsevier's Illustration Services to ensure the best presentation of their images and in accordance with all technical requirements.

Highlights
Highlights are mandatory for this journal. They increase the discoverability of your article via search engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the examples here: example Highlights.

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 125 characters, including spaces, per bullet point).

Keywords
Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations
Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements
Do not include acknowledgements on the title page, as a footnote to the title or otherwise. In a separate file to the manuscript, list those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.)

Formatting of funding sources
List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Math formulae
Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes
Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes in the text and present the footnotes themselves separately at the end of the article.

Artwork

Electronic artwork
General points
- Make sure you use uniform lettering and sizing of your original artwork.
- Preferred fonts: Arial (or Helvetica), Times New Roman (or Times), Symbol, Courier.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Indicate per figure if it is a single, 1.5 or 2-column fitting image.
- For Word submissions only, you may still provide figures and their captions, and tables within a single file at the revision stage.
- Please note that individual figure files larger than 10 MB must be provided in separate source files.

A detailed guide on electronic artwork is available.
You are urged to visit this site; some excerpts from the detailed information are given here.
Formats
Regardless of the application used, when your electronic artwork is finalized, please 'save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):
EPS (or PDF): Vector drawings. Embed the font or save the text as 'graphics'.
TIFF (or JPG): Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
TIFF (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.
TIFF (or JPG): Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.
Please do not:
- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); the resolution is too low.
- Supply files that are too low in resolution.
- Submit graphics that are disproportionately large for the content.

Color artwork
Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF) or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) in addition to color reproduction in print. Further information on the preparation of electronic artwork.

Figure captions
Ensure that each illustration has a caption. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references
This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

References in a special issue
Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software
Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley. Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. More information on how to remove field codes from different reference management software.

Users of Mendeley Desktop can easily install the reference style for this journal by clicking the following link:
http://open.mendeley.com/use-citation-style/computers-in-human-behavior
When preparing your manuscript, you will then be able to select this style using the Mendeley plug-ins for Microsoft Word or LibreOffice.

Reference formatting
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/ book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct. If you do wish to format the references yourself they should be arranged according to the following examples:

Reference style
Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Seventh Edition, ISBN 978-1-4338-3215-4, copies of which may be ordered online.
List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.
Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2010). The art of writing a scientific article. *Journal of Scientific Communications, 163*, 51–59. https://doi.org/10.1016/j.sc.2010.00372.
Reference to a journal publication with an article number:
Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2018). The art of writing a scientific article. *Heliyon*, *19*, Article e00205. https://doi.org/10.1016/j.heliyon.2018.e00205.
Reference to a book:
Strunk, W., Jr., & White, E. B. (2000). *The elements of style* (4th ed.). Longman (Chapter 4).
Reference to a chapter in an edited book:
Mettam, G. R., & Adams, L. B. (2009). How to prepare an electronic version of your article. In B. S. Jones, & R. Z. Smith (Eds.), *Introduction to the electronic age* (pp. 281–304). E-Publishing Inc.
Reference to a website:
Powertech Systems. (2015). *Lithium-ion vs lead-acid cost analysis*. Retrieved from http://www.powertechsystems.eu/home/tech-corner/lithium-ion-vs-lead-acid-cost-analysis/. Accessed January 6, 2016
Reference to a dataset:
[dataset] Oguro, M., Imahiro, S., Saito, S., & Nakashizuka, T. (2015). *Mortality data for Japanese oak wilt disease and surrounding forest compositions*. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.
Reference to a conference paper or poster presentation:
Engle, E.K., Cash, T.F., & Jarry, J.L. (2009, November). *The Body Image Behaviours Inventory-3: Development and validation of the Body Image Compulsive Actions and Body Image Avoidance Scales*. Poster session presentation at the meeting of the Association for Behavioural and Cognitive Therapies, New York, NY.
Reference to software:
Coon, E., Berndt, M., Jan, A., Svyatsky, D., Atchley, A., Kikinzon, E., Harp, D., Manzini, G., Shelef, E., Lipnikov, K., Garimella, R., Xu, C., Moulton, D., Karra, S., Painter, S., Jafarov, E., & Molins, S. (2020, March 25). *Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88)*. Zenodo. https://doi.org/10.5281/zenodo.3727209.

Video
Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including ScienceDirect. Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our video instruction pages. Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Data visualization
Include interactive data visualizations in your publication and let your readers interact and engage more closely with your research. Follow the instructions here to find out about available data visualization options and how to include them with your article.

Supplementary material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

Research data

This journal encourages and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings. To facilitate reproducibility and data reuse, this journal also encourages you to share your software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. If you are sharing data in one of these ways, you are encouraged to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the research data page.

Data linking

If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the database linking page.

For supported data repositories a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Mendeley Data

This journal supports Mendeley Data, enabling you to deposit any research data (including raw and processed data, video, code, software, algorithms, protocols, and methods) associated with your manuscript in a free-to-use, open access repository. During the submission process, after uploading your manuscript, you will have the opportunity to upload your relevant datasets directly to *Mendeley Data*. The datasets will be listed and directly accessible to readers next to your published article online.

For more information, visit the Mendeley Data for journals page.

Data in Brief

You have the option of converting any or all parts of your supplementary or additional raw data into a data article published in *Data in Brief*. A data article is a new kind of article that ensures that your data are actively reviewed, curated, formatted, indexed, given a DOI and made publicly available to all upon publication (watch this video describing the benefits of publishing your data in *Data in Brief*). You are encouraged to submit your data article for *Data in Brief* as an additional item directly alongside the revised version of your manuscript. If your research article is accepted, your data article will automatically be transferred over to *Data in Brief* where it will be editorially reviewed, published open access and linked to your research article on ScienceDirect. Please note an open access fee is payable for publication in *Data in Brief*. Full details can be found on the Data in Brief website. Please use this template to write your *Data in Brief* data article.

Appendix 1.2 – Quality Assessment Tool

INTRODUCTION

JBI is an international research organisation based in the Faculty of Health and Medical Sciences at the University of Adelaide, South Australia. JBI develops and delivers unique evidence-based information, software, education and training designed to improve healthcare practice and health outcomes. With over 70 Collaborating Entities, servicing over 90 countries, JBI is a recognised global leader in evidence-based healthcare.

JBI Systematic Reviews

The core of evidence synthesis is the systematic review of literature of a particular intervention, condition or issue. The systematic review is essentially an analysis of the available literature (that is, evidence) and a judgment of the effectiveness or otherwise of a practice, involving a series of complex steps. JBI takes a particular view on what counts as evidence and the methods utilised to synthesise those different types of evidence. In line with this broader view of evidence, JBI has developed theories, methodologies and rigorous processes for the critical appraisal and synthesis of these diverse forms of evidence in order to aid in clinical decision-making in healthcare. There now exists JBI guidance for conducting reviews of effectiveness research, qualitative research, prevalence/incidence, etiology/risk, economic evaluations, text/opinion, diagnostic test accuracy, mixed-methods, umbrella reviews and scoping reviews. Further information regarding JBI systematic reviews can be found in the JBI Evidence Synthesis Manual.

JBI Critical Appraisal Tools

All systematic reviews incorporate a process of critique or appraisal of the research evidence. The purpose of this appraisal is to assess the methodological quality of a study and to determine the extent to which a study has addressed the possibility of bias in its design, conduct and analysis. All papers selected for inclusion in the systematic review (that is – those that meet the inclusion criteria described in the protocol) need to be subjected to rigorous appraisal by two critical appraisers. The results of this appraisal can then be used to inform synthesis and interpretation of the results of the study. JBI Critical appraisal tools have been developed by the JBI and collaborators and approved by the JBI Scientific Committee following extensive peer review. Although designed for use in systematic reviews, JBI critical appraisal tools can also be used when creating Critically Appraised Topics (CAT), in journal clubs and as an educational tool.

JBI CRITICAL APPRAISAL CHECKLIST FOR QUASI-EXPERIMENTAL STUDIES

Reviewer_____Date_____

Author_____Year_____ Record Number_____

	Yes	No	Unclear	Not applicable
1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	☐	☐	☐	☐
2. Were the participants included in any comparisons similar?	☐	☐	☐	☐
3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	☐	☐	☐	☐
4. Was there a control group?	☐	☐	☐	☐
5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?	☐	☐	☐	☐
6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	☐	☐	☐	☐
7. Were the outcomes of participants included in any comparisons measured in the same way?	☐	☐	☐	☐
8. Were outcomes measured in a reliable way?	☐	☐	☐	☐
9. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Comments (Including reason for exclusion)

EXPLANATION FOR THE CRITICAL APPRAISAL TOOL FOR QUASI-EXPERIMENTAL STUDIES

How to cite: Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis. JBI, 2020. Available from https://synthesismanual.jbi.global

Critical Appraisal Tool for Quasi-Experimental Studies (Experimental Studies without random allocation)

Answers: Yes, No, Unclear or Not/Applicable

1. Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?

Ambiguity with regards to the temporal relationship of variables constitutes a threat to the internal validity of a study exploring causal relationships. The 'cause' (the independent variable, that is, the treatment or intervention of interest) should occur in time before the explored 'effect' (the dependent variable, which is the effect or outcome of interest). Check if it is clear which variable is manipulated as a potential cause. Check if it is clear which variable is measured as the effect of the potential cause. Is it clear that the 'cause' was manipulated before the occurrence of the 'effect'?

2. Were the participants included in any comparisons similar?

The differences between participants included in compared groups constitute a threat to the internal validity of a study exploring causal relationships. If there are differences between participants included in compared groups there is a risk of selection bias. If there are differences between participants included in the compared groups maybe the 'effect' cannot be attributed to the potential 'cause', as maybe it is plausible that the 'effect' may be explained by the differences between participants, that is, by selection bias. Check the characteristics reported for participants. Are the participants from the compared groups similar with regards to the characteristics that may explain the effect even in the absence of the 'cause', for example, age, severity of the disease, stage of the disease, co-existing conditions and so on? *[NOTE: In one single group pre-test/post-test studies where the patients are the same (the same one group) in any pre-post comparisons, the answer to this question should be 'yes.']*

3. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?

In order to attribute the 'effect' to the 'cause' (the exposure or intervention of interest), assuming that there is no selection bias, there should be no other difference between the groups in terms of treatments or care received, other than the manipulated 'cause' (the intervention of interest). If there are other exposures or treatments occurring in the same time with the 'cause', other than the intervention of interest, then potentially the 'effect' cannot be attributed to the intervention of interest, as it is plausible that the 'effect' may be explained by other exposures or treatments, other than the intervention of interest, occurring in the same time with the intervention of interest. Check the reported exposures or interventions received by the compared groups. Are there other exposures or treatments occurring in the same time with the intervention of interest? Is it plausible that the 'effect' may be explained by other exposures or treatments occurring in the same time with the intervention of interest?

4. Was there a control group?

Control groups offer the conditions to explore what would have happened with groups exposed to other different treatments, other than to the potential 'cause' (the intervention of interest). The comparison of the treated group (the group exposed to the examined 'cause', that is, the group receiving the intervention of interest) with such other groups strengthens the examination of the causal plausibility. The validity of

causal inferences is strengthened in studies with at least one independent control group compared to studies without an independent control group. Check if there are independent, separate groups, used as control groups in the study. *[Note: The control group should be an independent, separate control group, not the pre-test group in a single group pre-test post-test design.]*

5. Were there multiple measurements of the outcome both pre and post the intervention/exposure?

In order to show that there is a change in the outcome (the 'effect') as a result of the intervention/treatment (the 'cause') it is necessary to compare the results of measurement before and after the intervention/treatment. If there is no measurement before the treatment and only measurement after the treatment is available it is not known if there is a change after the treatment compared to before the treatment. If multiple measurements are collected before the intervention/treatment is implemented then it is possible to explore the plausibility of alternative explanations other than the proposed 'cause' (the intervention of interest) for the observed 'effect', such as the naturally occurring changes in the absence of the 'cause', and changes of high (or low) scores towards less extreme values even in the absence of the 'cause' (sometimes called regression to the mean). If multiple measurements are collected after the intervention/treatment is implemented it is possible to explore the changes of the 'effect' in time in each group and to compare these changes across the groups. Check if measurements were collected before the intervention of interest was implemented. Were there multiple pre-test measurements? Check if measurements were collected after the intervention of interest was implemented. Were there multiple post-test measurements?

6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?

If there are differences with regards to the loss to follow up between the compared groups these differences represent a threat to the internal validity of a study exploring causal effects as these differences may provide a plausible alternative explanation for the observed 'effect' even in the absence of the 'cause' (the treatment or exposure of interest). Check if there were differences with regards to the loss to follow up between the compared groups. If follow up was incomplete (that is, there is incomplete information on all participants), examine the reported details about the strategies used in order to address incomplete follow up, such as descriptions of loss to follow up (absolute numbers; proportions; reasons for loss to follow up; patterns of loss to follow up) and impact analyses (the analyses of the impact of loss to follow up on results). Was there a description of the incomplete follow up (number of participants and the specific reasons for loss to follow up)? If there are differences between groups with regards to the loss to follow up, was there an analysis of patterns of loss to follow up? If there are differences between the groups with regards to the loss to follow up, was there an analysis of the impact of the loss to follow up on the results?

7. Were the outcomes of participants included in any comparisons measured in the same way?

If the outcome (the 'effect') is not measured in the same way in the compared groups there is a threat to the internal validity of a study exploring a causal relationship as the differences in outcome measurements may be confused with an effect of the treatment or intervention of interest (the 'cause'). Check if the outcomes were measured in the same way. Same instrument or scale used? Same measurement timing? Same measurement procedures and instructions?

8. Were outcomes measured in a reliable way?

Unreliability of outcome measurements is one threat that weakens the validity of inferences about the statistical relationship between the 'cause' and the 'effect' estimated in a study exploring causal effects. Unreliability of outcome measurements is one of different plausible explanations for errors of statistical inference with regards to the existence and the magnitude of the effect determined by the treatment ('cause'). Check the details about the reliability of measurement such as the number of raters, training of raters, the intra-rater reliability, and the inter-raters reliability within the study (not to external sources).

This question is about the reliability of the measurement performed in the study, it is not about the validity of the measurement instruments/scales used in the study. *[Note: Two other important threats that weaken the validity of inferences about the statistical relationship between the 'cause' and the 'effect' are low statistical power and the violation of the assumptions of statistical tests. These other threats are not explored within Question 8, these are explored within Question 9.]*

9. Was appropriate statistical analysis used?

Inappropriate statistical analysis may cause errors of statistical inference with regards to the existence and the magnitude of the effect determined by the treatment ('cause'). Low statistical power and the violation of the assumptions of statistical tests are two important threats that weakens the validity of inferences about the statistical relationship between the 'cause' and the 'effect'. Check the following aspects: if the assumptions of statistical tests were respected; if appropriate statistical power analysis was performed; if appropriate effect sizes were used; if appropriate statistical procedures or methods were used given the number and type of dependent and independent variables, the number of study groups, the nature of the relationship between the groups (independent or dependent groups), and the objectives of statistical analysis (association between variables; prediction; survival analysis etc.).

Major Research Project Appendices (Chapter 2)

Appendix 2.1 – Study Protocol

Augmenting psychological treatment for fear of falling using Virtual Reality: A feasibility study in older adults

19.06.2020

Version-1

Actual word-count: 3276

Maximum word-count: 3000 (+≤20%)

Abstract

Background

Falls in older adults are expensive to the NHS and reduce patients' quality of life. Fear of falling (FoF) increases the risk of falls and so is an important treatment target. Virtual reality (VR) supported exposure treatments potentially save labour and costs, and can improve FoF; however, few VR treatment protocols have been co-productively designed. This feasibility study will evaluate the acceptability of a custom-designed VR FoF intervention targeting psychological process related to FoF in older adults.

Aims

- Evaluate feasibility, including acceptability and tolerability, of a VR intervention in older adults.
- Determine if patients are willing to participate in this treatment.
- Develop and evaluate FoF measurements within virtual environments.

Methods

Participants with current or past FoF from NHS psychology services will interact with a short VR intervention, involving psychological exposure to commonly feared scenarios. It will be designed in collaboration with computer science colleagues. Outcomes gathered include quantitative anxiety ratings (e.g. Likert scales) within the virtual environment and post-intervention qualitative semi-structured interview feedback.

Applications

Results will form the beginnings of a co-produced intervention. The rich user experience data will aid psychologists and software-developers in designing future automated VR interventions.

Introduction

Background

Approximately one third of older adults (≥65 years) fall annually (National Institute for Health and Care Excellence [NICE], 2013). This increases with age, with half of those aged 80 years or older at risk of falling (NICE, 2013). Falls can result in serious injuries, particularly fractures. Amongst older adults, they cost the NHS billions of pounds yearly for outpatients and inpatients (Public Health England [PHE], 2017; NICE, 2018). Annually, emergency hospital admissions cost over £2-billion (NICE, 2018) and social care following fragility fractures costs over £1-billion (PHE, 2017). Despite this, most falls are not seen by healthcare services (Graham & Firth, 1992), with around 80% of non-injurious falls going unreported to healthcare staff (Age Concern, 1997). This is concerning considering past falls can predict future falls (NICE, 2013). Risk factors are intrinsic or environmental (Todd & Skelton, 2004). Unsuitable lighting, walking aids or floor surfaces are extrinsic factors that increase falling risk (Dean & Ross, 1993; Lord et al., 2000). Intrinsic physical and mental health conditions that increase risk include arthritis, depression and stroke (NICE, 2013); multimorbidity further heightens risk (NICE, 2018).

Fear of Falling

Falls drastically reduce quality of life (QoL), with effects including activity avoidance, increased frailty and reduced socialising (PHE, 2017; Arfken et al., 1994). With an ageing population, falls prevention is becoming increasingly important to reduce NHS costs and enhance people's wellbeing (McLean et al., 2015). A fear of falling (FoF) equally impacts QoL, limiting living activities (Suzuki et al., 2002). FoF is defined as people's reduced confidence in their balance abilities (Maki et al., 1991). FoF can develop whether people have fallen previously or not (PHE, 2017), and this fear can increase risk of falling via impaired balance ability (Li et al., 2003).

Young and Williams (2015) describe psychological mechanisms behind this, drawing inferences from Attentional Control Theory (Eysenck et al., 2007). These include increased anxiety which negatively alters attentional movement-related processes. Hence, people become preoccupied with threatening stimuli, or stimuli irrelevant to

movement tasks. They may be consumed with anxious thoughts about slipping and falling, leaving inadequate attentional resources remaining to safely guide movement. This anxiety also reduces ability to retain visuospatial information in their working memory, for example, where obstacles are spatially. Moreover, people stiffen their body to avoid falling, compromising ability during postural tasks with high working memory demands, such as navigating uneven pavements (Young & Williams, 2015).

Interventions: Virtual Reality

Given the role of psychological processes, elements of Cognitive Behavioural Therapy (CBT) have been successfully used to reduce FoF, as well as improve depression and QoL (Parry et al., 2016; Liu et al., 2018). There is a necessity for efficient replicability, improved costs and reduced labour in psychological interventions (Freeman et al., 2018). There is evidence that interventions to reduce falls in older adults can be cost-effective when there is a reduction in medical care costs (McLean et al., 2015). Virtual Reality (VR) is increasingly being used in psychological exposure interventions to address this. VR is defined as an interactive computer simulation in which users' actions are sensed and fed back to one or more senses (e.g. visual or haptic), such that they become immersed in virtual worlds (Mihelj et al., 2014). Its advantages include ecological realism, low physical risk, exposure to situations impossible in reality, and, low monetary and logistical efforts (Fromberger, et al., 2018). A recent meta-analysis found VR exposure therapy to be as effective at improving anxiety disorders as *in-vivo* therapy, as well as having a large effect size (Carl et al., 2019). Some studies have demonstrated specific benefit for anxiety disorders using automated VR-treatment, which is conducive to replicable low-labour therapy (Freeman et al., 2018). VR FoF exposure therapy interventions have had success in reducing anxiety and demonstrated that older adults tolerate the associated head mounted devices (HMDs) (Levy et al., 2016). VR interventions are particularly successful when they include both exposure to challenge FoF beliefs and interaction in the environment to internalise these new beliefs (Levy et al., 2016).

Co-production

Co-production of mental health interventions has been used less than in physical health (Larkin et al., 2015). Co-production is increasingly considered crucial in development of psychological VR interventions. A seminal paper describes three stages for VR healthcare studies to follow to gain the best outcome for end-users (Birckhead et al., 2019). The first stage, “VR1”, focuses on content development to “promote empathy, team collaboration, and continuous user feedback”. VR2 explores “early testing… feasibility, acceptability, tolerability, and initial clinical efficacy.” ‘Acceptability’ is patients’ willingness to use the intervention, ‘Feasibility’ is the extent it can be effectively utilised in current care and ‘Tolerability’ involves evaluating adverse treatment effects, physical or emotional. The final stage, VR3, comprises randomised controlled trials (RCTs). Some CBT-based FoF treatments have co-designed interventions using patient interviews (Parry et al., 2016). However, few VR-based interventions have co-produced interventions, including RCT studies of FoF and other phobias (Carl et al., 2019; Levy et al., 2016). Nonetheless, older adults with FoF tolerate HMDs and experience improved anxiety (Levy et al., 2016).

Consequently, this study combines elements of Birckhead et al.’s (2019) VR1 and VR2 stages, evaluating a FoF VR intervention in terms of feasibility, tolerability and acceptability. VR is not used to treat FoF in NHS settings, making this novel and beginning iterative processes of developing cost and labour saving FoF interventions in a patient centred way.

Aims

- To evaluate the feasibility and acceptability of a VR intervention in older adults, designed to target psychological process related to FoF. Specifically:
    - Determine the tolerability and acceptability of VR as a FoF treatment, gaining qualitative user experience feedback
    - Determine the proportion of FoF patients that are willing to participate in VR interventions
    - Develop and evaluate measurement of FoF outcomes within the virtual environment

Plan of Investigation

Participants

Older adults in contact with NHS services who currently or have historically experienced FoF as diagnosed by Clinical Psychologists.

Inclusion Criteria

Currently or previously treated within NHSGGC older adult services and have/had FoF.

Exclusion Criteria

Never been treated within older adult NHSGGC services or had FoF. Any disorder that undermines capacity to give informed consent.

Recruitment

Current or past patients of NHSGGC Clinical psychology physical rehabilitation services and day hospitals will be approached to participate voluntarily; the primary contact for this being a liaison Clinical psychologist.

Measures

Prior to intervention design, Clinical psychologists and service-users will be consulted via a brain-storming group on acceptability, tolerability and feasibility. Self-rated scales such as the State-Trait Anxiety Inventory (Spielberger, 1983) will gather data within the VR world pre and post-exposure, assessing tolerability. Post-intervention, individual semi-structured interviews will be conducted, gaining qualitative user experience (UX) data to explore acceptability and tolerability. 'Presence' in the environment (feeling within the world) will be measured via a 'sense of presence' questionnaire (Freeman et al., 2003; Slater et al., 1998); higher presence indicates better feasibility as an intervention. Demographics including age, sex and medical/ cognitive conditions will be gathered. A brief cognitive screen, such as Addenbrooke's cognitive examination (ACE-III), could be given beforehand to highlight memory or visuospatial difficulties.

Research Procedures

The study will be largely based on Birckhead et al.'s (2019) VR1 and VR2 research stages, as outlined. A bespoke virtual world will be created in collaboration with the University of Glasgow's Computing School, which includes features targeting FoF-related psychological processes. These will involve psychological exposure and environmental interaction. Virtual environments will incorporate extrinsic risk factors for falling, including varying lighting, weather conditions (snow, rain etc.) or uneven floor surfaces, such as door thresholds (Dean & Ross, 1993; Lord et al., 2000). Specific features of exposure environments will be collectively determined by a group of Clinical psychologists, service-users and researchers familiar with FoF. Participants will use a Likert scale within the world to rate their present-moment anxiety. They will experience this world for a timeframe around 30 minutes or less, wearing wireless Oculus Quest HMDs. Immediately post-intervention, participants will be semi-structurally interviewed on UX, exploring acceptability and tolerability.

As suggested by the main supervisor, the **Appendix** outlines contingency procedures.

Analysis

Users' anxiety ratings and researchers' observations will be reported descriptively, adhering to recommendations on reporting feasibility studies (Arain et al., 2010). Interviews will be audio-recorded, transcribed and analysed thematically (Braun & Clarke, 2006), via qualitative analysis software. As recommended by the UK Medical Research Council (MRC) for intervention evaluation, inferences from quantitative and qualitative data will be combined to strengthen findings. Themes will be reviewed by a second coder to confirm validity (Moore et al., 2015). Other analyses are also possible, including estimating effect sizes, such as rate of anxiety habituation as a function of time exposed in VR.

Sample Size Justification

Research examining older people's perspectives on FoF via interviews have varied in sample size, from under 10 to nearly 100 (McMahon et al., 2011). Generally, those with smaller samples collected "richer" data. The National Institute for Health Research (NIHR, 2017) suggest sample calculations are unnecessary for most qualitative research, but indicate samples must be large enough to reach theme "saturation" and represent target population diversity. A similar co-production study gaining qualitative feedback for a VR psychosis intervention, used 20 participants via convenience sampling (Realpe et al., 2019). Guidelines on "small" thematic analyses suggest under 10 participants can be used (Braun & Clarke, 2013).

Data from an involved NHSGGC older adult psychology service suggest 14 referrals were directly FoF related over the past year (March 2019-20). In addition to the short time-period available and early stages of this research, we will use convenience sampling to recruit around 5 participants. This will be adequate to determine preliminary aspects of feasibility (e.g. resources and timescale), compliance, acceptability and tolerability. Recruiters will track numbers of patients approached vs. those who participate. Within this, we aim to collect quantitative data from all who tolerate the full intervention.

Settings

Physical rehabilitation or day hospital settings.

Equipment

Oculus Quest VR HMDs and associated software, to be determined by University of Glasgow's Computing School colleagues, namely the bespoke virtual world as described earlier. These will be provided by the computing school and borrowed on a day-by-day basis.

Health and Safety

Researcher Safety

Researchers will be briefed on safe use of VR equipment by computing school staff.

Participant Safety

Participants with physical accessibility issues will receive required support (e.g. disabled toilets, ramps). VR-induced side-effects (VRISE) are a potential issue and can include motion-sickness, however they are generally transient and mild (Gregg & Tarrier, 2007; Nichols & Patel, 2002). Participants will be warned of these and can withdraw any time during the research. Risk of actual falls will be low as the intervention will involve participants sitting, which has been effective in past VR FoF studies (Levy et al., 2016).

Ethics

Full written informed consent will be gained. By participating, participants will not be excluded from any current or future FoF 'treatment as usual'.

Finances

VR equipment will be borrowed without charge. We will not financially reimburse participants, but will offer refreshments, requiring a budget of approximately £20.

Printing costs to provide potential participants and clinicians with information will be approximately £20. Recruitment locations are to be determined by the liaison Clinical psychologist, who is the main contact for this. With this current knowledge we do not anticipate any significant researcher travel costs between hospital sites.

Overall Timeline

- March–June 2020
    - Clinical psychology colleagues brain-storm VR environment features, with patient input.
    - Discuss development of VR world with computing school, including identifying an MSc student to complete it.
    - Determine recruitment locations and clinics.
    - Begin systematic review.
- June–December 2020
    - Final MRP proposal and ethics completed.
    - Source clinic rooms and times for collection.
    - MSc student completes programming for VR-world.
    - Begin collecting data.
- January–April 2021
    - Continue and complete data collection.
- April–July 2021
    - Write-up MRP and systematic review.
    - Submission.

Practical Implications

- Beginnings of a co-productive VR FoF intervention creation, using a structured staged process. Such automated interventions could reduce cost and labour (i.e. few therapists needed).
- Gain rich qualitative UX information on VR for FoF.

- Inform later creation of VR FoF virtual worlds.
- First development stage of interventions which could ultimately save the NHS money, via reducing anxiety-related behaviour which increases falls risk.

References

Age Concern. (1997). *Looking for a fall. A report on falls incidence in the UK*. London: Age Concern.

Arain, M., Campbell, M. J., Cooper, C. L., & Lancaster, G. A. (2010). What is a pilot or feasibility study? A review of current practice and editorial policy. *BMC Medical Research Methodology, 16*, 10:67.

Arfken, C. L., Lach, H. W., Birge, S. J., & Miller, J. P. (1994). The prevalence and correlates of fear of falling in elderly persons living in the community. *American Journal of Public Health* , *84*: 565–570.

Birckhead, B., Khalil, C., Liu, X., Conovitz, S., Rizzo, A., Danovitch, I., … Spiegel, B. (2019). Recommendations for Methodology of Virtual Reality Clinical Trials in Health Care by an International Working Group: Iterative Study. *Journal of Medical Internet Research Mental Health, 31*, 6(1).

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*, 77-101.

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners.* London: Sage.

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., … Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders, 61*, 27-36.

Dean, E., & Ross, J. (1993). Relationships among cane fitting, function, and falls. *Physical therapy, 73*, 494-504.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion, 7:2*, 336.

Freeman, D., Haselton, P., Freeman, J., Spanlang, B., Kishore, S., Albery, E., … Nickless, A. (2018). Automated psychological therapy using immersive virtual reality for treatment of fear of heights: a single-blind, parallel-group, randomised controlled trial. *Lancet Psychiatry, 5(8)*, 625-632.

Freeman, D., Slater. M, Bebbington, P. E., Garety, P. A., Kuipers, E., Fowler, D., Met, A., Read, C. M., Jordan, J., & Vinayagamoorthy, V. (2003). Can virtual reality be used to investigate persecutory ideation? *The Journal of Nervous and Mental Disease, 191(8),* 509-14.

Fromberger, P., Jordan, K., & Müller, J. L. (2018). Virtual reality applications for diagnosis, risk assessment and therapy of child abusers. *Behavioral Sciences & the Law, 36(2)*, 235-244.

Graham, H. J., & Firth, J. (1992). Home accidents in older people: role of primary health care team. *BMJ, 305*, 30-32.

Gregg, L., & Tarrier, N. (2007). Virtual reality in mental health: a review of the literature, *Social Psychiatry and Psychiatric Epidemiology, 42(5)*, 343–354.

Larkin, M., Boden, Z., & Newton, E. (2015). On the brink of genuinely collaborative care: Experience-based co-design in mental health. *Qualitative Health Research, 25(11)*, 1463–1476.

Levy, F., Leboucher, P., Rautureau, G., Komano, O., Millet, B., & Jouvent, R. (2016). Fear of falling: efficacy of virtual reality associated with serious games in elderly people. *Neuropsychiatric Disease and Treatment, 12*, 877-8.

Li, F., Fisher, K. J., Harmer, P., McAuley, E., & Wilson, N. L. (2003). Fear of falling in elderly persons: association with falls, functional ability and quality of life. *The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 58*, 283–90.

Liu, T. W., Ng, G. Y., Chung, R. C., & Ng, S. S. (2018). Cognitive behavioural therapy for fear of falling and balance among older people: a systematic review and meta-analysis. *Age and Ageing, 47(4)*, 520–527.

Lord, S. R., Sherrington, C., & Menz, H. B. (2000). *Falls in older people: risk factors and strategies for prevention.* Cambridge, Cambridge University Press.

Maki, B. E., Holliday, P. J., & Topper, A. K. J. (1991). Fear of falling and postural performance in the elderly. *Journal of Gerontology, 46(4)*, 123-31.

McLean, K., Day, L., & Dalton, A. (2015). Economic evaluation of a group-based exercise program for falls prevention among the older community-dwelling population. *BMC Geriatrics, 15*, 33.

McMahon, S., Talley, K. M., & Wyman, J. F. (2011). Older people's perspectives on fall risk and fall prevention programs: a literature review. *International Journal of Older People Nursing, 6(4)*, 289-98.

Mihelj, M., Novak, D., & Beguš, S. (2014). *Virtual reality technology and applications*. London: Springer.

Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., … Baird, J. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*, 350.

National Institute for Health and Care Excellence. (2013). Falls in older people: assessing risk and prevention. Retrieved from www.nice.org.uk/guidance/cg161

National Institute for Health and Care Excellence. (2018). NICE impact falls and fragility fractures. Retrieved from https://www.bgs.org.uk/sites/default/files/content/resources/files/2018-08-29/NICE-Impact-falls-and-fragility-fractures.pdf

National Institute for Health Research: Research Design Service East Midlands. (2017). Sample size calculation. Retrieved from https://www.rds-eastmidlands.nihr.ac.uk/resources/Newsletters/RDS%20newsletter%20APRIL%202017%20v3%20FINAL%20WEB.pdf

Nichols, S., & Patel, H. (2002). Health and safety implications of virtual reality: a review of empirical evidence. *Applied Ergonomics, 33(3)*, 251–271.

Parry, S. W., Bamford, C., Deary, V., Finch, T. L., Gray, J., MacDonald, C., … McColl, E. M. (2016). Cognitive-behavioural therapy-based intervention to reduce fear of falling in older people: therapy development and randomised controlled trial - the Strategies for Increasing Independence, Confidence and Energy (STRIDE) study. *Health Technology Assessment, 20(56)*, 1-206.

Public Health England. (2017). Falls and fracture consensus statement- Supporting commissioning for prevention. Retrieved from https://www.england.nhs.uk/south/wp-content/uploads/sites/6/2017/03/falls-fracture.pdf

Realpe, A., Elahi, F., Bucci, S., Birchwood, M., Vlaev, I., Taylor, D., & Thompson, A. (2019). Co-designing a virtual world with young people to deliver social cognition therapy in early psychosis. *Early Intervention In Psychiatry, 13(1)*, 1-9.

Slater, M., Steed, A., McCarthy, J., & Maringelli, F. (1998). The influence of body movement on subjective presence in virtual environments. *Human Factors, 40*, 469–477.

Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory: STAI (Form Y)*. Consulting Psychologists Press.

Suzuki, M., Ohyama, N., Yamada, K., & Kanamori, M. (2002). The relationship between fear of falling, activities of daily living and quality of life among elderly individuals. *Nursing & Health Sciences, 4*, 155–61.

Todd, C., & Skelton, D. (2004). *What are the main risk factors for falls among older people and what are the most effective interventions to prevent these falls?*. Copenhagen, WHO Regional Office for Europe (Health Evidence Network report).

Young, W. R., & Williams, A. (2015). How fear of falling can increase fall-risk in older adults: applying psychological theory to practical observations. *Gait Posture, 41(1)*, 7-12.

Appendix

Table 1: Potential contingency options in light of COVID-19

Plan	Participants	Pre-Intervention	Intervention	Post-Intervention
Original (If physical contact *is* possible with older adults)	• Older adults from FoF service	• Possible cognitive screen (ACE-III) • Anxiety questionnaire within VR (STAI – Spielberger, 1983)	• VR Intervention	• Anxiety questionnaire within VR (STAI – Spielberger, 1983) • Sense of 'presence' questionnaire (Freeman et al., 2003). • Semi-structured interview including UX questions

Contingency 1 (If *no* physical contact is possible with vulnerable older adults)	• Older adults from FoF service		• Send materials depicting VR Intervention (e.g. screenshots/ video)	• Semi-structured phone interview including UX questions
	Adjunct screening sample: • Younger adults (e.g. students) with or without FoF (or e.g. fear of heights)	• Anxiety questionnaire within VR (STAI – Spielberger, 1983)	• VR Intervention	• Anxiety questionnaire within VR (STAI – Spielberger, 1983) • Sense of 'presence' questionnaire (Freeman et al., 2003). • Semi-structured phone interview including UX questions
Contingency 2	• Older adults from FoF service	• Anxiety questionnaire (STAI – Spielberger, 1983)	• Send materials depicting VR Intervention (e.g. screenshots/ video)	• Anxiety questionnaire (STAI – Spielberger, 1983)- *After viewing specific*

(If *no* physical contact is possible with anyone)				*scenario image/ video* • Semi-structured phone interview including UX questions

VR = Virtual reality

FoF = Fear of falling

UX = User experience

ACE-III = Addenbrooke's Cognitive Examination 3

STAI = The State-Trait Anxiety Inventory

Appendix 2.2 – Template for email to NHS GG&C Older People's Psychology Service Clinical Psychologists

Hi [Recruiting Clinical Psychologists],

[Psychologist 1] and I had a good discussion today around recruitment- Thanks again [Psychologist 2] for outlining the eligible sample numbers.

The main outcome is that we are going to go ahead with recruitment; I'm expected to finish data collection around May. [Recruiting Psychologists] are going to kindly start contacting potential participants for their initial interest, and ask if they consent for the researcher, myself, to contact them via phone. We also have an ethics-approved Participant Information Sheet to send them (attached), or I can send them, before I call - What do you think would be the best way to get this to them?

In this first call I'll explain the study further and gain their verbal consent for the actual study- which will be in a final phone call with myself. Between these two calls I'll post/ email them the VR intervention materials (images & written text) for them to read, which the final structured phone interview will be based on. All we require from you [Recruiting Psychologists] is their name/ phone number (& email if they have one)- which [Psychologist 1] and I agreed can be sent to me via my NHS email whenever you have someone [Primary Researcher's NHS email].

For ease, here is a preliminary flowchart of the expected process; Green represents your involvement as Clinicians:

[Psychologist 1], you also asked for an example of what you could say to patients to gain initial interest, I was thinking something along the lines of:

- *"We were wondering if you would be interested in taking part in a study on Fear of Falling.*
- *It would involve a trainee Psychologist/ researcher, Luke, calling you to discuss your view on a new treatment for Fear of Falling involving 'Virtual Reality'.*

- *It can be done entirely from home over the phone, and you would be sent information on the treatment, which you will later tell us your thoughts on.*
- *Here is (/we will send) you an information sheet on the study.*
- *You do not have to decide now, however, if you are interested now, do we have your permission to send the researcher your name/ phone number?*
- *This is for Luke to call you to explain more about the study and you can decide whether you want to take part or not."*

Thanks all, I hope this is helpful. I'll be sending some potential times for a next meeting which hopefully we can all attend.

Kind Regards,

Luke

Luke Barracliffe

Trainee Clinical Psychologist

***Appendix 2.3* – Summary of Expert and service-user discussion and feedback for VR FoF Treatment**

Summary of Expert and service-user discussion and feedback for VR FoF Treatment

Service user:

Primary researcher's telephone discussion with female service user of Older Adult Psychology service in her 60s, working part-time. The recruiting Clinical Psychologists consensually provided her details to the primary researcher.

Aim: To explore her experience and needs around FoF to inform VR treatment design.s

Her experience/ history of FoF

- Has been seeing clinical psychologist (CP) since before Christmas 2019- First time seeing CP, expected only a few sessions, but pleased she's had prolonged input.
- FoF improved a lot but still somewhat present.
- Has experienced multiple falls, some resulting in dental damage and fractures- big source of fears. Has had hip replacement.
- One fall involving a revolving door at her work, which knocked her over.
- Uses a walking stick
- Initially terrified to leave house/ wouldn't unless had to.
- Would park near buildings to reduce walking
- Thoughts of "I'm going to fall", "I can't walk anywhere"
- Had dreams about falling
- Used to be a very independent person- dislikes idea of relying on others.
- Worried if can't take dog for a walk.

- Is able to stay in house during Covid quarantine without facing fears currently- No children at home, so less reason to go out.

What helped improve her FoF

- Has found Psychologist's 'soothing voice' helpful and being told which behaviours increase falling risk (e.g. looking down). Has been gradually going outside/ exposing self to situations- going with her husband helps as he assures her he'll catch her. Has been out alone successfully- felt pleased/ gained confidence.

Feared environmental factors & related behaviours

- A pebble/ stone on the ground
- Black ice, snow- worries about winter approaching- especially getting dark earlier.
- Will scan ground to see if its even- constantly looks down when scared.
- Busy places- avoids walking near people ("someone's going to bump into me")
- People walking dogs- they'll jump up and unbalance her, or she'll get tangled in the lead
- Using quieter routes or planning routes before
- Inclines/ hills/ uneven pavements- will cross the road to avoid this
- Prefers uphill to downhill
- Unfamiliar routes
- School kids out in streets at lunchtime- avoids this time period
- Imagines others falling (e.g. if sees someone riding fast on a bike)
- Handrails help her- would be worried if weren't any- has asked ahead of going on holidays if accommodation has these and requests ground floor; would still go if didn't get this, but not ideal.
- Prefers lift over stairs.

Perceived participation

- She feels people would be willing to engage- but perhaps not those in early stages of treatment (said she would not have considered it a few months ago, but would now).

Consultant Clinical Psychologist:

Summary of feedback from Older Adult Psychologist over multiple meetings with Computer Science colleagues, the primary research and their supervisor, on VR intervention design.

- ***Initial intervention version from Computer Science Colleague 1:***
    - Greater contrast in colours between ceiling and floor
    - Good range of task situations
    - Incorporate use of a Likert scale
    - Development of a 'tilt alarm'
        - Advice on when this should be triggered- e.g. when walking and looking down
    - Less weathered objects, such as cars
    - Advised on specific outdoor task
    - Discussion of exposure grading

- ***Second intervention version from Computer Science Colleague 2:***
    - Incorporating use of an 'avatar'
    - Very impressed overall- large improvement from previous version in tasks and realism
    - High ecological validity
        - Tasks relevant to older adults, and accurate/realistic visuals
    - Exposure tasks well graded from easy to difficult
    - Potentially more realistic avatar voice/ an actual voice recording- to make it relatable for users

- Minor language/ cultural differences in text- "cell phone" to "mobile phone"

Appendix 2.4 – Mental Health Measures

GAD-7 Anxiety

Over the last 2 weeks, how often have you been bothered by the following problems? *(Use "✔" to indicate your answer)*	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3

Column totals: ___ + ___ + ___ + ___

= *Total Score* _____

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	**Somewhat difficult**	**Very difficult**	**Extremely difficult**
☐	☐	☐	☐

PHQ-9 Depression

Over the last 2 weeks, how often have you been bothered by any of the following problems? *(Use "✔" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving .around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3
Column totals	___	+ ___	+ ____	+ ___

= *Total Score* _____

Scoring notes.

- ***PHQ-9 Depression Severity***

Scores represent: **0-5 = mild 6-10 = moderate 11-15 = moderately severe 16-20 = severe depression**

- ***GAD-7 Anxiety Severity.***

This is calculated by assigning scores of 0, 1, 2, and 3, to the response categories of "not at all," "several days," "more than half the days," and "nearly every day," respectively. GAD-7 total score for the seven items ranges from 0 to 21.

Scores represent: **0-5 mild 6-10 moderate 11-15 moderately severe anxiety 15-21 severe anxiety.**

FES-I – Falling Concern

Now we would like to ask some questions about how concerned you are about the possibility of falling. For each of the following activities, please circle the opinion closest to your own to show how concerned you are that you might fall if you did this activity. Please reply thinking about how you usually do the activity. If you currently don't do the activity (e.g. if someone does your shopping for you), please answer to show whether you think you would be concerned about falling IF you did the activity.

		Not at all concerned *1*	*Somewhat concerned* *2*	*Fairly concerned* *3*	*Very concerned* *4*
1	Cleaning the house (e.g. sweep, vacuum or dust)	*1*	*2*	*3*	*4*
2	Getting dressed or undressed	*1*	*2*	*3*	*4*
3	Preparing simple meals	*1*	*2*	*3*	*4*
4	Taking a bath or shower	*1*	*2*	*3*	*4*
5	Going to the shop	*1*	*2*	*3*	*4*
6	Getting in or out of a chair	*1*	*2*	*3*	*4*
7	Going up or down stairs	*1*	*2*	*3*	*4*
8	Walking around in the neighbourhood	*1*	*2*	*3*	*4*

9	Reaching for something above your head or on the ground	*1*	*2*	*3*	*4*
10	Going to answer the telephone before it stops ringing	*1*	*2*	*3*	*4*
11	Walking on a slippery surface (e.g. wet or icy)	*1*	*2*	*3*	*4*
12	Visiting a friend or relative	*1*	*2*	*3*	*4*
13	Walking in a place with crowds	*1*	*2*	*3*	*4*
14	Walking on an uneven surface (e.g. rocky ground, poorly maintained pavement)	*1*	*2*	*3*	*4*
15	Walking up or down a slope	*1*	*2*	*3*	*4*
16	Going out to a social event (e.g. religious service, family gathering or club meeting)	*1*	*2*	*3*	*4*

<u>Scoring:</u> 16-19= Low falling concern, 20-27= Moderate, 28-64= High.

Tinetti, M., Richman, D., & Powell, L. (1990). Falls efficacy as a measure of fear of falling. *Journal of gerontology, 45*(6), 239.

Appendix 2.5 – Intervention materials

Using Virtual Reality to treat Fear of Falling

Participant Handout

Thank you for agreeing to participate in our study. As discussed in our last phone call, you have been sent these materials to review before we call you to ask you your thoughts on them. Please take your time to read through this and look at the images. You do not have to read it all at once and you can take breaks, but try and look at all the information.

Introduction

We are developing a new Virtual Reality (VR) treatment to help people with their fear of falling. It will involve practising tasks people may do in the real world in order to reduce their anxiety and reduce the risk of falls. Before we physically test this on anyone, we would like people like yourself to read about and look at what we have developed and provide us with valuable feedback. This document outlines what would happen during the treatment.

Equipment

Virtual reality, or 'VR', is a computer-generated environment which is interacted with in a realistic and immersive way. It often uses goggles or a headset through which users can experience the virtual environment. Users can look and walk around in the virtual environment as they would in the real world. In the treatment we are developing, users would wear this headset and also hold a controller with buttons in each hand, to interact with the environment. These are widely and successfully used for other purposes, such as video games. Some people might experience side-effects like motion-

sickness; however, these are usually mild and disappear quickly. The headset can easily be taken off at any time and there would be a clinician present to support the user. Examples of the equipment are pictured below:

The Treatment

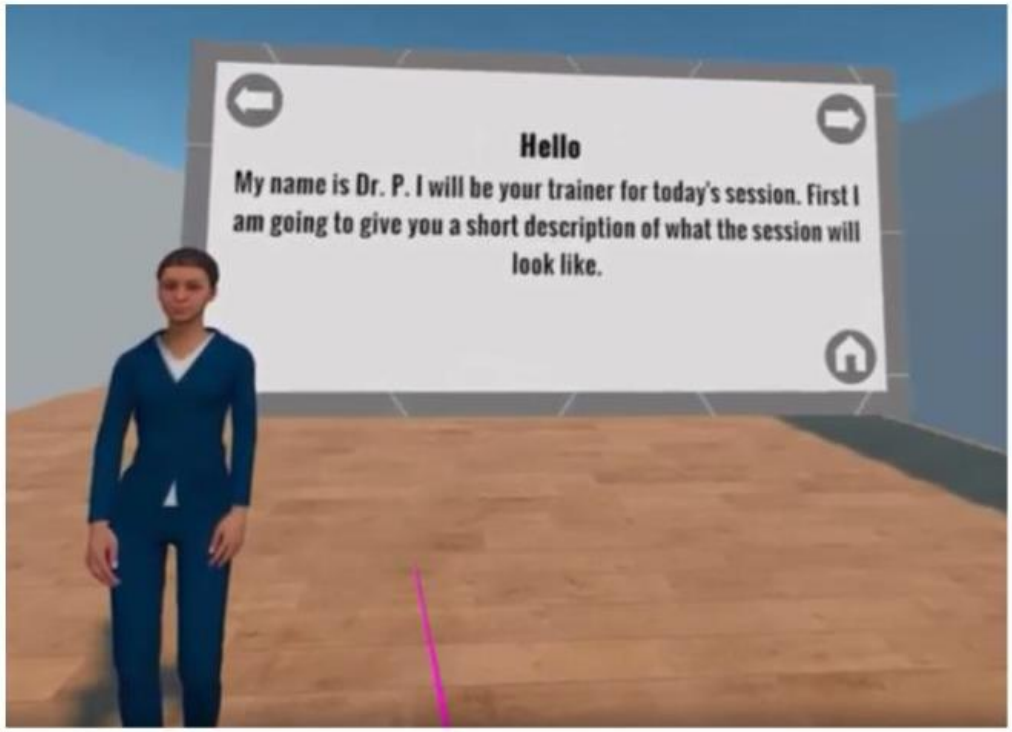
When the user puts on the equipment and the treatment begins, they will be greeted by a virtual person, or 'avatar', who will act as their clinician. The avatar is designed to be a friendly and helpful guide who supports the user in treatment by talking to them. Written instructions are also provided in the virtual environment. The controllers the user holds enables them to interact with things in the virtual environment by pointing and clicking, to select or manipulate objects. The user will also see a virtual pair of hands wherever they point the controllers they are holding. An example is provided below:

To help the user interact with items, such as buttons, there is a pink line or 'laser' which aims wherever they point.

This image shows the user pointing at an arrow button for example:

The image below shows the first view the user would see, including the avatar and a screen providing instructions. The avatar would also be reading these instructions:

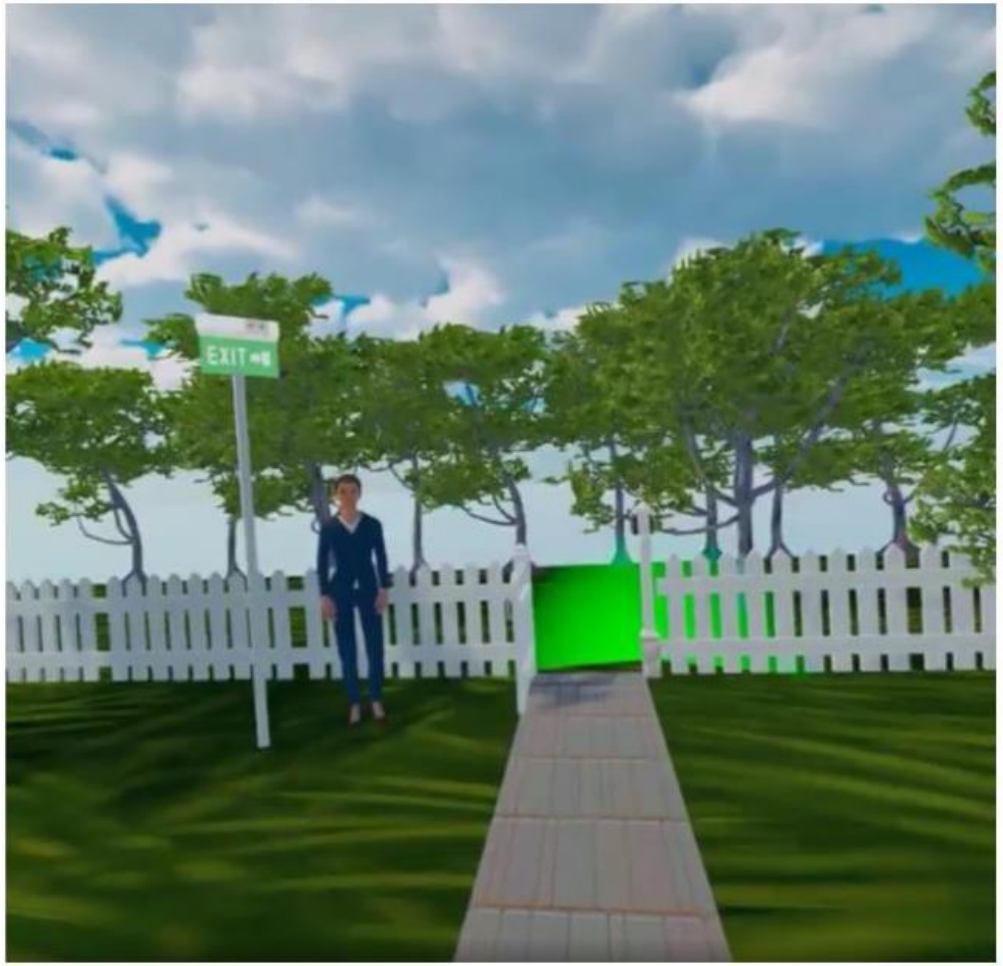
Here is another example of the menu screen. The user can select the arrows to move through the instructions:



Once the avatar has introduced the treatment, the user can choose tasks to complete which are similar to those they might do in the real world, such as opening a cupboard or answering a phone. These tasks are graded from easy to hard. The idea is to gradually work up to more challenging tasks. As the user does this and gets used to each task, their anxiety and fear of falling is expected to gradually reduce. Tasks can be repeated as many times as the user would like.

This is what the task selection menu would look like. In this example, the menu outlines the tasks and the location where the task is to be completed, such as picking up a magazine in the living room. This menu depicts the 'easy' difficulty tasks for the user to choose from:

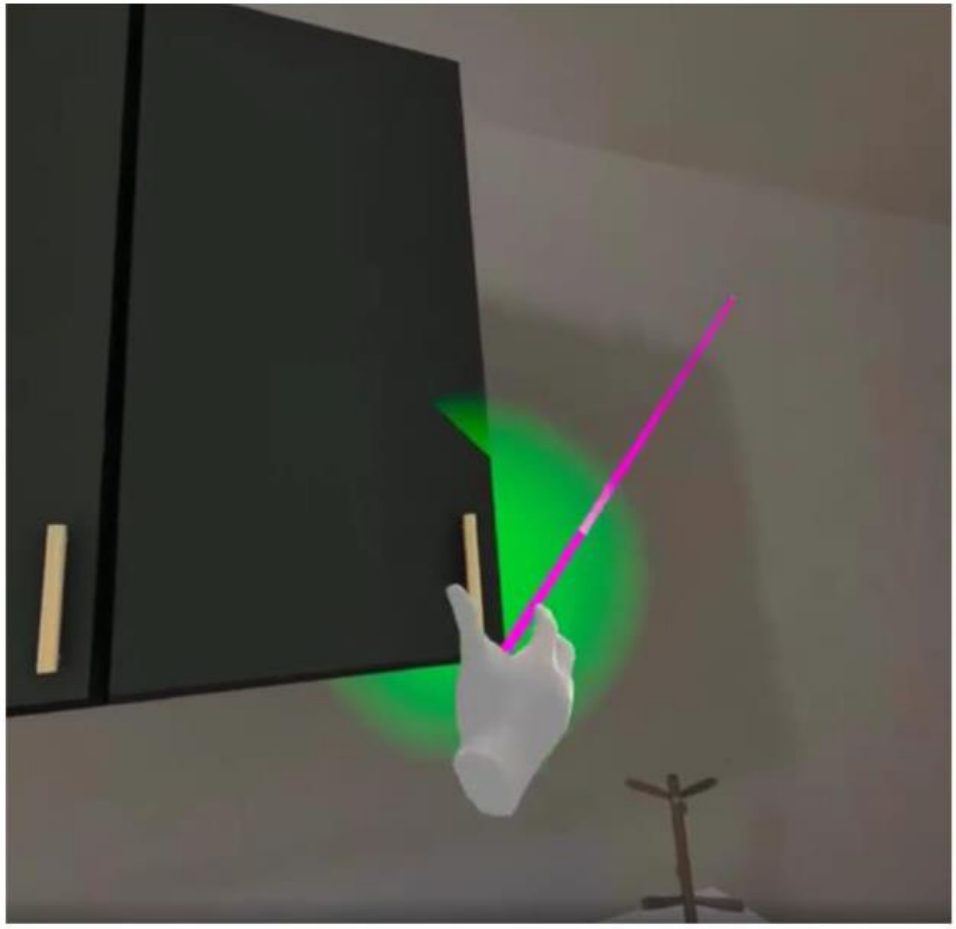
Here is an example of a task graded as 'easy' difficulty. The environment is a front garden, and the task is to walk to the post box/ mailbox, the location of which is highlighted with a green light. The avatar will also verbally remind the user of the task:



Once a task has been successfully completed, a message like this appears, with instructions on how to return to the task menu. This requires walking back to the start point and selecting an "Exit" sign, like the one shown below left:

This is another example of a task graded as 'easy', The environment is a kitchen and the task is to open the top cupboard. The cupboard location is highlighted with a green light:

This shows the user's virtual hand reaching to open the cupboard to complete the task:



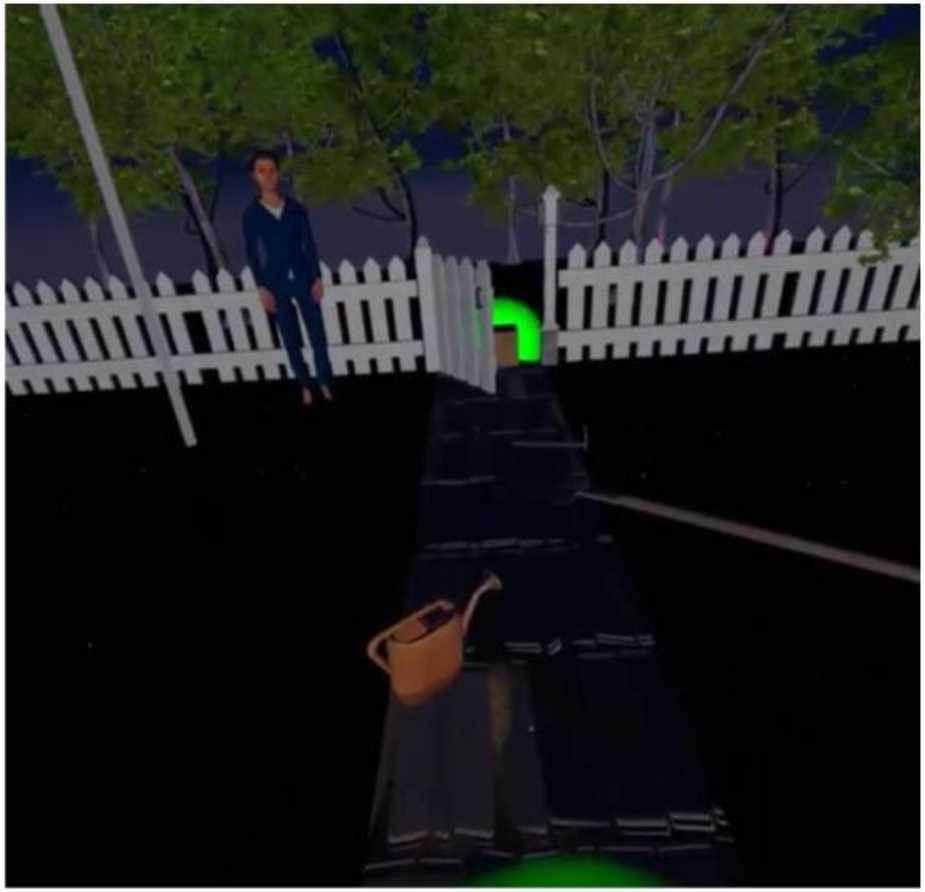
This is an example of a task graded as 'medium' difficulty. Again, the task is to walk to the post box. However, this time the light is dimmer, and the post box is lower; meaning that the user must bend to around waist height to reach it. This makes the task more challenging:

There are also some obstacles blocking the path which the user must navigate. If the user accidentally touches or walks through an object, the controllers will vibrate to alert them to this error:

This is another example of a task graded as medium difficulty. The environment is a living room and the task is to reach the TV remote to mute the TV, which requires navigating around furniture. The lighting is slightly dim, and the remote control is at waist height. The TV is also audible:

This shows the TV remote on the table, highlighted in green:

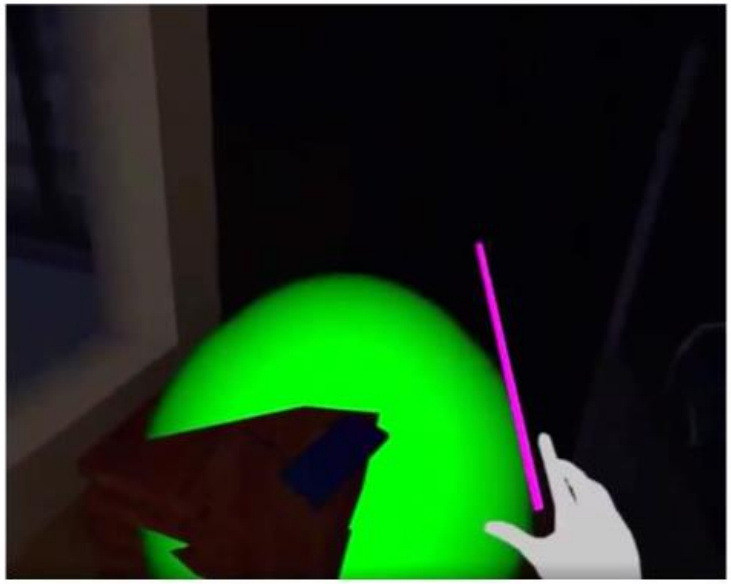
This is an example of a task graded as 'hard' difficulty. The environment is the garden and the task is to pick up a package on the ground. Added challenges include the reduced lighting conditions and stormy weather, including hail and thunder sounds. There are obstacles to navigate on the path and retrieving the package requires bending down:



This is the package on the ground:

This is another example of a harder task. The environment is a bedroom and the task is to answer a ringing phone, highlighted in green. Again, the lighting is dim and there are obstacles to navigate around, such as the bed and a chair. The phone is on a low surface that requires bending:

This shows the user reaching for the mobile phone, highlighted by a green light:



In order to track the effect of completing these tasks on the users' anxiety levels, everyone will be asked to rate their anxiety before and after completing each task. The range of scores include 'very relaxed', 'relaxed', neutral', 'anxious' and 'very anxious'. These ratings will be tracked so that users can see whether their fears reduce after a task. Here is an example of this scale:

This shows the user selecting an option from this scale:

Another feature of the treatment is a 'tilt alarm' which makes a sound whenever a user looks down at their feet whilst both tilting forward and walking. This alarm is included in the program because people tend to look down at their feet instead of their surroundings when they are fearful of falling. This alert aims to help users notice when they do this and it is expected that this feedback will reduce this unhelpful behaviour. Users will be told how many times they set off the tilt alarm after completing each task. An example of this is shown below, along with other information, such as time taken to complete the task:

What happens next?

Thank you for taking the time to carefully read and think about this document. As explained during the recruitment and consent call, the next step involves having an interview with the researcher to discuss your views on this new Virtual Reality treatment for fear of falling. You do not need to prepare anything for this, only have this document with you for the call. Your feedback is most important and highly valued. We look forward to speaking with you.

Luke Barracliffe, Trainee Clinical Psychologist

Luke.Barracliffe@ggc.scot.nhs.uk; l.barracliffe.1@research.gla.ac.uk

&

Hamish McLeod, Professor of Clinical Psychology, University of Glasgow

Hamish.McLeod@glasgow.ac.uk; 0141 211 3922

Appendix 2.6 –Semi-structured interview process & schedule

Virtual Reality Intervention for Fear of Falling:

Semi-structured interview schedule

Phone call 1 to participant:

Approx. **10-20min**

- Researcher answers any queries on study and consent procedure.
- Researcher gains verbal consent using consent document as reference, which participant received previously from NHS clinician.
- Mutually arrange date and time to call for main study, approximately one week or more from expected arrival time of VR materials.

Researcher sends participant VR example materials

Phone call 2 to participant:

Approximately one week after materials are received, as agreed with participant in first call.

Approx. **30-75min total**

- Demographic questions
- Complete 3 questionnaires **(15-45min)**:
  - PHQ-9, GAD-7, FES-I
- Semi-structured interview **(15-30min)**:

Main topic	Probing questions
General impressions	- What are your overall impressions of the intervention? - *Does it appear to be a positive experience?* - Does it look realistic? - What do you think of the 'tilt alarm' feature? - Are the tasks realistic/ relevant to you?
Acceptability	- Would you be willing to try this intervention? - *What would encourage you to try it?* - *What makes you feel unsure about trying it?*
Feasibility	- Does it meet your needs for helping fear of falling (FoF)? - Can you see this being part of regular treatment for FoF (treatment as usual)?
Tolerability	- What do you think of the Virtual reality induced symptoms and effects (VRISE)? - Do you foresee any other issues with trying/ completing the intervention?

- Ask participant if they would like summary of study findings

These questions are based on recommendations for exploring user experience of VR via semi-structured interviews and on past research using these methods (Birckhead et al., 2019; Jung et al., 2017).

References:

Birckhead, B., Khalil, C., Liu, X., Conovitz, S., Rizzo, A., Danovitch, I., ... Spiegel, B. (2019). Recommendations for Methodology of Virtual Reality Clinical Trials in Health Care by an International Working Group: Iterative Study. *Journal of Medical Internet Research Mental Health, 31*, 6(1).

Jung, T., tom Dieck, C., Moorhouse, N., tom Dieck, D. (2017, January). Tourists' experience of virtual reality applications. In 2017 International conference on consumer electronics (ICCE). IEEE.

Kroenke, K., Spitzer, R. L., &, Williams, J. B. (2001). The PHQ-9: validity of a brief depression severity measure. *Journal of General Internal Medicine, 16(9)*, 606-13.

Spitzer, R. L., Kroenke, K., Williams, J. B., et al. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine, 166(10)*, 1092-7.

Tinetti, M., Richman, D., et al. (1990). Falls efficacy as a measure of fear of falling. *Journal of gerontology, 45(6)*, 239.

West Midlands - South Birmingham Research Ethics Committee

Attendance at PRS Sub-Committee of the REC meeting on 16 February 2021

Committee Members:

Name	*Profession*	*Present*	*Notes*
Dr Peter Guest	Retired Consultant Radiologist	Yes	
Dr Elizabeth Hensel	Consultant Clinical Psychologist	Yes	
Dr Kathryn Kinmond	Psychologist and University Lecturer	Yes	

Also in attendance:

Name	*Position (or reason for attending)*
Ms Amy Peters	

***Appendix 2.9* – Thematic Analysis Log of discussions with second researcher**

Log of Thematic Analysis discussions with second researcher:

Each meeting occurred in private with the two researchers present only. The primary researcher's proposed themes were presented and openly discussed to invigorate thinking and increase immersion into the data. They were not 'approved' or 'coded' by the second researcher, as per Braun & Clarke's (2006, 2019) approach.

Meeting 1:

- Discussed deductive-inductive approach.
    - Agree this as best given a priori question themes, based around study aims.
- Discussed demographics and nature/ context of data from this
    - I.e., lower SIMD, all female, no male perspectives of VR intervention etc.
- Agree on most themes as generally reflective of data.
- Discussion led to division of theme **'Certainty and safeness'**, to create **'Engagement and trust'**.
    - Initially combined but separated due to tentativeness of some statements in the latter theme, not fitting the original.

Meeting 2:

- Discussed primary researcher's reflections on data.
    - Overall participants' positive impressions of the intervention, with some points for improvement.
    - Reflected on fact that some suggested improvements are more

possible than others.
    - E.g., Creation of additional tasks (possible) vs. Removal VR sideeffects (not easily possible).
- Discussed **‘Relevance to real life’** and **‘Task choice & difficulty’** themes.
    - Led to combing these to **‘Task relevance, choice & difficulty’**, as definitions were too similar.
- Discussed **‘Additional VR features’** and **‘Task relevance, choice & difficulty’** themes.
    - Former sub-theme also merged with the latter, as not enough data points for **‘Additional VR features’** alone, and too similar in content.

Appendix 2.10 - Manuscript Submission Guidelines: "Journal of Computers in Human Behavior". (https://www.elsevier.com/journals/computers-in-human-behavior/0747-5632/guide-for-authors)

This write-up is transferable to the guidelines of the target journal. Some minor elements differ, for instance, their recommended 'Introduction' and 'Theory' sections are conflated, allowing readers to smoothly follow the project as a thesis.

GUIDE FOR AUTHORS

Your Paper Your Way

We now differentiate between the requirements for new and revised submissions. You may choose to submit your manuscript as a single Word or PDF file to be used in the refereeing process. Only when your paper is at the revision stage, will you be requested to put your paper in to a 'correct format' for acceptance and provide the items required for the publication of your article.
To find out more, please visit the Preparation section below.

INTRODUCTION

Computers in Human Behavior is a scholarly journal dedicated to examining the use of computers from a psychological perspective. Original theoretical works, research reports, literature reviews, software reviews, book reviews and announcements are published. The journal addresses both the use of computers in psychology, psychiatry and related disciplines as well as the psychological impact of computer use on individuals, groups and society. The former category includes articles exploring the use of computers for professional practice, training, research and theory development. The latter category includes articles dealing with the psychological effects of computers on phenomena such as human development, learning, cognition, personality, and social interactions. The journal addresses human interactions with computers, not computers per se. The computer is discussed only as a medium through which human behaviors are shaped and expressed. The primary message of most articles involves information about human behavior. Therefore, professionals with an interest in the psychological aspects of computer use, but with limited knowledge of computers, will find this journal of interest.

Types of contributions
Original theoretical works, research reports, literature reviews, software reviews, book reviews(by invitation only) and announcements.

Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:
- E-mail address
- Full postal address

All necessary files have been uploaded:
Manuscript:
- Include keywords
- All figures (include relevant captions)
- All tables (including titles, description, footnotes)
- Ensure all figure and table citations in the text match the files provided
- Indicate clearly if color should be used for any figures in print

Graphical Abstracts / Highlights files (where applicable)
Supplemental files (where applicable)

Further considerations
- Manuscript has been 'spell checked' and 'grammar checked'
- All references mentioned in the Reference List are cited in the text, and vice versa
- Permission has been obtained for use of copyrighted material from other sources (including the Internet)
- A competing interests statement is provided, even if the authors have no competing interests to declare
- Journal policies detailed in this guide have been reviewed
- Referee suggestions and contact details provided, based on journal requirements

For further information, visit our Support Center.

BEFORE YOU BEGIN

Ethics in publishing
Please see our information on Ethics in publishing.

Studies in humans and animals
If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The manuscript should be in line with the Recommendations for the Conduct, Reporting, Editing and Publication of Scholarly Work in Medical Journals and aim for the inclusion of representative human populations (sex, age and ethnicity) as per those recommendations. The terms sex and gender should be used correctly.

Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should comply with the ARRIVE guidelines and should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Institutes of Health guide for the care and use of Laboratory animals (NIH Publications No. 8023, revised 1978) and the authors should clearly indicate in the manuscript that such guidelines have been followed. The sex of animals must be indicated, and where appropriate, the influence (or association) of sex on the results of the study.

Declaration of interest
All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places: 1. A summary declaration of interest statement in the title page file (if double anonymized) or the manuscript file (if single anonymized). If there are no interests to declare then please state this: 'Declarations of interest: none'. 2. Detailed disclosures as part of a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. More information.

Submission declaration and verification
Submission of an article implies that the work described has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. To verify originality, your article may be checked by the originality detection service Crossref Similarity Check.

Use of inclusive language
Inclusive language acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Content should make no assumptions about the beliefs or commitments of any reader; contain nothing which might imply that one individual is superior to another on the grounds of age, gender, race, ethnicity, culture, sexual orientation, disability or health condition; and use inclusive language throughout. Authors should ensure that writing is free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions. We advise to seek gender neutrality by using plural nouns ("clinicians, patients/clients") as default/wherever possible to avoid using "he, she," or "he/she." We recommend avoiding the use of descriptors that refer to personal attributes such as age, gender, race, ethnicity, culture, sexual orientation, disability or health condition unless they are relevant and valid. These guidelines are meant as a point of reference to help identify appropriate language but are by no means exhaustive or definitive.

Author contributions
For transparency, we encourage authors to submit an author statement file outlining their individual contributions to the paper using the relevant CRediT roles: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing. Authorship statements should be formatted with the names of authors first and CRediT role(s) following. More details and an example

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscript has been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

Copyright

Upon acceptance of an article, authors will be asked to complete a 'Journal Publishing Agreement' (see more information on this). An e-mail will be sent to the corresponding author confirming receipt of the manuscript together with a 'Journal Publishing Agreement' form or a link to the online version of this agreement.

Subscribers may reproduce tables of contents or prepare lists of articles including abstracts for internal circulation within their institutions. Permission of the Publisher is required for resale or distribution outside the institution and for all other derivative works, including compilations and translations. If excerpts from other copyrighted works are included, the author(s) must obtain written permission from the copyright owners and credit the source(s) in the article. Elsevier has preprinted forms for use by authors in these cases.

For gold open access articles: Upon acceptance of an article, authors will be asked to complete a 'License Agreement' (more information). Permitted third party reuse of gold open access articles is determined by the author's choice of user license.

Author rights

As an author you (or your employer or institution) have certain rights to reuse your work. More information.

Elsevier supports responsible sharing

Find out how you can share your research published in Elsevier journals.

Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated.

Open access

Please visit our Open Access page for more information.

Elsevier Researcher Academy

Researcher Academy is a free e-learning platform designed to support early and mid-career researchers throughout their research journey. The "Learn" environment at Researcher Academy offers several interactive modules, webinars, downloadable guides and resources to guide you through the process of writing for research and going through peer review. Feel free to use these free resources to improve your submission and navigate the publication process with ease.

Language (usage and editing services)

Please write your text in good English (American or British usage is accepted, but not a mixture of these). Authors who feel their English language manuscript may require editing to eliminate possible grammatical or spelling errors and to conform to correct scientific English may wish to use the English Language Editing service available from Elsevier's Author Services.

Submission

Our online submission system guides you stepwise through the process of entering your article details and uploading your files. The system converts your article files to a single PDF file used in the peer-review process. Editable files (e.g., Word, LaTeX) are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail.

Submit your article
Please submit your article via https://www.editorialmanager.com/chb/default.aspx/

PREPARATION

Queries

For questions about the editorial process (including the status of manuscripts under review) or for technical support on submissions, please visit our Support Center.

NEW SUBMISSIONS

Submission to this journal proceeds totally online and you will be guided stepwise through the creation and uploading of your files. The system automatically converts your files to a single PDF file, which is used in the peer-review process.
As part of the Your Paper Your Way service, you may choose to submit your manuscript as a single file to be used in the refereeing process. This can be a PDF file or a Word document, in any format or lay-out that can be used by referees to evaluate your manuscript. It should contain high enough quality figures for refereeing. If you prefer to do so, you may still provide all or some of the source files at the initial submission. Please note that individual figure files larger than 10 MB must be uploaded separately.

References
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct.

Formatting requirements
There are no strict formatting requirements but all manuscripts must contain the essential elements needed to convey your manuscript, for example Abstract, Keywords, Introduction, Materials and Methods, Results, Conclusions, Artwork and Tables with Captions.
If your article includes any Videos and/or other Supplementary material, this should be included in your initial submission for peer review purposes.
Divide the article into clearly defined sections.

Figures and tables embedded in text
Please ensure the figures and the tables included in the single file are placed next to the relevant text in the manuscript, rather than at the bottom or the top of the file. The corresponding caption should be placed directly below the figure or table.

Peer review

This journal operates a double anonymized review process. All contributions will be initially assessed by the editor for suitability for the journal. Papers deemed suitable are then typically sent to a minimum of two independent expert reviewers to assess the scientific quality of the paper. The Editor is responsible for the final decision regarding acceptance or rejection of articles. The Editor's decision is final. Editors are not involved in decisions about papers which they have written themselves or have been written by family members or colleagues or which relate to products or services in which the editor has an interest. Any such submission is subject to all of the journal's usual procedures, with peer review handled independently of the relevant editor and their research groups. More information on types of peer review.

Double anonymized review

This journal uses double anonymized review, which means the identities of the authors are concealed from the reviewers, and vice versa. More information is available on our website. To facilitate this, please include the following separately:

Title page (with author details): This should include the title, authors' names, affiliations, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.
Anonymized manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.

REVISED SUBMISSIONS

Use of word processing software
Regardless of the file format of the original submission, at revision you must provide us with an editable file of the entire article. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier). See also the section on Electronic artwork.
To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

LaTeX
You are recommended to use the latest Elsevier article class to prepare your manuscript and BibTeX to generate your bibliography.
Our Guidelines has full details.

Article structure

Subdivision - numbered sections
Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction
State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods
Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

Theory/calculation
A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results
Results should be clear and concise.

Discussion
This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions
The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Appendices
If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.; in a subsequent appendix, Eq. (B.1) and so on. Similarly for tables and figures: Table A.1; Fig. A.1, etc.

Essential title page information

- ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

• ***Author names and affiliations.*** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
• ***Corresponding author.*** Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-publication. This responsibility includes answering any future queries about Methodology and Materials. **Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.**
• ***Present/permanent address.*** If an author has moved since the work described in the article was done, or was visiting at the time, a 'Present address' (or 'Permanent address') may be indicated as a footnote to that author's name. The address at which the author actually did the work must be retained as the main, affiliation address. Superscript Arabic numerals are used for such footnotes.

Abstract
A concise and factual abstract is required and should not be longer than 200 words. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Graphical abstract
Although a graphical abstract is optional, its use is encouraged as it draws more attention to the online article. The graphical abstract should summarize the contents of the article in a concise, pictorial form designed to capture the attention of a wide readership. Graphical abstracts should be submitted as a separate file in the online submission system. Image size: Please provide an image with a minimum of 531 × 1328 pixels (h × w) or proportionally more. The image should be readable at a size of 5 × 13 cm using a regular screen resolution of 96 dpi. Preferred file types: TIFF, EPS, PDF or MS Office files. You can view Example Graphical Abstracts on our information site.
Authors can make use of Elsevier's Illustration Services to ensure the best presentation of their images and in accordance with all technical requirements.

Highlights
Highlights are mandatory for this journal. They increase the discoverability of your article via search engines. They consist of a short collection of bullet points that capture the novel results of your research as well as new methods that were used during the study (if any). Please have a look at the examples here: example Highlights.

Highlights should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 125 characters, including spaces, per bullet point).

Keywords
Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations
Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements
Do not include acknowledgements on the title page, as a footnote to the title or otherwise. In a separate file to the manuscript, list those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.)

Formatting of funding sources
List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Math formulae
Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Footnotes
Footnotes should be used sparingly. Number them consecutively throughout the article. Many word processors build footnotes into the text, and this feature may be used. Should this not be the case, indicate the position of footnotes in the text and present the footnotes themselves separately at the end of the article.

Artwork

Electronic artwork
General points
- Make sure you use uniform lettering and sizing of your original artwork.
- Preferred fonts: Arial (or Helvetica), Times New Roman (or Times), Symbol, Courier.
- Number the illustrations according to their sequence in the text.
- Use a logical naming convention for your artwork files.
- Indicate per figure if it is a single, 1.5 or 2-column fitting image.
- For Word submissions only, you may still provide figures and their captions, and tables within a single file at the revision stage.
- Please note that individual figure files larger than 10 MB must be provided in separate source files.

A detailed guide on electronic artwork is available.
You are urged to visit this site; some excerpts from the detailed information are given here.
Formats
Regardless of the application used, when your electronic artwork is finalized, please 'save as' or convert the images to one of the following formats (note the resolution requirements for line drawings, halftones, and line/halftone combinations given below):
EPS (or PDF): Vector drawings. Embed the font or save the text as 'graphics'.
TIFF (or JPG): Color or grayscale photographs (halftones): always use a minimum of 300 dpi.
TIFF (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.
TIFF (or JPG): Combinations bitmapped line/half-tone (color or grayscale): a minimum of 500 dpi is required.
Please do not:
- Supply files that are optimized for screen use (e.g., GIF, BMP, PICT, WPG); the resolution is too low.
- Supply files that are too low in resolution.
- Submit graphics that are disproportionately large for the content.

Color artwork
Please make sure that artwork files are in an acceptable format (TIFF (or JPEG), EPS (or PDF) or MS Office files) and with the correct resolution. If, together with your accepted article, you submit usable color figures then Elsevier will ensure, at no additional charge, that these figures will appear in color online (e.g., ScienceDirect and other sites) in addition to color reproduction in print. Further information on the preparation of electronic artwork.

Figure captions
Ensure that each illustration has a caption. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Any references cited in the abstract must be given in full. Unpublished results and personal communications are not recommended in the reference list, but may be mentioned in the text. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either 'Unpublished results' or 'Personal communication'. Citation of a reference as 'in press' implies that the item has been accepted for publication.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

Data references
This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

References in a special issue
Please ensure that the words 'this issue' are added to any references in the list (and any citations in the text) to other articles in the same Special Issue.

Reference management software
Most Elsevier journals have their reference template available in many of the most popular reference management software products. These include all products that support Citation Style Language styles, such as Mendeley. Using citation plug-ins from these products, authors only need to select the appropriate journal template when preparing their article, after which citations and bibliographies will be automatically formatted in the journal's style. If no template is yet available for this journal, please follow the format of the sample references and citations as shown in this Guide. If you use reference management software, please ensure that you remove all field codes before submitting the electronic manuscript. More information on how to remove field codes from different reference management software.

Users of Mendeley Desktop can easily install the reference style for this journal by clicking the following link:
http://open.mendeley.com/use-citation-style/computers-in-human-behavior
When preparing your manuscript, you will then be able to select this style using the Mendeley plug-ins for Microsoft Word or LibreOffice.

Reference formatting
There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/ book title, chapter title/article title, year of publication, volume number/book chapter and the article number or pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct. If you do wish to format the references yourself they should be arranged according to the following examples:

Reference style
Text: Citations in the text should follow the referencing style used by the American Psychological Association. You are referred to the Publication Manual of the American Psychological Association, Seventh Edition, ISBN 978-1-4338-3215-4, copies of which may be ordered online.
List: references should be arranged first alphabetically and then further sorted chronologically if necessary. More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c', etc., placed after the year of publication.
Examples:
Reference to a journal publication:
Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2010). The art of writing a scientific article. *Journal of Scientific Communications, 163*, 51–59. https://doi.org/10.1016/j.sc.2010.00372.
Reference to a journal publication with an article number:
Van der Geer, J., Hanraads, J. A. J., & Lupton, R. A. (2018). The art of writing a scientific article. *Heliyon, 19*, Article e00205. https://doi.org/10.1016/j.heliyon.2018.e00205.
Reference to a book:
Strunk, W., Jr., & White, E. B. (2000). *The elements of style* (4th ed.). Longman (Chapter 4).
Reference to a chapter in an edited book:
Mettam, G. R., & Adams, L. B. (2009). How to prepare an electronic version of your article. In B. S. Jones, & R. Z. Smith (Eds.), *Introduction to the electronic age* (pp. 281–304). E-Publishing Inc.
Reference to a website:
Powertech Systems. (2015). *Lithium-ion vs lead-acid cost analysis*. Retrieved from http://www.powertechsystems.eu/home/tech-corner/lithium-ion-vs-lead-acid-cost-analysis/. Accessed January 6, 2016
Reference to a dataset:
[dataset] Oguro, M., Imahiro, S., Saito, S., & Nakashizuka, T. (2015). *Mortality data for Japanese oak wilt disease and surrounding forest compositions*. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.
Reference to a conference paper or poster presentation:
Engle, E.K., Cash, T.F., & Jarry, J.L. (2009, November). *The Body Image Behaviours Inventory-3: Development and validation of the Body Image Compulsive Actions and Body Image Avoidance Scales*. Poster session presentation at the meeting of the Association for Behavioural and Cognitive Therapies, New York, NY.
Reference to software:
Coon, E., Berndt, M., Jan, A., Svyatsky, D., Atchley, A., Kikinzon, E., Harp, D., Manzini, G., Shelef, E., Lipnikov, K., Garimella, R., Xu, C., Moulton, D., Karra, S., Painter, S., Jafarov, E., & Molins, S. (2020, March 25). *Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88)*. Zenodo. https://doi.org/10.5281/zenodo.3727209.

Video
Elsevier accepts video material and animation sequences to support and enhance your scientific research. Authors who have video or animation files that they wish to submit with their article are strongly encouraged to include links to these within the body of the article. This can be done in the same way as a figure or table by referring to the video or animation content and noting in the body text where it should be placed. All submitted files should be properly labeled so that they directly relate to the video file's content. In order to ensure that your video or animation material is directly usable, please provide the file in one of our recommended file formats with a preferred maximum size of 150 MB per file, 1 GB in total. Video and animation files supplied will be published online in the electronic version of your article in Elsevier Web products, including ScienceDirect. Please supply 'stills' with your files: you can choose any frame from the video or animation or make a separate image. These will be used instead of standard icons and will personalize the link to your video data. For more detailed instructions please visit our video instruction pages. Note: since video and animation cannot be embedded in the print version of the journal, please provide text for both the electronic and the print version for the portions of the article that refer to this content.

Data visualization
Include interactive data visualizations in your publication and let your readers interact and engage more closely with your research. Follow the instructions here to find out about available data visualization options and how to include them with your article.

Supplementary material

Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

Research data

This journal encourages and enables you to share data that supports your research publication where appropriate, and enables you to interlink the data with your published articles. Research data refers to the results of observations or experimentation that validate research findings. To facilitate reproducibility and data reuse, this journal also encourages you to share your software, code, models, algorithms, protocols, methods and other useful materials related to the project.

Below are a number of ways in which you can associate data with your article or make a statement about the availability of your data when submitting your manuscript. If you are sharing data in one of these ways, you are encouraged to cite the data in your manuscript and reference list. Please refer to the "References" section for more information about data citation. For more information on depositing, sharing and using research data and other relevant research materials, visit the research data page.

Data linking

If you have made your research data available in a data repository, you can link your article directly to the dataset. Elsevier collaborates with a number of repositories to link articles on ScienceDirect with relevant repositories, giving readers access to underlying data that gives them a better understanding of the research described.

There are different ways to link your datasets to your article. When available, you can directly link your dataset to your article by providing the relevant information in the submission system. For more information, visit the database linking page.

For supported data repositories a repository banner will automatically appear next to your published article on ScienceDirect.

In addition, you can link to relevant data or entities through identifiers within the text of your manuscript, using the following format: Database: xxxx (e.g., TAIR: AT1G01020; CCDC: 734053; PDB: 1XFN).

Mendeley Data

This journal supports Mendeley Data, enabling you to deposit any research data (including raw and processed data, video, code, software, algorithms, protocols, and methods) associated with your manuscript in a free-to-use, open access repository. During the submission process, after uploading your manuscript, you will have the opportunity to upload your relevant datasets directly to *Mendeley Data*. The datasets will be listed and directly accessible to readers next to your published article online.

For more information, visit the Mendeley Data for journals page.

Data in Brief

You have the option of converting any or all parts of your supplementary or additional raw data into a data article published in *Data in Brief*. A data article is a new kind of article that ensures that your data are actively reviewed, curated, formatted, indexed, given a DOI and made publicly available to all upon publication (watch this video describing the benefits of publishing your data in *Data in Brief*). You are encouraged to submit your data article for *Data in Brief* as an additional item directly alongside the revised version of your manuscript. If your research article is accepted, your data article will automatically be transferred over to *Data in Brief* where it will be editorially reviewed, published open access and linked to your research article on ScienceDirect. Please note an open access fee is payable for publication in *Data in Brief*. Full details can be found on the Data in Brief website. Please use this template to write your *Data in Brief* data article.