This is a pre-publication version of the following article: Coxon, M. (2013). Immersive virtual reality in the psychology classroom: What purpose could it serve? *Psychology Teaching Review, 19*(1), 21-30.

Immersive Virtual Reality in the Psychology Classroom: What Purpose Could It Serve?

Matthew Coxon

York St John University, UK

Author Note

Matthew Coxon, Counselling and Psychology, York St John University

Correspondence concerning this article should be addressed to Matthew Coxon, Counselling and Psychology, York St John University, Lord Mayor’s Walk, York, YO31 7EX, UK.

Immersive Virtual Reality in the Psychology Classroom: What Purpose Could It Serve?

Virtual reality is by no means a new technology, yet it is increasingly being used, to different degrees, in education, training, rehabilitation, therapy, and home entertainment. Although the exact reasons for this shift are not the subject of this short opinion piece, it is possible to speculate that decreased costs, and increased performance, of the technology may be key drivers in this change. As immersive virtual environments are increasingly integrated into a wide range of practices it is appropriate to consider, as academics and teachers of psychology, what purpose they could serve in the psychology classroom.

This short article provides a brief overview of the most common forms of immersive virtual environments, highlighting some ways in which these have been used in other discipline areas, and ways in which they have been used in psychology research. In drawing these together it will be speculated how best to make use of this technology in psychology education, and a potential way forward will be argued for. In writing this article the purpose is not to provide a comprehensive account of the many different research areas that may contribute to adopting such a technology, but simply to provide the interested reader with a starting point and some suggestions for further reading. Overall, with developments oriented to other fields (e.g. medicine, home entertainment) and sparse research in this area, it is argued that to embrace the potentials of the technology we must first engage with where it might fit within our curriculums. The opportunity to provide practical demonstrations that may be otherwise unachievable in conventional environments seems most viable at this very early stage.

Defining Immersive Virtual Reality

The term virtual reality has been used to refer to many different experiences. At its most liberal some authors have considered books, films, daydreaming etc. to be a form of virtual reality. In this interpretation what an individual believes to be the physical or ‘real’ world is distinguished from all other forms of reality which are labelled collectively as virtual reality (Blascovich & Bailenson, 2011). The advantage of such an approach is that it provides a convenient route around defining reality, through making the definition of reality dependent upon the individual's perception of it. However, more frequently, the literature on virtual reality and its applications has been considered in terms of specific technologies used to implement different experiences in 3D environments.

For example, the term virtual reality has been used by some authors to encompass experiences created through interacting with computer game technology. In these environments participants move a virtual representation of themselves (an avatar) around a virtual world that is displayed on a computer monitor or TV. Avatars can communicate, interact and learn from each other and help each other complete tasks. Two relatively well-known and popular examples of such an application are the virtual worlds of SecondLife® and World of Warcraft®. Readers interested in this use of virtual worlds may wish to refer to Dalgarno and Lee (2010) or Duncan et al., (2012) for useful reviews.

Alternatively, some authors have focused on technology that simulates the more immersive forms of virtual reality that some readers may be familiar with from the realms of science fiction. Fox, Arena and Bailenson (2009) have published a useful and accessible guide to this immersive virtual reality technology specifically for social scientists. As a means of providing a brief introduction, an immersive virtual environment (IVE) typically has three components: a computer running software to create the virtual environment; a headset for the world to be viewed through; and a sensor attached to the headset to track the position of the head.

In terms of creating the first component, the virtual environment itself, different software can be used to complete this task. For example, the company World Viz markets their Vizard VR Software toolkit which is a set of virtual world creation software specifically designed to build interactive virtual reality simulations. World Viz is an example of just one company, and many can now be found with an appropriate online search. It is worth noting that licensing issues may prevent individuals from sharing resources if these commercial software packages are used. If the intention is to create resources for sharing within the education community then this aspect should be checked before purchase.

In contrast, some developers are making software openly available for free online. For example, NeuroVR is an open source virtual reality platform design to support clinical psychologists and others in the behavioural neurosciences. This software, whilst more limited than other commercial products, is freely available online and is currently developed and provided by a research team in Italy, who themselves are experienced in psychological science (Riva et al., 2007). Alternatively, it is entirely possible to model 3D environments by making use of freely available software that is mainly used to design and produce computer games. For example, Unreal Engine 3 (UE3) is currently freely available online as a development version (Unreal Developer Kit, UDK) which, if not used for commercial purposes, can be used in an educational context. Unreal Engine 3 is a system for the creation and development of computer games (a game engine), and is used in many popular commercial games. These computer games make use of 3D virtual environments, in which the player can move around and interact with objects and characters within these worlds. Although freely available using such software requires a greater personal investment of time to acquire the skills to develop and produce relatively simple virtual worlds. The main advantage of acquiring the skills to use such software is that you will have greater flexibility, and freedom, than many commercial software packages that are directly marketed to researchers and academics. In supporting the necessary skill development it is worth noting that there is currently a wealth of training material freely available online to support such activities, as well as other freely available online resources suitable for importing into these worlds (such as objects for rooms or characters). In comparison, commercial software packages will provide their own technical support and their own libraries of people and objects to populate your environments. They will also usually be more user-friendly and require less technical expertise.

The costs associated with such products are changing rapidly and are therefore difficult to estimate here. However, for comparison purposes, an estimate of the current costs of purchasing such software, in the UK, may be anywhere between £3,000 and £10,000 dependent upon the number of potential users and the software requested. In general, it is perhaps advisable that any developments are supported through collaborative work with colleagues in game design or computer science who may be more experienced in this aspect and can provide specialised support. Alternatively, many manufacturers acknowledge that potential customers may not have the necessary experience and can provide advice and support in making purchasing decisions.

The actual content of any virtual environment created will depend upon the software chosen and the intentions of the person using it. For example, the virtual environment could be modelled to reflect physical reality, such as a room in a building, or the virtual environment could be modelled to reflect the products of someone’s imagination, such as a distant alien planet. The main limitations to the design of these environments are the skills of the modeller, the software that is used, and the time available to create the environment.

Once programmed the virtual world is typically presented through the use of a headset known as a head-mounted display (HMD). As far as possible this headset blocks out all external stimulation to the eyes, with visual stimulation just provided from two computer screens embedded within the eye piece of the headset. The purpose of the two screens is to present the virtual environment separately to each eye, with appropriate adjustments to create the 3D experience. Physically, the individual wearing the headset is free to move their head and in some cases to walk around. If not free to walk around then forwards and backwards motion in the virtual environment may be achieved through the use of a mouse or other suitable peripheral, such as a joystick, that can be held in the participant's hand. In keeping with the software, costs for HMDs vary widely depending upon different technical specifications (e.g. field of view, weight, display resolution, aspect ratio, luminance etc.) but can currently cost anywhere from £1,000 to £25,000 in the UK.

Finally, the position and orientation of the head of the individual is tracked through sensors so that the virtual environment, generated by the computer, is updated in real-time to reflect these movements. These two processes are known as tracking and rendering. If only head movements are tracked then the current cost of an appropriate sensor, in the UK, can range from £500 to £3500.

The above description is that of an IVE that makes use of a HMD and provides visual stimulation to create the virtual environment. There are however different variations of IVEs that have been developed that interested readers should be aware of. Some IVEs do not make use of enclosed headsets but instead make use of large displays projected on to multiple walls around the individual with head/hand trackers and specialised shutter glasses (e.g. CAVE technology, see Cruz-Neira et al., 1993). Similarly, even if the IVE does make use of a headset it is not always restricted to presenting just visual aspects of the computer generated virtual environment. Technological developments have included the production of gloves that allow for haptic stimulation so that individuals can virtually touch other people (e.g. Haans & Ijsselsteijn, 2006), some researchers have developed the use of spatialised sound in such environments (e.g. Västfjäll, 2003), as well as the introduction of olfactory stimulation (e.g. Dinh et al., 1999).

In general then, a useful and common description of an IVE is one in which the technology is used in a way that "…allows a user to be perceptually surrounded by sights and sounds while he or she interacts with computer simulated environments." (Segovia & Bailenson, 2009, p.372). This use of the technology could include touch and smells, as well as sights and sounds, but these developments are further behind the visual aspects that have received wider commercial backing and development. The focus here shall primarily remain upon the use of the most common setup described above: that of a HMD that provides an immersive visual experience.

Psychology and IVEs

The use of IVE technology is having an increasing impact within the psychological research literature as both a methodological tool, and a subject of study in its own right. In general, the clear message from within this research is that, both psychologically and physiologically, individuals process and respond to the virtual experience in many respects as if it were real (for an accessible introduction see Sanchez-Vives and Slater, 2005). Examples from both social psychology and psychotherapy may usefully illustrate this point.

It has been argued elsewhere that IVEs may play a useful and important role in the future of social psychological research (see Blascovich et al., 2002 for examples). Social psychologists have already demonstrated that social norms, such as eye contact and personal space, persist in virtual worlds (Bailenson et al., 2001, 2003). This processing of the virtual world, in the same ways as physical reality, has also been embraced by researchers concerned with therapeutic practice. Most commonly, use of this technology this has been linked to the treatment of phobias, such as fear of flying (e.g. Rothbaum et al., 2000; Muhlberger et al., 2001), fear of heights (e.g. Rothbaum et al., 1995), or fear of spiders (e.g. Garcia-Palacios et al., 2002). It has been demonstrated that virtual reality simulations can allow for a graded introduction of the anxiety-provoking stimulus and may act as a cost-effective alternative to real-world exposure (see Parsons & Rizzo, 2008; Powers and Emmelcamp 2008).

The potential impact for therapeutic practices has been significant, with clear evidence that graded exposure in IVEs may be marginally more effective than exposure in physical reality (see Powers & Emmelcamp, 2008). Nevertheless, it has yet to be readily adopted in real-world practice. It has been argued that this lack of adoption, despite the available evidence, is because of perceptions (and misperceptions) regarding the associated costs, training and expertise required (Schwartzman et al., 2012; Segal et al., 2011). It is widely acknowledged that current equipment costs are now considerably lower than 5 years ago, more user-friendly software is available, and less technical expertise is required to create basic environments. Whilst these barriers have been lowered it remains to be seen what the threshold costs, training needed and level of expertise required will in reality allow for wider adoption. Yet developments within therapeutic practice have been informative in terms of both the possibilities that the technology has afforded, and the resistance to adopting such technology.

Psychology in the Classroom

With an increasing presence of IVEs in psychological research literature it is useful to ask what purpose it may also serve in the education of psychologists. Where the educational benefits of virtual environments generally have been evident, outside of psychology, the technology has allowed the individual to take part in an experience that could not be undertaken in physical reality. For example, there is a long tradition of using immersive environments for training procedural skills such as those required by pilots (Lintern et al., 1990) or those skills required by surgeons (see Haque & Srinivasan,2006 for a meta-analysis). More recently, some educators have been using IVEs to train people to throw basketballs (Covaci et al., 2012), or even develop skills such as welding (McLaurin & Stone, 2012). For each of these examples it is notable that they have been developed to meet the specific needs for the discipline and have generally focused upon the development of procedural skills with spatial elements, often including an additional peripheral (e.g. a glove or a device) that allows the user to interact with the environment. Indeed, it was not possible for this author to identify a single research paper that has investigated the use of an IVE in psychology education specifically. Asking how psychology education may be able to embrace such technology therefore involves speculating how best we could harness the opportunities it offers, where they have predominantly been used in the past to develop procedural skills in virtual classrooms. One point for consideration is whether an IVE is best suited to re-creating our psychology classroom in virtual form.

To the best knowledge of this author a small number of researchers have published findings relevant to the use of IVEs for the delivery of traditional lectures and seminars (see Mania & Chalmers, 2001; Bailenson et al., 2008). It remains an open question as to whether traditional educational experiences delivered in IVEs surpass the same experiences in physical reality. For example, Mania

& Chalmers (2001) presented their participants with a brief verbal seminar in an immersive virtual environment, the same environment on a desktop PC, and the same presentation in the physical world. When it came to memory for the ideas and facts presented in the seminar, participants in the physical world outperformed those who experienced the seminar in a virtual environment. This preliminary evidence suggests that there may be no specific advantage to an IVE over physical reality in the didactic delivery of learning, and that it may indeed be disadvantageous. It is of course difficult to separate out this finding from technological advances that may mean the more ‘realistic’ environments that are now possible may be more effective. In evaluating research across this area this will always pose a difficulty as technology can advance rapidly. These results may also vary according to a wide range of variables such as the type of materials presented, the nature of the presenter, the motivations of the students, the degree of adaptation etc. Whilst further research may help clarify these aspects it is argued latterly that such research may not be a current priority.

Bailenson et al. (2008) have suggested that the potential benefits of such technology do not lie in recreating existing classrooms but the possibility to tailor these experiences to the individual to optimise their learning. Specifically, the technology used for IVEs could be adjusted so that the teacher behaviour and student experience is not identical to the physical world but instead improved in ways that are not physically possible. For example, digital representations of the lecturers could be guided to give each and every student an equal or optimal amount of eye-contact. Similarly, by presenting the student a virtual environment containing just themselves and the teacher, the student could feel as if they are receiving a one-to-one lecture even if there are (virtually) hundreds of other students in the room – all having the same experience of a personal lecture. In their study, Bailenson et al. (2008) investigated a range of variables that could be tailored in these ways to optimise the learning experience. They reported that correct recognition of material from their virtual lecture was chiefly facilitated through every learner having eye contact from the lecturer, sitting in the optimal position in the room, and not being able to see any co-learners in the room. Importantly, their work clearly clarified that the potential benefits of lecture delivery in IVEs extend beyond merely replicating the physical world experience, to manipulating this reality into a more idealised classroom environment.

Whilst there is some promise in using the technology to optimise a virtual classroom experience this may not be the most appropriate use of the technology. In practical terms there are a number of immediate concerns such as the accessibility of the software/hardware for all students, especially if classes of 200 or 300 are being taught. Additionally, if used for long periods the weight of the headsets may lead to physical complaints such as neck pain and headaches, although lightweight headsets for prolonged use in home entertainment have been recently brought to market by SONY. Importantly, there are alternative options which do not have these practical limitations.

Whilst the evidence for using IVEs in this way is extremely limited the use of non-physically-immersive virtual worlds, such as SecondLife®, may better serve the purposes of the virtual classroom. The benefits of using such environments for content delivery have been documented elsewhere and by practitioners in a range of other disciplines (e.g. Dalgarno & Lee, 2010; Duncan et al., 2012). The ready availability of software (such as SecondLife®) and the relatively small hardware requirements make it better suited to mass delivery of didactic, or interactive, content as might be imagined in a virtual classroom. Recent years have also seen the development of specific software, other than virtual worlds, designed to fill this gap. These virtual classrooms make use of features such as web cameras, shared desktops, and the ability to instantly send each other messages, to create a virtual classroom experience. Each of these alternatives is available now and makes use of software and hardware that is readily available to most students. It is therefore argued here that if IVEs can serve a purpose in the psychology classroom, it is unlikely to be in the effective design and delivery of virtual classroom experiences.

Added Value of IVEs in the Psychology Classroom

Thus far it has been noted that IVEs have begun to be embraced across different disciplines for a range of different purposes. Within educational settings these have involved the use of IVEs to develop procedural skills, whilst some research psychologists have engaged with the technology to simulate scenarios of interest to their research aims. In considering the relevance of such technology for psychology education it has been argued that the concept of a ‘virtual classroom’ may be better served by other technological developments. It is therefore reasonable to ask whether IVEs have any potential role in the psychology classroom. If they do then it is clear that any use must harness the benefits of the technology, whilst minimising the limitations. So what could this use be?

On the surface there would not appear to be much overlap between a technology that has largely been used to train procedural skills and an academic area that often focuses upon conceptual and theoretical issues. As a starting point then we must note that in being used to train procedural skills, a key feature is that the trainee or student has the opportunity to experience something in a safe environment that they may not have experienced before and would not be possible in a normal classroom environment. This key aspect is paralleled in the research efforts of some psychologists who have also used the technology to place individuals in situations that are not possible within the normal constraints of an average research environment. If IVEs are to serve a purpose in the classroom of the future then it is sensible to assume that it must take advantage of these properties.

Perhaps the greatest potential for the psychology classroom could be the ability to immerse our students in virtual experiences that may, in a ‘real-world’ simulation, be costly or time-consuming. Indeed it is an interesting feature of psychology education that whilst we encourage our students to theorise about concepts, and think critically about them, we rarely expose them to the psychological experiences that are being theorised about. An immersive virtual environment could be a powerful tool to demonstrate to students, or one of their peers, specific psychological phenomenon that may not be normally physically possible given the constraints of a typical classroom. Providing the experience may enable the students to reflect upon the relationship between the phenomena and the theory in a more integrated way, potentially enhancing their critical analysis.

Given the speculative nature of this proposal it is reasonable to ask which phenomena may benefit from such classroom demonstrations. In considering this question it is important that any that are chosen are likely to form part of any existing psychology curriculum, and are not chosen for the single purpose of demonstrating the technology rather than enhancing the educational experience. In this regard the best candidates for consideration may be instances in which 2D visual illustrations may currently be used. These may be diagrams, videos, or other 2D visual representations with the aim of helping to explain or demonstrate a particular psychological effect or finding. Examples may include cognitive phenomena such as attentional blindness to changes in environments (change blindness), or distortions in memory for witnessed events (eyewitness testimony). In both cases a useful part of any demonstration may not only be observing the first-hand experience of a willing participant but the opportunity to repeat and review this experience, using appropriate screen capture software (e.g. Camtasia Studio, Jing or other commercially available products). Potential demonstrations are of course not limited to cognitive phenomena, and there are different aspects of psychology that may benefit from immersive in-class demonstrations. For example, students may benefit from taking part in a virtual conformity scenario, or observing virtual children in a virtual playground.

If we were to use IVEs to provide classroom demonstrations then the current costs make it likely that only 1 or 2 students may be able to take part whilst their peers observe. In practical terms this involves extending the environment, displayed to the participant, to an overhead projector or alternative display. Inevitably the extent to which these experiences may be beneficial, rather than detrimental, is an open question because, as far as this author knows, the potential beneficial effects of experiencing or observing psychological phenomena in an IVE has yet to be widely reported. However, the benefit of practical demonstrations in the classroom is commonly agreed upon. The opportunity to expand upon these demonstrations in controlled environments, demonstrating a wider range of phenomena, in an immersive way, can reasonably be hypothesised as beneficial. In the first instance it is likely that novelty may also play an important role in motivating students and encouraging them to engage with the classroom activities.

It is therefore suggested here that if IVE technology has the potential to enhance and enliven psychology education it is through allowing for more immersive demonstrations of psychological phenomena that may not be possible within the current classroom environment. This is inevitably speculative and represents a ‘call-to-arms’ for academics, researchers and teachers to consider engaging with these wider developments. Appropriate research and evaluation is of course central to this endeavour, and if these exciting developments are embraced it should be with a measure of caution and careful consideration.

Concerns and Limitations

As with embracing any new technology there are concerns and limitations that must be carefully considered. Two key concerns are likely to be the cost associated with the purchase of specialist equipment, and any additional technical expertise that is required. Indeed, we have seen already that such concerns have been prohibitive of rapid adoption of the technology within the clinical practice of psychological therapies, despite the research evidence (Schwartzman et al., 2012; Segal et al., 2011).

As noted in the introduction to this article achieving this in a practical sense may involve developing virtual environments in collaboration with colleagues in other disciplines such as game design and computer science. It will also require investment in hardware and software, the cost of which would depend upon the intentions and ambitions of the project and will change over time with advances in technology and other commercial developments. At the time of writing this a conservative estimate of purchasing such a system in the UK may be anywhere between £5,000 and £45,000, with these costs dependent upon the hardware and software choices made. It is also noteworthy that such an estimate does not include any costs associated with developing virtual environments. On the one hand it is likely that anyone engaging with such a project would wish to develop their own skills in constructing virtual environments, or make use of those of an appropriately skilled colleague or contact. Alternatively an external developer may be employed, or research assistants hired, which would clearly inflate these costs. The costs of investing in commercial software that is designed to be user-friendly and require less expertise may be offset here against the cost of hiring skilled individuals to develop environments. If considering such a purchase it is advisable to seek the advice of commercial resellers, or experienced colleagues in other discipline areas.

There are also health and safety concerns with several potential undesirable side-effects of immersion including eye-strain, headaches, sweating, disorientation, nausea and vomiting (LaViola, 2000). Whilst these are experienced by many individuals there is evidence to suggest that these are often mild and quickly go away (see Nichols & Patel, 2002). Estimates for the exact duration of such symptoms are difficult to define. Such estimates are highly influenced by a wide range of variables from the technological specifications of the environment through to individual differences between users. As such it would be impossible to appropriately summarise these here, but readers should consult the review of Nichols & Patel (2002) as a starting point. For the purposes of this brief introduction it is simply noteworthy that if this technology is adopted careful consideration should be given to detecting and managing any simulator sickness and consideration should be given to such factors when piloting an environment. Identifying relevant literature will be highly dependent upon the hardware and software purchases that are made, but the company from which these have been purchased should be able to provide advice on this.

As mentioned earlier, the size and weight of a headset can also be prohibitive of spending long periods of time within such environments. In such instances it would be reasonable to anticipate that prolonged periods of exposure may result in neck pain or other physical difficulties. Again, this will depend upon the size, design and weight of any headset purchased. It is however anticipated that the development of headsets for entertainment purposes will result in lighter headsets, making them more conducive to the physical demands of prolonged exposure. If creating virtual environments for demonstration purposes it is therefore sensible to design them for relatively short periods of exposure, e.g. 3 to 5 minutes. Once again, documentation supplied by the manufacturer should always be consulted.

In Summary

This article has provided a brief overview of immersive virtual environments for the interested reader as a primer to its potential uses in psychology education. For the psychology classroom, the opportunity to provide students with immersive psychological experiences from which to better appreciate theoretical constructs provides an exciting and potentially rich mine of possibilities. This draws upon the broad finding within the research literature that experiences in IVEs, although of low fidelity, produce similar (if not identical) psychological experiences. The nature of the technology allows these experiences to be gained in controlled environments, in ways that have not previously been possible. Whilst exciting, the adoption of this technology is at a very early stage and the most effective use of it remains a case for speculation whilst the research evidence accumulates. It is therefore of great importance that early adopters of such technology, within psychology education, be willing to support and guide other academics, researchers and teachers in making similar steps to improving their students’ learning experience. Nevertheless, there is a clear potential to enhance and enliven the delivery of our curriculums through engaging sensibly with this developing technology.

References

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2001). Equilibrium revisited: Mutual gaze and personal space in virtual environments. *Presence: Teleoperators and Virtual Environments*, *10,* 583-598.

Bailenson, J.N., Blascovich, J.,Beall, A.C., & Loomis, J.M., (2003). Interpersonal distance in immersive virtual environments. *Personality and Social Psychology Bulletin*, *29,* 1-15.

Bailenson, J.N., Yee, N., Blascovich, J., Beall, A.C., Lundblad, N., & Jin, M. (2008). The use of immersive virtual reality in the learning sciences: Digital transformations of teachers, students, and social context. *The Journal of the Learning Sciences*, 17, 102-141.

Blascovich, J., & Bailenson, J.N. (2011). *Infinite Reality – Avatars, Eternal Life, New Worlds and the Dawn of the Virtual Revolution.* New York: William Morrow.

Blascovich, J., Loomis, J., Beall, A., Swinth, K., Hoyt, C., & Bailenson, J.N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, 13, 103-124.

Covaci, A., Postelnicu, C-C, Panfir, A.N., & Talaba, D. (2012). A virtual reality simulator for basketball free-throw skills development*. IFIP Advances in Information and CommunicationTechnology, 372,* 105-112.

Cruz-Neira, C., Sandin, D.J., & DeFanti, T.A. (1993). Surround-screen projection –based virtual reality: the design and implementation of the CAVE. *Proceedings of the 20th annual conference on Computer graphics and interactive techniques: ACM Press*, pp.135-142.

Dalgarno, B. & Lee, M.J.W. (2010). What are the learning affordances of 3D virtual environments? British Journal of Educational Technology, 40(6), 10-32.

Dinh, H., Walker, N., Hodges, L., Song, C., and Kobayashi, A. (1999). Evaluating the Importance of Multi-Sensory Input on Memory and the Sense of Presence in Virtual Environments. *Proceedings of IEEE Virtual Reality*, 222-228.

Duncan, I., Miller, A., & Jiang, S. (2012). A taxonomy of virtual worlds usage in education. *British Journal of Educational Psychology, 43,* 949-964.

Fox, J., Arena, D., & Bailenson, J.N. (2009). Virtual Reality: A survival guide for the social scientist. *Journal of Media Psychology, 21*(3), 95-113.

Garcia-Palacios, A., Hoffman, H., Carlin, A., Furness, T. A., III, & Botella, C. (2002). Virtual reality in the treatment of spider phobia: A controlled study. *Behavior Research and Therapy, 40,* 983–993.

Haans, A., & Ijsselsteijn, W. (2006). Mediated social touch: A review of current research and future directions. *Virtual Reality, 9,* 149–159.

Haque, S., & Srinivasan, S. (2006). A meta-analysis of the training effectiveness of virtual reality surgical simulators. *IEEE Transactions on Information Technology in Biomedicine, 10,* 51-58.

LaViola, J.J. (2000). A discussion of cybersickness in virtual environments. *ACM SIGCHI Bulletin, 32,* 47-56.

Lintern, G., Roscoe, S. N., Koonce, J. M., & Segal, L. D. (1990). Transfer of landing skills in beginning flight training. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *32*(3), 319-327.

Mania, K., & Chalmers, A. (2001). The effects of levels of immersion on memory and presence in virtual environments: A reality centered approach. *CyberPsychology & Behavior*, *4*(2), 247-264.

McLaurin, E, & Stone, R. (2012). Comparison of virtual reality training vs. integrated training in the development of physical skills. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 56*, 2532-2536.

Muhlberger, A., Herrmann, M. J., Wiedemann, G. C., Ellgring, H., & Pauli, P. (2001). Repeated exposure of flight phobics to flights in virtual reality. *Behavior Research and Therapy, 39,* 1033–1050.

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

Parsons, T.D., & Rizzo, A.A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy & Experimental Psychiatry, 39 (3),* 250-61.

Powers, M.B., & Emmelkamp, P.M. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of Anxiety Disorders, 22,* 561-569.

Riva, G., Gaggioli, A., Villani, D., Preziosa, A., Morganti, F., Corsi, R., Faletti, G., & Vezzadini, L. (2007). NeuroVR: an open source virtual reality platform for clinical psychology and behavioral neurosciences. *Studies in Health Technology and Informatics*, *125*, 394-399.

Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995). Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. *American Journal of Psychiatry, 152,* 626–628.

Rothbaum, B. O., Hodges, L., Smith, S., Lee, J. H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying*. Journal of Consulting and Clinical Psychology, 68,* 1020–1026.

Sanchez-Vives, M. V., & Slater, M. (2005). From presence to consciousness through virtual reality. *Nature Reviews Neuroscience*, *6*(4), 332-339.

Schwartzman, D., Segal, R., & Drapeau, M. (2012). Perceptions of virtual reality among therapists who do not apply this technology in clinical practice. *Psychological Services, 9*, 310-315.

Segal, R., Bhatia, M., & Drapeau, M. (2011). Therapists' perception of benefits and costs of using virtual reality treatments. *Cyberpsychology, Behavior, & Social Networking, 14,* 29-34.

Segovia, K.Y. & Bailenson, J.N. (2009). Virtually true: Children's Acquisition of False Memories in virtual reality. *Media Psychology*, 12, 371-393.

Västfjäll, D. (2003). The Subjective Sense of Presence, Emotion Recognition, and Experienced Emotions in Auditory Virtual Environments. *CyberPsychology & Behavior, 6,* 181-188.