Gradual and shared immersion in virtual reality exposure therapy

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ABSTRACT

Virtual Reality demonstrates potential to reduce the high dropout rates in exposure therapy. Yet evidence of its efficacy is more mixed for treatment of PTSD than phobia. While this may be down to fewer studies for PTSD, we argue that it might be because conventional approaches replace rather than complement methods of controlling engagement. We report on two approaches aimed at complementing methods of engagement through graduated immersion, shared with the therapist, in evocative stimuli. The high-end approach uses Immersive Projection Technology (IPT) to place the therapist and client within the simulation together. Graduation of immersion is achieved through turning on more projection walls. The commodity approach uses VR ready mobile phones that can be held in the hand and later inserted into a headset. This approach is currently being used in the treatment of some of the victims of the recent Manchester Arena bombing. A further novelty is the use of 360 video. This has facilitated rapid customisation after a terrorist incident, allowing victims to re-enter the stadium in which they were attacked, from the safety of the clinic. This work demonstrates alternative technology solutions for VRET that might overcome the variability in its efficacy when used with more vulnerable clients. It also demonstrates how customised stimuli can be quickly and cheaply gathered after a major incident.

1. INTRODUCTION

The growth in acceptability of mental illness and its treatment is putting therapist services under pressure across the world, while terrorist and other mass causality incidents are increasingly placing sudden surge in demands. More efficient ways of working are needed to meet this growing and unpredictable demand. Exposure Therapy is the most evidenced treatment for phobia and PTSD, however, it suffers high dropout rate, typically from too low or high engagement. Virtual Reality Exposure Therapy (VRET) has potential to address this, as it seems more engaging to resistant populations and stimuli can be controlled to theoretically manage engagement. VRET has demonstrated clear efficacy across the treatment of phobias but efficacy varies across studies of treatment of PTSD. It could be argued that those with PTSD are in general in more need of greater control of engagement and support from the therapist. We argue that using traditional technologies, management of engagement is hampered by immersing the client alone within the stimuli before they have had help to approach it.

Exposure Therapy (ET) is one of the most evidenced treatments for PTSD (Cukor, Spitalnick, Difede, Rizzo, & Rothbaum, 2009). Yet it suffers a 40% dropout rate, largely as a result of either lack of, or too sudden, engagement of the client (Imel, Laska, Jakupcak, & Simpson, 2013). Reluctance to engage in ET is a key predictor of negative treatment outcomes (Rothbaum & Schwartz, 2002). Seemingly engaging to resistant populations, VRET might help by reducing dropout rates (Goncalves, Pedrozo, Coutinho, Figueira, & Ventura, 2012) and improve treatment outcomes. Consumer VR is beginning to facilitate clinical treatment in ecologically

valid conditions (Slater & Sanchez-Vives, 2016). VRET gives the control of imaginal and ecological validity of in vivo ET (Goncalves et al., 2012). Under control of the clinician, clients are gradually exposed to evocative stimuli, according to individual needs (Rothbaum & Hodges, 1999). Yet it is the stimuli rather than immersion in it that is graduated. Efficacy has been demonstrated in four independent meta-analyses (Page & Coxon, 2016) and effects transfer to the real world (Morina, Ijntema, Meyerbroker, & Emmelkamp, 2015). However, the majority of the independent studies covered in the meta-analysis where for treatment of phobias. There have been insufficient Randomised Control Trial (RCT) in VRET for PTSD for a meta-study to measure efficacy. Reports of efficacy, including dropout rate, in the treatment of PTSD, have been mixed across studies. A recent larger RCT actually showed slightly less efficacy including slightly higher dropout when VRET was compared to a control group undertaking conventional ET (McLay et al., 2017). McLay et al., proposed that the reason for the big differences in study results is related to the role of a therapist. The therapists we have talked to worry that conventional technologies hinder traditional methods of controlling engagement.

ET facilitates sustained awareness of a problem in order to rationalise (A Carey, 2010). Both avoidance of (Spinhoven, Drost, de Rooij, van Hemert, & Penninx, 2014) and fixation towards (Van Bockstaele et al., 2014) anxiety-provoking experiences maintains psychological distress, whilst improved attentional control is associated with recovery from mental health problems (Goschke, 2014). Dual awareness between evoked memories and present-moment experience is seen to facilitate exposure in traumatised individuals (Rothschild, 2003). Rothschild shows how therapist use Non-verbal communication (NVC) to mediate a client's attention between the two. Conversely, "immersive virtual environments can break the deep, everyday connection between where our senses tell us we are and where we are actually located and whom we are with" (Sanchez-Vives & Slater, 2005). Traditional VRET uses Head Mounted Displays (HMD) (Sanchez-Vives & Slater, 2005), which block both the present surroundings and therapist from view (Roberts, Fairchild, Campion, García, & Wolff, 2016). Immersive Projection Technology (IPT) puts people together within the simulation, whereas Augmented Reality (AR) does so without removing the present. Although both have been sparsely used in VRET related studies, e.g. IPT (Pan, Gillies, Barker, Clark, & Slater, 2012), their potential to encourage natural client-therapist interaction is yet to be studied. However, these systems are expensive, take a long time to install and are not generally portable. Traditional IPT systems combine stereo and parallax enabled through viewpoint tracking. Less technical surround projection that does not have these features, is beginning to be used in reminiscence therapy for dementia.

2. RECOMENDATIONS FROM INITIAL CONSULTATION WITH THERAPISTS

Based on the apparent paradox between the importance of dual awareness in exposure therapy and the blocking out if the real world in conventional VR, we have consulted six therapists from a range of backgrounds in exposure therapy. From this we have derived the following recommendations.

Recommendations:

- Client and therapist are in the environment together;
- A familiar and safe environment remains visible in initial therapy;
- The level of immersion is gradually increased;
- The client can move or look away from stimuli that they find threatening;
- The client can approach stimuli in their own time;
- Natural interpersonal space between client and therapist to be maintained and adjustable;
- Non-verbal communication should not be obstructed in early therapy;
- The therapist should be able to see how a client reacts to stimuli and identify what part of the stimuli is being reacted to;
- The therapist can judge when a client dissociates and if the they are fixating on or away from threat, by monitoring their gaze;
- The therapist can use non-verbal communication when bringing the client's attention back to the present.

3. HIGH-END SOLUTION – IMMERSIVE PROJECTION

Our high-end solution is a laboratory demonstrator that situates client and therapist together within potentially evocative stimuli, figure 1. The system is based on a VR CAVE. Importantly our display is larger than a standard CAVE, being an octagon with over 5m between opposite screens. Stimuli can be projected on all eight walls and floor or any subset. Stereo is provided through active stereo shutter glasses but can be turned off when not needed. Viewpoint parallax is supported to a single user, the client. Parallax can be disabled to allow both to view from the same stationary perspective. Positional sound is provided to all occupants, for example client and therapist, through wavefield synthesis. We now describe the solution in terms of the above recommendations:

Client and therapist are in the environment together – The client and therapist stand together, surrounded by controllable and potentially evocative stimuli. The client can thus be reassured by the presence of the therapist. *A familiar and safe environment remains visible in initial therapy* – The display system remains clearly visible, for example, edges between walls, tracker and lack of projection roof. Seats can be taken into the environment to replicate the seated situation in a clinic. Other furniture can be brought in. However, the environment will not be familiar until it has been experienced many times. *The level of immersion is gradually increased* – by starting with one projection wall in mono, adding stereo and parallax and then gradually turning on additional walls and floor. Additionally, to facilitate client engagement and feeling of safety, the dose of exposure can be controlled by a client through interface devices, or through communication with a therapist within the feedback loop. This loop might include qualitative methods such as verbal and non-verbal communication, quantitative methods such as questionnaires or psychophysiological monitoring in real time. *The client can move or look away from stimuli that they find threatening* – The display system is 5 metres across and the stimuli can appear to be far behind the screens. Less threatening stimuli can be projected on some screens and some may be turned off. *The client can approach stimuli in their own time* – is facilitated through freedom of movement within a 2.5m radius. *Natural interpersonal space between client and therapist to be maintained and adjustable*; The extra display size allows two people to easily maintain intimate (up to 0.5m), personal (0.5-1.2m) or social (1.2-3.6m) distance. Much of public space (3.6-7.7m) can be maintained by moving to opposite ends of the display, although the application of this within therapy is not obvious. *Non-verbal communication should not be obstructed in early therapy*; The only non-verbal communication that is obstructed is that related to the eyes. This includes gaze, pupil dilation, narrowing or widening and tears. This occlusion can be avoided in early therapy by delaying the use of stereo. Even when stereo glasses are worn, body language and head gaze can be used to judge how *a client reacts to stimuli and identify what part of the stimuli is being reacted to*. For example, when exposed to a virtual height, we have seen and filmed people shuffling and hunched as they edged along what appears to be a suspended beam, figure 1 right. When no stereo is used, interpersonal gaze can be used to reassure the client and the therapist has more non-verbal resources from which to *judge when a client dissociates by monitoring their gaze* and whether client is fixating on or away from threat. The latter is easier when parallax is not enabled. *The therapist can use non-verbal communication when bringing the client's attention back to the present*; The therapist can physically move between the client and threat and/or use gestures along with spoken word to direct attention back to the present.

Figure 1. Immersive Projection Technology allowing a shared experience in an exposure therapy experiment with a phobic subject. Left) The researcher (acting as a therapist) offers reassurance to the participant before evocative stimuli is encountered. Right) The participant's body language shows fear as she shuffles along a board that appears to be above a drop.

4. COMMODITY SOLUTION – VR CAPABLE PHONE

The commodity mobile solution uses VR capable phones. These allow 360 video or virtual worlds to be experienced while the phone is held in the hand or warn within a VR headset. Therapy might start by a therapist showing the client how to navigate the stimuli when the phone is held in the hand. To begin with, this can be done by swiping the finger. The client is then shown how to look around the environment by moving the phone around them. They are shown how to change stimuli, which is described in the next section. Finally the therapist demonstrates how to put the phone into the head-mounted display, put the display on and select and navigate the stimuli through it. Initially, this is all done using neutral stimuli that has nothing to do with what is feared. Once the client has practiced such use, he/she can be encouraged to select and navigate stimuli that might be evocative, starting with the least evocative. The client is encouraged to use the phone in the hand while the therapist watches how they explore and respond to the stimuli, intervening when necessary to reassure and perhaps reground the client.

Figure 2. Phone-based VR display. Therapists at the Manchester Resilience Hub practice the use of the technology before widening its use with victims of the Manchester Arena bombing. In this practice, therapists take turn playing the role of the client.

A Samsung / Oculus solution has been used. This combines Samsung phones with GearVR headset. S7 and S8 edge phones have been used with both versions of the GearVR headset. We now describe the solution in terms of the recommendations:

Client and therapist are in the environment together - While the phone is held in the hand, the therapist and client are completely visible to each other and clearly in the same place. However, that is not the place of the stimuli. Rather the stimuli are seen through a small window held in the hand of the client. *A familiar and safe environment remains visible in initial therapy* – This solution is easily deployed in the clinic, home and neutral environments. The familiar environment is visible to the client until they decide to put on the head-mounted display (HMD). *The level of immersion is gradually increased* – starting with a phone held in the hand, then moved around the head and finally worn on the head. *The client can move or look away from stimuli that they find threatening* – Natural movement can be used to move aspects of the stimuli out of view but the client cannot step away from the stimuli. *The client can approach stimuli in their own time* - The client can't physically walk towards the stimuli but can gradually select stimuli of every more evocative nature. *Natural interpersonal space between client and therapist to be maintained and adjustable* – The phones and definitely the headset lend themselves to the typical seated situation of therapy. However, interpersonal space can be adjusted by moving chairs and changing posture. *Non-verbal communication should not be obstructed in early therapy* – All NVC is clearly visible when the phone is held in the hand but eyes are occluded when the headset is worn. *The therapist should be able to see how a client reacts to stimuli and identify what part of the stimuli is being reacted to;* The therapist might sometimes be able to see what is on the screen of the phone when held in the hand. This will become more difficult when the phone is panned around the head and impossible when worn on the head. Non-verbal reactions will be visible, with the above caveat of eye occlusion when HMD is worn. *The therapist can judge when a client dissociates and if they are fixating on or away from the threat, by monitoring their gaze* – When the phone is held in the hand, the therapist can see if the client is fixating on it or away from it. Given the low field of view, this is a reasonable indication of fixating on or away from stimuli. However, the stimuli may or not be visible to the therapist, as above. *The therapist can use non-verbal communication when bringing the client's attention back to the present* – This is only hindered when the HMD is worn.

5. MEDIUM

Traditional VRET has used 3D interactive computer graphics. This gives high levels of customisation, allows content to be created that cannot easily be collected and increases engagement through integration. However, even the best computer graphics falls short of the realism of video. Furthermore, the creation of new content is typically lengthy and expensive. This has not been too much of a problem where triggers are generic. For example, many war veterans have experienced traumas in similar settings. However, terrorist attacks and other mass casualty civilian incidence can be more diverse. Furthermore, many involved in such incidence feel they want to go back to where it happened but want graduated exposure to prepare them. The wide availability, low cost and ease of use of 360 cameras and VR based phones that can use them, offers an alternative to conventional computer graphics. Footage of the site and even aftermath of particular traumatic incidences can be collected and edited within the timelines of therapy, especially given the cooling off period that is advised before therapy begins. After the Manchester Arena attack, we gathered 360 photographs and video of the entrance foyer in which the attack took place and the escape routes. Videos have included both footage of therapists walking around the space and walkthroughs, figure 3. 180 panoramic videos have also been collected. Our approaches have both been used with a variety of mediums. Both support interactive computer graphics, 360 video, and the two combined. The high end system also supports free viewpoint video, which is full 3D computer graphics reconstructed from multiple video streams. There is nothing but lack of funding stopping us from porting this to the phones.

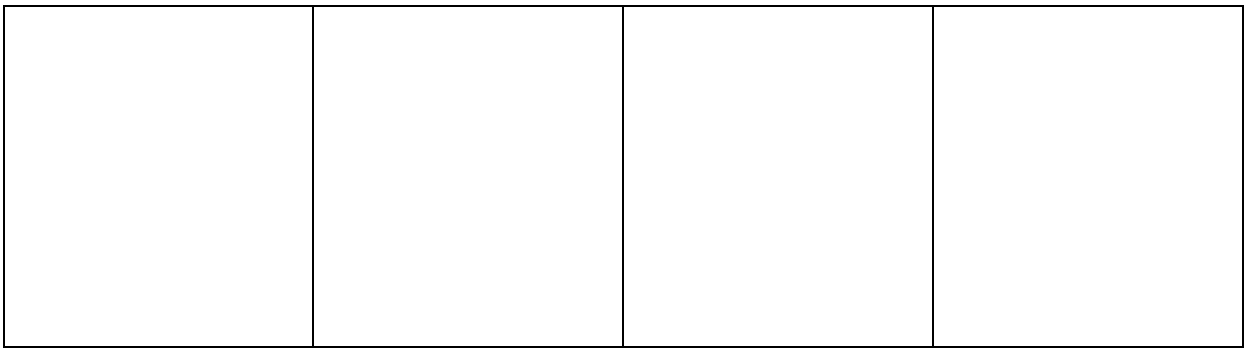

Figure 3. Snapshots of the 360 footage of Manchester Arena Bomb attack. **<Awaiting permission from Manchester Arena>.**

6. INITIAL FEEDBACK FROM CLIENTS, THERAPISTS AND PARTICIPANTS

Twenty Seven healthy and fourteen phobic participants have taken part in exposure therapy experiments in the high end approach. No problems of excessive anxiety were encountered. Prefrontal cortex activity as measured through fNIRS showed significant inhibitory learning across three sessions in phobic participants. This suggests efficacy. The participant with the highest score on the fear of heights questionnaire, showed clear signs of low level fear in initial sessions. Shortly after the experiments she reported back that the experience had given her the confidence to walk across a bridge close to her home for the first time. Both Therapists and clients at Pennine NHS Foundation Care Trust have experienced our approaches. One war veteran experienced the high end system running BRAVEMIND in low immersion mode. This was a highly experienced veteran of multiple tours of duty in many campaigns, who had been successfully treated for PTSD. He became very engaged in the experience, talking excitedly about the differences between the modelled Iraq environment and his own experiences. Sweat became noticeable on his forehead and the session was stopped. It is notable that this sweat would likely have been missed if he had been wearing an HMD. In the debrief he expressed much enthusiasm for the approach as a treatment for PTSD in war veterans. A second veteran, also considered treated in clinical terms, was shown the two approaches as well as a conventional VRET approach using a tethered headset and interactive computer graphics. He again was enthusiastic about the approaches. He suggested, without being prompted or given the background, that the less immersive options be used at the start of therapy and the more immersive towards the end. Therapists who have used the commodity approach with victims of the Manchester arena attack have also been highly positive. They report that the clients take quickly to the technology and seem to enjoy experimenting with its use. No problems have been encountered. Clients have controlled graduation of immersion for

themselves and have transitioned through the levels far quicker than expected. All have put on the HMD by the end of the first session with the technology. Interestingly, one of the clients chose to hold the HMD to her face rather than having it strapped in place.

7. DISCUSSION

VRET has been widely researched for over a decade and demonstrated efficacy across four metastudies. We have not found any literature directly suggesting problems of over engagement or anxiety caused from the therapist being out of site. There does seem to be growing evidence that efficacy of VRET is not as straight forward in the PTSD population as it is in the phobic one. This might simply be down to the number of trials. However, the latest RCT was a substantial trail that concluded efficacy was less than conventional exposure therapy. Both the literature and discussions with therapists reveal a mismatch in the kind of client therapist interactions and in particular methods for grounding in the present, between conventional exposure therapy and VRET. We were unable to find literature that attempts either to study this or propose technology solutions that might avoid it. It is notable that the majority of VRET uses traditional Head Mounted Displays and CGI, while immersive projection technology and augmented reality are better suited to shared experience and merging of simulated and real environments.

For the phobic subjects, IPT offered a clear advantage over surround projection that does not incorporate stereo or tracking driven viewpoint. This was because we employed IPT in VRET for treatment of acrophobia, and depth cues are important in giving a strong impression of height. Depth cues might be particularly relevant to other phobias, such as a bird flying into the face. However, for PTSD, depth cause are generally only useful in terms of creating a greater feeling of being there. The feeling of being present in the simulated environment can be achieved, albeit to a lesser extent, without these cues. Furthermore, this feeling might need to be balanced with that of feeling in the presence during therapy and it might be useful to keep the stimuli from seeming too real. Classic IPT does not resemble either an everyday or clinical environment and cannot be considered a familiar setting. While everyday objects can be brought into the environment, being surrounded by screens might be unsettling to people who are already unnerved. Surround projection onto existing walls that does not require stereo glasses or viewpoint tracking might be a better fit to therapy that does not specifically need depth cues. Such technology is already being used in reminiscence therapy for dementia by companies including 4D Immersive. Such an approach seems well suited to the treatment of PTSD within clinics. However, even this simpler variety of projection technology is far more expensive than our commodity phone based solution.

VR ready phones and tablets offer a low cost, highly portable solution that both therapists and clients can learn to use in minutes. It integrates smoothly with both 360 video and computer game engines. While initial use fits well to client therapist interaction, the technology lends itself well to home therapy, once therapist has helped the client gain confidence. 360 cameras offer a way of capture the places that an incident occurred before exposure therapy treatment is began.

The two approaches are very different. Augmented reality solutions might fill some of the gap. However, head mounted augmented reality, will for the moment, hide the eyes, which are probably the most important non-verbal communicational resource in therapy. Thus devices that can be held in the hand before warn on the head will not become obsolete with AR. Tango based systems would not only allow view of the real environment and company but also virtual assets to be placed around the clinic or living room and approached as one approaches stimuli in the large IPT.

8. CONCLUSIONS

The literature suggests that the evidence of efficacy of VRET is more convincing in phobia than in PTSD. This might suggest that VRET is more problematic in more vulnerable cases. Comparison of literature of exposure therapy and virtual reality suggests a paradox between: the importance of dual awareness of present and what is feared in exposure therapy; and virtual reality's ability to convince that what is simulated is real. Discussing this paradox with a variety of therapists led to a list of recommendations for VRET technology used with more vulnerable clients. We presented two technological approaches to VRET that each give affordances to these recommendations. The High End approach used immersive projection technology, whereas the commodity approach used phone based VR. Both allow graduated immersion and high levels of non-verbal communication between client and therapist during initial therapy. Both have been shown to therapists and treated clients who have provided supportive feedback. The high end approach has demonstrated efficacy in trials with a sub clinical phobic population. The commodity approach is now in use, treating victims of the Manchester Arena Bombing. Early feedback from the therapists suggests the approach is popular with both clients and therapists.

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