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RESEARCH PAPER

Developing an automated VR cognitive treatment for psychosis: gameChange VR therapy

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Abstract The automated delivery of psychological treatment using virtual reality (VR) has the potential to revolutionise patient access to evidence-based care. VR creates immersive, interactive computer simulations, which elicit responses similar to the real world. VR simulations provide an ideal opportunity for the experimentation and experiential learning that are key to successful cognitive therapy. If automated, and using the latest consumer kit, VR treatment can substantially scale-up the delivery of psychological therapy. However, the successful application of automated VR to mental health difficulties requires precise treatment targets linked to the right psychological theory and techniques. This paper describes the process of development of an automated VR cognitive therapy targeting anxious avoidance of everyday social situations by patients with psychosis. In the gameChange project, a person-centered design process was used involving people with lived experience of psychosis, clinical psychologists, designers, and software developers. The six-session gameChange VR therapy consists of six everyday scenarios: a street, a bus, a café, a pub, a doctor's waiting room, and a shop. Each scenario has five levels of difficulty. Every level provides an opportunity to test out fearful cognitions while limiting the

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use of safety-seeking behaviours, allowing patients to build confidence in their ability to cope. Learning is facilitated by a virtual coach and therapeutic gaming elements are included. Data from user testing indicates that the gameChange VR therapy is easy to use and engaging. The clinical effectiveness of gameChange VR therapy is now being tested in a randomised controlled trial with several hundred patients with psychosis.

Introduction

Virtual Reality (VR) could revolutionise the delivery of powerful psychological treatments. The automation of evidence-based treatments using VR could allow services to substantially scale up the provision of effective psychological therapy. If an automated treatment is shown to work well in clinical trials, then there can be confidence in the outcomes when implemented in clinical services. But how best is an automated VR psychological treatment developed? This paper describes the development process for gameChange (www.gameChangeVR.com), an automated VR cognitive therapy targeting the highly prevalent anxious social avoidance in psychosis.

VR for mental health disorders

VR is a term often used very broadly. We use it to describe three-dimensional computer simulations of environments that can be navigated around and interacted with (we do not use it, for example, to describe the viewing of 3D film). Virtual environments can elicit similar cognitive and emotional responses to their real world counterparts (e.g. Martens, Antley, Freeman, Slater, Harrison & Tunbridge, 2019). It is therefore possible to enter virtual replicas of troubling situations and make new learning through the use of specific psychological techniques. Using VR in this way has a number of advantages. It allows full control over the environment. Situations can be entered repeatedly and the difficulty graded. Specific stimuli, or scenarios of therapeutic value, can be embedded in the simulations to increase the potency of the experience. Similarly, the treatment can be made much more engaging than traditional therapies, and tasks can be designed to increase the sense of reward and achievement. Furthermore, although VR elicits similar emotions to the real world, people are aware that the situations are not real. This provides a substantial benefit for psychological treatment: patients are more willing to enter challenging situations and experiment with alternative ways of responding. This is particularly relevant in psychosis where fearful beliefs can be extreme and make real world tests very daunting. Crucially, however, the learning made in VR translates into the real world. The power of VR interventions thus far has been most evident in the treatment of anxiety disorders (Freeman et al., 2017). A meta-analysis of 30 randomised controlled trials of VR exposure therapy showed a large effect size compared to waitlist controls and equivalent effects compared to in vivo exposure therapy (Carl et al., 2018). Though still in its relative infancy, promising evidence is emerging for the use of VR treatments in psychosis (Freeman et al., 2016; Pot-Kolder et al., 2018; Freeman, Lister et al., 2019). It is important to note that the overwhelming majority of the VR interventions tested to date have relied on a therapist being present to deliver the psychological techniques, greatly limiting the scalability of these treatments.

Automating therapy delivered in VR

We have automated the delivery of VR interventions through the use of a virtual coach, who explains the psychological principles and guides the person through the treatment (Freeman et al., 2018; Freeman, Lister et al., 2019). This, coupled with the use of consumer VR hardware, means provision of cognitive therapy can be substantially scaled up. Our first automated VR therapy, for fear of heights, was shown in a randomised controlled trial with 100 participants to have a large effect size ($d = 2.0$; Freeman et al., 2018), exceeding that expected from therapist-assisted exposure using real world heights ($d = 1.1$; Wolitzky-Taylor, Horowitz, Powers & Telch, 2008). This suggests automated VR therapy can be as effective, if not more effective, than treatments delivered in traditional formats. Nonetheless, it may be that specific phobias are more tractable than the mental health difficulties seen in secondary services. The next stage of our work has therefore been to develop and test automated VR therapy for more complex difficulties, starting with the highly prevalent anxious social withdrawal in psychosis.

Targeting anxious social withdrawal in psychosis

Many people with psychosis are socially withdrawn and isolated, with significant consequences for both mental and physical health. Patients with psychosis are sedentary for large periods of the day (Stubbs, Williams, Gaughran, & Craig, 2016). Life expectancy is on average 14.5 years shorter (Hjorthøj, Stürup, McGrath, & Nordentoft, 2017), due to largely preventable conditions such as high blood pressure, diabetes, and heart disease. Partly this physical ill health reflects unhealthy lifestyles including inactivity. Our view is that inactivity arises, at least in part, from anxious avoidance. In a recent survey of 1800 patients with non-affective psychosis in NHS services, two-thirds of patients reported levels of anxious avoidance comparable to those with agoraphobia (Freeman, Taylor, Molodynski, & Waite, 2019). The causes of this anxious withdrawal may be many: paranoia, threatening voices, social anxiety, negative self-image, panic attacks, and lack of confidence in ability to

cope. Difficult experiences may have happened outside too. However the end result is unfounded or exaggerated fear cognitions (with a range in content). These fearful cognitions lead to the avoidance of social situations, or when this is not possible the use of in-situation defence (safety-seeking) behaviours. These behaviours prevent the receipt and processing of disconfirmatory information and hence the fear cognitions persist. Overcoming anxious avoidance requires a highly active treatment directly in the troubling situations, with the dropping of defence behaviours, so that patients can evaluate the fear cognitions in the moment (Clark, 1999). Such an intervention could be effectively delivered in VR.

The gameChange project

gameChange is a three-year project funded by the UK's National Institute for Health Research (NIHR). Led by researchers at the University of Oxford and Oxford Health NHS Foundation Trust, the project has collaborators from many other organisations, including the Royal College of Art, the McPin Foundation, NIHR MindTech, Oxford VR, and several other NHS trusts. The project has four main objectives spanning treatment development to implementation:

- to develop a powerful VR treatment—which is usable, engaging, and scalable - targeting anxious avoidance of social situations by patients with psychosis;
- to identify the barriers and facilitators for the implementation of the VR therapy and produce an implementation plan;
- to conduct a multisite randomised controlled trial testing the clinical effectiveness and cost effectiveness of the gameChange VR therapy;
- and to create a commissioning case and commercialisation plan to enable the rolling out of this intervention across the UK's National Health Service.

This paper describes the development of the automated VR therapy, which was carried out over the first 12 months of the project.

The design process

gameChange VR therapy was developed using a person-centred design process. This is an iterative approach where the end-user's perspective and needs are incorporated into all stages of the design process with the aim of creating an easy to use, meaningful, and accessible treatment (Lyon & Koerner, 2016). Designs had to reflect the needs of patients with psychosis, whilst incorporating the psychological principles of the treatment and adhering to the parameters of the project (e.g. timetable, technical feasibility). The design process was a collaboration between people with lived experience of psychosis, clinical psychologists, designers, and software developers. Overall responsibility for final design decisions was held by the clinical psychology team in Oxford, who co-ordinated input from different contributors. The stages of the design process included the setting out of the initial design brief, workshops and individual sessions addressing key questions for outlining the treatment, production of thirty-three workflows, a script for the virtual therapist, prototypes of the scenarios to obtain feedback, 3D modelling of the virtual environments, creating and animating the virtual characters, software implementation of the workflows, extensive user testing revisions to the software and quality assurance procedures.

The treatment brief

gameChange built on a series of studies from our group showing that VR: could elicit unfounded fearful thoughts about other people (e.g. Freeman et al., 2003); is safe to use with patients with psychosis (e.g. Freeman, Pugh, Vorontsova, Antley & Slater, 2010); and that it could be successfully used in treatment for patients with psychosis (Freeman et al., 2016). Freeman and colleague's (2016) treatment study demonstrated that it is not simply exposure to a troubling situation that is key for clinical change but actively testing out fears with the dropping of defence behaviours. This approach follows the successful real-world behaviour experiments described by Clark (1999) for the treatment of anxiety disorders, and is also consistent with the theory of inhibitory learning that indicates the benefits of a belief disconfirmation approach over a habituation approach (Craske, Treanor, Conway, Zbozinek, & Vervliet, 2014). Key learning about the automation of VR therapy was taken from two previous VR interventions that we have developed: for treating the fear of heights (Freeman et al., 2018) and persecutory delusions (Freeman, Lister et al., 2019). This previous work provided the treatment structure, including 30 minute sessions, graded levels of difficulty, and automation through the use of a virtual coach. The virtual coach (in a virtual office) would explain the treatment rationale and then accompany the patient into the different simulations. We used our experience of developing intensive, short-term face-to-face treatments for psychosis focussed on clear, single goals (e.g. Freeman et al., 2015). We planned to develop a treatment of approximately a six session length and to incorporate practice tasks between sessions. Thus the outline treatment brief was to target anxious avoidance in psychosis, creating 6 scenarios with 5 levels of difficulty in each. Every level would provide an opportunity to test out fearful cognitions with defence behaviours dropped. Participants would be guided through the treatment by a virtual coach. This brief provided a framework for the treatment, but clearly detailed work was required concerning the environments to be developed, the tasks within them, the content of the scripts, and how tasks would be set between VR sessions.

The input of users

The expertise of people with lived experience of psychosis was central to all design decisions. In total 53 people with lived experience contributed to the design of the gameChange therapy (with over 500 hours of input). Patient involvement was set up and supported by the McPin Foundation, a mental health research charity that helps involve experts by experience in research. Participants were recruited through adverts circulated in NHS services, social media, and patient involvement groups. Participants varied in their stage of recovery, familiarity with technology, and

we deliberately encouraged involvement from individuals sceptical about VR.

From the outset a gameChange Lived Experience Advisory Panel (LEAP) was set up consisting of ten people with lived experience of psychosis. The LEAP was recruited evenly from the five different centres in the UK that would be taking part in the clinical trial (Bristol, Manchester, Newcastle, Nottingham, and Oxford). They provided consultation throughout design and development, initially helping to define the six VR scenarios and later feeding into the design of characters, the script, VR prototyping, and the development of usability measures.

In addition to the LEAP, twelve design workshops were run in London, Newcastle, Nottingham, Manchester, Bristol and Oxford. These included people with lived experience of psychosis (n = 3-9 in each workshop). All workshops were arranged and facilitated by a member of the McPin Foundation, with longstanding expertise in supporting involvement of those with mental health difficulties in research. A clinical psychologist was also always present to provide support to participants if needed. In addition workshops were also attended by designers, and a member of the software development team.

Each workshop had a specific set of design aims which included, for example, the choice of scenarios, the tasks completed in each scenario, the coach's appearance and what they said, background characters, and important situational triggers. For example participants described the types of characters that were more challenging (e.g. men, teenagers and groups of people), the importance of background noise as a trigger for anxiety, and the tasks that are particularly challenging e.g. queuing with people behind.

Following each workshop, designs and VR prototypes were developed and these were then tested at the subsequent workshop in a continuous, iterative process. In the later stages of development, seventeen individual user testing sessions were held to provide feedback on the gameChange application.

Five workshops were also held with NHS staff in Bristol, Nottingham, Newcastle, Manchester and Oxford. Staff from a range of different services and professional backgrounds. They provided feedback on the gameChange programme (including the scenarios) and how the intervention would fit within the current care pathways.

Script development

The script included the dialogue of the virtual coach as well as other virtual characters in the scenarios and thus is fundamental to successful automation. The script needed to effectively communicate psychological principles in an engaging and accessible way, as well as ensuring that the therapy content was relevant and appropriate for a range of different psychosis presentations. Key fears and associated defence behaviours were identified and highlighted throughout the script. Preferences for the wording of feedback and encouragement from the coach was provided through the user workshops. The result of this iterative process was an early draft of the script (100 pages). The script was role-played in full, and feedback by psychologists, developers, and individuals with lived experience, who then provided feedback. The feedback form these sessions was then incorporated into the script. This process was repeated three times before reaching the final script, which was then reviewed by the LEAP who provided additional feedback.

Scenario workflows

Once designs were finalised, the sequence of events, timings, and the journey of the user through each VR scenario was mapped out in detail using workflows. This ensured that designs were effectively translated into VR. Workflows were designed based on timed, real world role plays of each scenario. These visual flows were then implemented in VR by the software development team. Thirty-three workflows define the logics of the gameChange application.

Software development

Software development was carried out by Oxford VR (www.oxfordvr.org), a spin-out company from the University of Oxford. Their team included virtual environment artists, character artists, animators, software developers and audio engineers, many of whom were recruited from the games industry. The character animations were recorded with an infrared camera-based motion capture system with the help of a team of professional actors. Many of the voice lines were recorded during five extra sessions in a sound recording studio. Each version of the therapy went through scrutiny by Oxford VR's quality and assurance lead. The different scenario prototypes were reviewed on a weekly basis by clinical psychologists, who provided feedback back to the development team.

gameChange was certified as a Class I medical device in conformity with the Essential Requirements of the Directive 93/42/EEC. The process involved evaluating risks, software, usability, clinical safety and efficacy of the application.

gameChange VR therapy

The design process led to the development of the automated VR treatment. An initial list of scenarios relevant to patients was generated by the LEAP. This included: being on the street; using public transport (e.g. trains, buses); places where you have to queue, such as banks or doctor's surgeries; shops and supermarkets; a pub or café; enclosed spaces such as a lift; open plan office spaces; waiting rooms; job centres, hairdressers; and lectures. Some of these situations had to be excluded, either because they would be too challenging to replicate in VR or because the scenario highlighted was unrelated to anxious avoidance. Each LEAP member was asked to select the three scenarios they considered the most important. The reasons they thought these were important were also recorded, so that if, for example, a lift scenario was selected because it involves being enclosed then this aspect could be incorporated in a different scenario if necessary e.g. being enclosed in on a crowded bus. In this way, we attempted to ensure each 'trigger' was embedded in one of the final scenarios. The final six gameChange scenarios selected were: a bus, a street, a café, a pub, a doctor's waiting room, and a shop (see Fig. 1).

Fig. 1 The six gameChange scenarios: (A) Street, (B) Bus, (C) Café, (D) Doctor's waiting room, (E) Corner shop, and (F) Pub.

The VR therapy begins in the coach's room where the patient meets Nic, their virtual coach (see Fig. 2). Nic explains how VR works and introduces the psychological principles and aims of the treatment. One lived experience advisor described Nic's role as *''not just the person who is providing instructions, it is the person who is there to reassure, not about the facts she is saying, but the trust part. Yes, it's about having someone who is there for you in any situation, not someone who spouts facts at you. It's about not being alone, a sense of bond, understanding and care. It's helpful for her to say, ''Whenever you need to exit it is ok, I will be there whenever you leave''*. Patients are asked to rate their confidence in managing everyday situations before selecting the scenario they wish to try, starting with level 1 and repeating levels when needed. Patients then re-rate their confidence again at the session end. Each session in VR lasts approximately 30 minutes (see Fig. 3).

The gameChange scenarios

In each of the six scenarios, first level is relatively quiet and empty, so that patients have the chance to learn the essential elements of the situation. As patients progress through the levels, the scenarios become busier and noisier; other triggers of anxiety appear or become more prominent, for example CCTV cameras, characters standing closer to the patient or blocking the exit, police officers, hooded teenagers and people looking at them. In each scenario, patients have to carry out key tasks such as ordering a drink, finding items in shop or calling across a room to someone. These were specifically designed activate fearful cognitions and thus provide opportunities for the patient to test out their fears. Some tasks are shared across scenarios whilst others are unique and thus made the principal challenge within that scenario (See Table 1).

In addition, the testing of fearful cognitions is prompted in two ways. Throughout levels, Nic encourages patients to test out their fears by doing something different and seeing what happens, for example, '*try looking around and making eye contact with others and see what happens*'. Secondly, events occur that require patients to drop defences that they may be using. For example, in the café a customer

Fig. 2 The virtual coach, Nic who walks patients through the gameChange therapy.

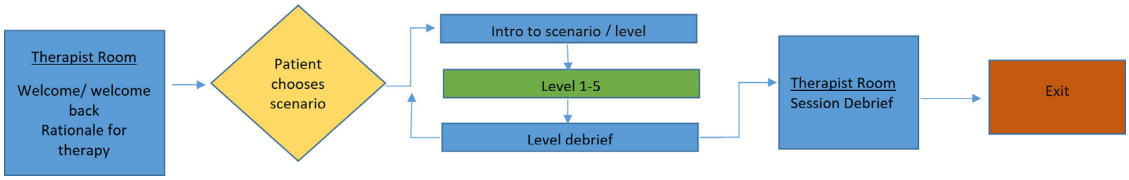

Fig. 3 The structure of the virtual reality treatment.

Table 1 The main challenges encountered in each scenario.

Challenges	Scenarios					
	Café	Pub	Bus	Doctor's surgery	Food shop	Street
Make a request/order	✓ *			✓		
Stay in a situation	✓	✓	✓	✓	✓	✓
Give personal information				✓		
Unexpected event/erratic behaviour		✓ *				
People looking towards you			✓	✓		✓
Trapped/shut in	✓		✓ *			
Required to find an item					✓ *	
Transition from safe place to unknown						✓ *
Open/exposed place		✓				✓ *
Awkwardly quiet				✓ *		

* Denotes the principal challenge for the scenario.

leaves their wallet on the counter and the patient is asked to shout after them across the café, drawing attention to themselves and prompting other characters to look at them, Thereby the patient has the experience of coping with this type of situation and they are thanked by the customer who left their wallet.

Delivery

gameChange is an automated psychological therapy and thus does not require a trained CBT therapist to deliver it. gameChange can be delivered by any member of staff, who's role would be to set up the equipment and provide encouragement and support. All delivery staff are trained to help the patient to get the most out of the programme. As with all interventions regular supervision remains important. Workshops with staff and patients identified peer support workers as well placed to deliver this intervention, as well as being delivered by assistant psychologists and psychologists. Workshops also suggested gameChange could be of value at different stages of the care pathway and could complement available treatments. gameChange can be delivered using commercially available VR equipment. This equipment is portable and quick to set up allowing gameChange to be delivered in clinic settings or in people's homes, as required.

Usability testing

The gameChange design process aimed to develop a powerful VR treatment targeting anxious avoidance that was useable and highly engaging. The success criterion set at the beginning of the project was for 90% of users to rate gameChange as immersive, easy to use, and engaging. A usability questionnaire was developed during the project. Formal usability testing was carried out initially in the later stages of development with five patients. Patients with lived experience of psychosis completed a session of gameChange VR therapy, providing feedback and completing the usability questionnaire. A second usability testing session was held with six patients when development was complete. The success criterion was achieved at this session with all six patients rating gameChange VR as immersive, easy to use, and engaging (see Table 2).

Next steps

gameChange VR therapy has been built and is currently being tested in a randomised controlled trial in five centres in the UK. The trial protocol has been published (Freeman et al., 2019b). The aim is to recruit 432 patients with psychosis who are anxious going into everyday situations. Patients are randomised either to the VR therapy plus usual care or to usual care only. The primary outcome measure is avoidance and anxiety in the real world using the Oxford Behavioural Avoidance Task (Freeman et al., 2016), in which patients are asked to move through a hierarchy of the situations they typically avoid, rating their anxiety at each step and stopping when the anxiety is too great. Secondary outcomes include activity levels measured by actigraphy;, psychiatric symptoms including depression and suicidality, and quality of life. The clinical trial will be completed in January 2021. In parallel with the trial, a process evaluation is being conducted to identify the facilitators and barriers to delivering gameChange in the UK's National Health Service. After the extensive and intensive design process that has been

Table 2 Results from usability testing sessions.

	Usability testing 1 (pre-completion) ($n = 5$)		Usability testing 2 (post-completion) ($n = 6$)	
	Easy	Difficult	Easy	Difficult
1. Knowing what to do in any given VR situation was...	2	3	6	0
2. Understanding the coach's instructions was...	4	1	6	0
3. Carrying out an action (for example, use the confidence rating scale, burst the bubbles) was...	5	0	6	0
4. Using the circles to move through the program was...	5	0	6	0
5. Learning what to do and how to do it was...	4	1	6	0
6. Remembering how to do things a second time was...	5	0	6	0
	Agree	Disagree	Agree	Disagree
7. When using the VR, I felt like I was in the situation.	3	2	6	0
8. When other people were there in the VR, I felt like I was sharing the space with them.	4	1	6	0
9. I enjoyed using the treatment	3	2	6	0
10. The VR made me feel sick	1	4	0	6

conducted to produce a highly engaging and useable automated treatment, these evaluation elements will provide a thorough test of the gameChange VR therapy.

Disclosure of interest

DF is a co-founder and non-executive board director of Oxford VR, a University of Oxford spin-out company. DF and JF hold equity in Oxford VR AR and SL do consultancy work for OxfordVR. RP and BG work for Oxford VR as part of the development team. TK, JW, IK, RL, LR and FW have no conflict of interest.

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