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Virtual Reality in Psychology

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Abstract

The benefits of using virtual environments (VEs) in psychology arise from the fact that movements in virtual space, and accompanying perceptual changes, are treated by the brain in much the same way as those in equivalent real space. The research benefits of using VEs, in areas of psychology such as spatial learning and cognition, include interface flexibility, the reproducibility of virtual experience, and the opportunity for on-line monitoring of performance. Applications of VEs are many and varied, but are especially beneficial where experience can be tailored via augmentation, and where dangerous training situations can be avoided. The use of programmable agents has great future potential in relation to training and interpersonal skill development, also perhaps in clinical diagnosis and therapy. Progress in VE usage in psychological education is limited by cost and availability, though VEs are being used increasingly in classroom and laboratory teaching exercises. Virtual Reality was said to be "an answer waiting for a question", but questions are being recognized, so that applications of VEs within the behavioural sciences are likely to multiply.

Overview of VEs in psychology

Why is VR/3-D especially significant for behavioural sciences?

A technology that "… [generates] graphic environments which both produce in the users the feeling of being physically present in a virtual world and also allows them interaction in real time" (Botella, Garcia-Palacios, Quero, Banos, & Breton-Lopez, 2006) clearly has particular relevance to the study, assessment, and training of behaviour. The term "Virtual Reality" (VR) has been used historically to describe 3-D environment displays with which participants can interact in pseudo-real time, though many prefer terms such as VET (Virtual Environment Technology) or VEs (Virtual Environments) which avoid assumptions about the replacement of true reality with an alternative simulated reality. Many encountering VEs for the first time might assume that the addition of a third dimension (screen depth, the z-coordinate) to the depiction, perception of, and interaction with, environments is no more than a cosmetic extra which, though it may generate environments and experiences that subjectively feel more "real", has little impact on cognitive processing per se.

In fact, the addition of the third dimension plus pseudo real-time interactivity does make more than a cosmetic difference to the experience. VEs may invoke the same cognitive modules as real equivalent environmental experience, or hijack these in ways that are specific to the processing of virtual information (Lee & Jung, 2005). But a VE arguably involves a different form of user engagement from that elicited by 2-D representations, in particular because it provides virtual movement-contingent re-afferent feedback of the kind experienced during self-initiated spatial displacements. VE technology has sometimes been described as "soft-where" in view of its promoting and encouraging spatial cognitive processing. Since a virtual world can be scaled to any size – from an atom to a universe – VEs provide opportunities to augment real world experience, enabling interaction with environments that would be hard to imagine in any other medium.

Spatial processing and VEs

Since the natural perceptual world is 3-dimensional, systematic changes in the size and shape of objects occur as we move in relation to them (Gibson, 1966, 1979), and this arguably facilitates the building of cognitive representations of spaces. Only when an observer *decides to move* in space (for example, get up and move to another room or leave a building) is it necessary to fully implement the processes that monitor and up-date spatial location. Self-produced movement is correlated with the sensory changes (including optic flow; cf. Gibson, 1966, 1979) that it brings about, allowing successive places and vistas to be connected within a single coherent "map". Despite the many strategies available for way-finding in large-scale environments - it would be naïve to think that way-finding in experts such as taxi drivers does not have substantial landmark and hierarchical topological features (Chase, 1983) - the survival of our animal or human ancestors would often have depended crucially on possessing a rough spatial cartoon of the surrounding environment (see Tolman, 1948; Tolman, Ritchie, & Kalish, 1946). Without such a map as a means of navigating, the individual is potentially helpless and vulnerable; this may be a reason why entirely novel environments can be regarded as stressors (Gray, 1971). An individual can escape predation and danger (and intercept prey) by taking short cuts and making detours which are enabled only by having acquired and maintained an up-dated configurational cognitive spatial representation which includes their own current position.

We do not yet know what changes occur in the brain when self-directed movement is initiated in a specifically *3-D* environment (either in reality or in a virtual simulation), though we may speculate. Route *information* can be provided from viewing a map alone, despite being an altogether different experience from walking the route. Yet while map-based learning gives rise to an orientation-specific representation, VE learning, like real world exploration, gives rise to orientation-free representations (Tlauka & Wilson, 1996; Witmer, Bailey, Knerr, & Parsons, 1996). In theory, the most plausible explanation is that the brain mechanisms driving hippocampus and para-hippocampal cortex, also parietal and frontal cortices (cf. Maguire et al., 1998, 2000; Maguire, Frackowiak, & Frith, 1996, 1997; Maguire, Frith, Burgess, Donnett, & O'Keefe, 1998) to up-date cognitive maps and current location engage only when they are useful, that is, when 3-D displacements are detected (as systematic changes in the sensory environment) *that are contingent on self-initiated spatial displacements*. If this occurs in the natural real-world environment, it certainly appears to do so within a 3-D environment as well, allowing the use of 3-D technology to examine large scale environmental navigation and its brain representation (cf. Maguire et al., 1998). Consequently, when participants make directional judgements within a familiar large scale environment, they do so more accurately (indeed, as accurately as in reality) when it is represented as an immersive or desk-top VE than when it is represented by static images (Waller, Beall, & Loomis, 2003). However, against such a model there has never been a satisfactory explanation as to why good spatial representations are usually obtained from passive observation alone, for example when one participant observes another participant's movements in virtual space by viewing a screen over their shoulder (see Wilson & Peruch, 2002; Wilson, Foreman, Gillett, & Stanton, 1997), when the linkage between self-initiated movement and perceptual changes is broken. Perhaps, the observation of the consequences of someone else's intentional movements may be adequate – a form of shared intentionality – or processes may be invoked by 2-D displays that allow deductions to be made on the basis of partial information. Clearly, this is an issue worthy of further investigation.

The emergence of VEs in psychology

VR emerged in the 1960s and has been regarded largely as a research tool in psychology (Rose & Foreman, 1999), though applications within psychology education are developing rapidly. VEs have the benefit of flexibility; environments can be altered instantaneously so that experimental studies can be conducted in new ways in VEs when the limitations of reality are removed, providing behavioural experimenters with entirely new experimental tools (Gaggioli, 2001). Immersive systems (head mounted displays) are still expensive. When VEs were first taken seriously as research tools, immersive VR technology was often assumed to be superior to desk-top presentation (cf. Loomis, Blascovich, & Beall, 1999) although many subsequent studies in which head immersion and desk top displays have been compared have failed to reveal any differences in learning and performance, despite participants usually reporting a feeling of greater subjective presence with immersion; see, for example, Moreno and Mayer (2004) and Hoffman, Richards, Coda, Richards, and Sharar (2003) who argued that VE presentation (using magnet friendly fibre-optic cable) during immersive brain scanning can allow phenomena related to presence to be mapped within the brain. Nevertheless, the simpler and less expensive desk-top presentation (or, wide angle wall projection) has proved popular and also useful. Despite the tendency for distances to be underestimated in VEs (Foreman, Sandamas, & Newson, 2004), unsophisticated head immersion VEs have proved adequate for such things as investigating choice of spatial representations (Gramann, Muller, Eick, & Schonebeck, 2005), and the virtual training of children, adults, brain-injured and elderly participants, when navigating virtual buildings, spaces and mazes (Attree et al., 1996; Brooks et al., 1999; Brooks, Attree, Rose, Clifford, & Leadbetter, 1999; Foreman, Stanton, Wilson, & Duffy, 2003; Foreman, Stanton-Fraser, Wilson, Duffy, & Parnell, 2005; Jansen-Osmann & Wiedenbauer, 2004; McComas, Pivik, & LaFlamme, 1998; Rose et al., 1999, 2000; Ruddle, Payne, & Jones, 1997; Stanton, Wilson, & Foreman, 1996; see Foreman, 2006 for a recent review), including when transporting themselves in a virtual wheelchair (Harrison, Derwent, Enticknap, Rose, & Attree, 2002). Clearly, whether there is benefit in using VEs as practical training media rests crucially on the effective transfer of information acquired in VEs to real equivalent environments, but these studies, among many others, have usually been encouraging (Wilson, Foreman, & Tlauka, 1996; 1997) though see Witmer et al. (1996). One educational benefit is children's potential use of VEs to find their way around school buildings (see Foreman et al., 2003), which could be especially useful when they move between schools; the anticipation of getting lost and arriving late to lessons is one of the potential hazards that many children report when asked about relocating. This poses a persistent problem for pupils with special educational needs, whose disabilities may limit their exploratory opportunities and thus limit their establishment of effective cognitive representations of their school campus (see Foreman et al., 2003). Moreover, improved spatial representations, for all pupils, are also likely to impact on important areas of the academic syllabus and thus convey benefits beyond campus familiarity (see Foreman, 2000 for a review).

In behavioural research especially, VEs have allowed psychologists to think outside the box – to use a range of new paradigms that were not possible for conducting experiments in reality – and to consider old problems in new ways, for example using VEs to examine an individual's ability to reason about simple rotations of objects (Pani, Chariker, Dawson, & Johnson, 2005). Probably the full benefits of using VEs, for example, using object distortion or object "misbehaviour", to investigate aspects of perception, such as illusions and children's perceptual hypotheses, have not yet been exploited. Nonetheless, it should always be borne in mind that where a VE is used because real testing is for some reason impossible, there is no way of checking the veracity of data gathered in the VE against reality.

VE technology development: Issues in research and training

Spatial cognition research

As indicated above, spatial cognition is one of the areas that has most benefited from the development and use of 3-D computer technology. VEs allow a high level of experimental control and precise data collection, while preserving ecological validity (Blades, 1997). It was possible, for example, to demonstrate the existence of early developmental "windows" in which independent spatial experience seems especially crucial for the development of skills related to maze problem solving (Stanton, Wilson, & Foreman, 2002). In many participant groups, VE training was found to be almost as effective as real exploration for the establishment of cognitive "maps" of environments, as measured using standard criteria for assessing cognitive mapping Foreman et al., 2000; Wilson et al., 1997). Navigation through large scale virtual spaces has sometimes been reported to be subject to disorientation effects, particularly when very large environments are navigated using head immersion gear (Darken & Silbert, 1996; Westerman, Cribbin, & Wilson, 2001; Witmer et al., 1996), although many studies have reported effective and apparently accurate functional spatial transfer (see e.g., Foreman et al., 2003, 2005; McComas et al., 1998; Ruddle et al., 1997), except when moving between levels in complex multi-storey buildings (Foreman et al., 2005; see Holscher, Meilinger, Vrachliotis, Brosamle, & Knauff, 2006). Moreover, participants' ability to form an accurate spatial representation of a familiar large scale space correlates highly with their ability to perform in a virtual test situation (Waller, 2005). Farrell et al. (2003) pointed out that it is no longer necessary to ask whether spatial information transfers from virtual to real environments, but rather to ask whether it confers added value. They found that in terms of route learning, adding virtual training to map use did not benefit performance. On the other hand, while having a bird's eye view of an environment may assist in conveying overall spatial layout, the eye-height view is likely to confer different kinds of information, available only from primary, first-person sources. Farrell et al. (2003) point out that providing a map alongside a virtual environment (cf. Shelton & Gabrielli, 2004; Tlauka, Brolese, Pomeroy, & Hobbs, 2005) might be an ideal solution. This issue has implications for the optimising of navigational accuracy, for example using satellite-based global positioning navigation devices.

Newman et al. (2006) were able to compare landmark and layout use in a situation in which virtual taxi drivers had to pick up customers at random points and transport them to virtual shopping malls, adopting the most economical routes. Taking advantage of the flexibility of VEs, they selectively altered landmarks and buildings and were able to show that when layout and landmark information conflicted, landmarks are used preferentially.

In other areas of spatial research, VEs have allowed bridging between paradigms adopted with animals and applications within human research, again capitalising on the flexibility and authenticity of VEs. Human versions of standard paradigms used with animal subjects have been developed to compare human performance with that of other species. Indeed, there have now been many studies with human participants using environments that represent the equivalent of those used in animal studies (Stanton, Wilson, & Foreman, 2003; Sturz, Bodily, & Katz, 2006). Foo, Duchon, Warren, and Tarr (2007) have compared honeybee and ant orientation systems with humans, using shortcut paradigms, finding that humans share some strategies with lower species, particularly heavily biased toward the use of landmark information. Shortcut and multiple choice spatial environments which have been used to test spatial memory in many different species can be adapted for comparative purposes in VEs, allowing the examination of paradigms such as the watermaze task (Astur, Ortiz, & Sutherland, 1998; Nadel et al., 1998), and overshadowing in a virtual pool task (Chamizo, Aznar-Casanova, & Artigas, 2003; Jacobs, Laurance, & Thomas, 1997), to assess consequences of brain damage in adults and children (Foreman, 2000; Lehnung et al., 2003; Leplow et al., 2002) and human cognitive development and its enhancement within educational settings (Akhutina et al., 2003).

Gender differences in spatial encoding: exaggerated in a VE?

It is important to identify gender differences in spatial performance, in part because it has become increasingly clear that males and females encode spatial information differently and second because there are important training implications. Indeed, brain systems related to navigation, orientation and way-finding are reportedly quite different between the sexes since activity in the male brain while performing spatial tasks appears (conventionally; see O'Keefe & Nadel, 1978 and Maguire et al., 1997) to focus on the right temporal lobe hippocampus, while in females the right parietal and frontal cortices are predominant (Gron, Wunderlich, Spitzer, Tomczak, & Riepe, 2000). This perhaps explains why, in the real world, females use landmarks preferentially, in contrast to males' predominant use of configurational information (Dabbs, Chang, & Strong, 1998), use different distal cues in a VE (Sandstrom, Kaufman, & Huettel, 1998), and make more errors in a virtual maze when exploring the maze without landmarks present (Jansen-Osmann & Wiedenbauer, 2004). However, the point at which gender differences emerge is unclear; in some cases (and for some skills) this seems to be adolescence. Below 8-9 years, it appears that all children tend to use landmark-based strategies, tending to prefer local cues to more distal cues, the latter being more beneficial for constructing configurational representations of large scale spaces (Cornell, Heth, & Broda, 1989). Recognition of the emergence of gender differences has important implications for, *inter alia*, the way in which science and mathematics is taught in schools in the pre- and post-adolescent periods, and career choice, since the conventional strong career choice bias of males toward more spatially-based science and technology might be balanced in future if females can be taught the related curriculum areas in ways that correspond to their own spatial skills. This might be accomplished by taking advantage of the flexibility and adaptability of VEs.

In an early study of virtual maze place discrimination, Astur et al. (1998) suggested that effect sizes and reliability for gender differences in performance were especially large and high in VEs. However, some (if not all) apparent male superiority is attributable to their greater experience with computer technology and 3-D game experience (Waller, 2000; Waller, Knapp, & Hunt, 2001). Male superiority in navigation was found after virtual navigation of shopping malls supported by either paper or digital (screen-based) maps, or challenged with different cognitive loads (Tlauka et al., 2005). Jansen-Osmann and Wiedenbauer (2004) found gender and age differences in a virtual task with children that did not occur when Cohen and Schuepfer ran it in a real situation in 1980: males performed better than females, especially when intramaze cues were removed, and children aged 11-12 years in cue-rich conditions performed just as well as adults, contrasting with the Cohen and Schuepfer (1980) study where adults performed better. Jansen-Osmann and Wiedenbauer (2004) concluded that landmarks in VEs may be more eye-catching and salient, due to the fact that objects modelled in VEs differ from real world objects in terms of colour, size or structure – to which, add colour saturation. This might explain both discrepancies: female dependence on local intramaze cues may have made them especially vulnerable to cue removal, and 11-12 year old children may have used intramaze cues more effectively than in a real environment. Sandamas and Foreman (2007) were able to replicate the earlier study by Herman (1980) involving 6-9 year old children's environmental reconstruction, but after virtual experience of the layout, with the exception that active-passive differences failed to emerge in the virtual version. Many studies report that active exploration confers no benefit in a VE (reviewed by Wilson & Peruch, 2002), although activity in a VE can confer benefits, especially when input device demands are minimised (Sandamas, Foreman, & Coulson, 2009). Active navigation is thought to "… [facilitate] the integration of spatial information in a more complex environmental configuration", and where this can be provided, in a VE, it might be expected that VE-based paradigms can improve upon real world equivalents. This area is in urgent need of further research.

Positive and negative aspects of 3-D gaming

Silverman, Johns, Weaver, and Mosley (2007) envisage a world where many games will in the future be used therapeutically, to assist people in understanding the problems that others face, and to overcome health problems, child rearing difficulties and interpersonal traumas. Against this positive view, however, there are persistent controversies among psychologists about possible negative effects in children and adolescents of playing video games, an issue which becomes especially sensitive when realistic VE-based games are involved (Anderson, 2004). Calvert and Tan (1994) found that actively playing a violent 3-D game (compared with just passively watching as another participant played) produced a higher heart rate, and provoked more aggressive thoughts on a post-test questionnaire. Carnagey, Anderson, and Bushman (2007) recently found that violent video gaming had a desensitising effect (reducing heart rate and GSR responses) when participants were subsequently shown images of real life violence. The realism of VE-based games ("Manhunt" is a prime example), is created by the addition of three-dimensionality in the context of realistic urban environments in which, to succeed, a participant has to commit virtual murders at a rapid rate, often using gruesome methods, extra points being scored for employing especially violent and macabre means of destroying the virtual victims.

Trainee aircraft pilots have reportedly left a virtual cockpit vomiting and perspiring after near miss virtual accidents, and even seated in a laboratory peering at a computer screen, participants become immersed in the action to the extent that they are apparently unaware of the real world around them. Against this background, there is a fear that the realism associated with 3-D games could produce a greater carry-over to reality than 2-D formats. Indeed these fears have been exacerbated by news reports of several well-documented murders committed in schools, when the youngsters responsible had been playing violent realistic 3-D games shortly before committing the crimes. However, reviewers generally conclude that due to inconsistent findings in the literature and the rate of advancement in video game technology, it is difficult to draw firm conclusions about the causal relationship between game playing and real world aggression and violence (Unsworth & Ward, 2001).

Clearly, VEs can be put to both positive and negative use; while the Manhunt game rewards acts of virtual violence and destruction, the police force in Manchester, UK, has used a virtual environment with school pupils to teach them to identify areas within the city that are most safe and most dangerous. A further positive application might be the use in the future of VEs to depict scenes which clinically hyper-aggressive patients find violence-provoking, and use these for progressive desensitisation as one element in anger management programmes (Barnett, 2009). Anderson et al., (2006) report studies using video games varying in their levels of virtual violence to examine brain changes, recorded in an fMRI (functional magnetic resonance imaging) scanner, in some of the first studies that attempt to identify the underlying brain changes produced by the playing of violent realistic games. Children who are institutionalised for crimes of violence are particularly affected by violent game-playing, and typically identify with the most violent characters depicted. Future identification of brain changes triggered by both real and virtual violent experience could enable psychologists to provide information-based advice about the advisability of allowing games to be sold openly.

Data file navigation

The uses of 3-D environments extend beyond the strict navigation of conventional routes, spaces and places, and can also be applied to the remembering and locating of "places" within an environment that consists of electronic data files. Hypertext navigation has been discussed by Gamberini and Bussolon (2001), who point out that naïve users of complex systems can become disoriented and lose their way, so that strategic navigation requires the construction of a "cognitive map" of the nodes visited in order to retain paths and orientation. (Think back to the final scenes of the film Jurassic Park for an example of such a data "park"). The uses of VEs in the future by students and researchers, enabling them to efficiently navigate around information sources and data sets, has yet to be fully investigated.

Avatars: Believable agents

One of the developments that has particularly benefited education and research in clinical and behavioural sciences has been the programming of realistic behaviours into computer generated characters. Two types of virtual person can be programmed into VEs: first, the avatar which is a character on screen which represents the participant (the controller, who operates the viewpoint and navigates within the VE), and second, a virtual or simulated person, who is an independent agent, that can be programmed with specific personality characteristics and to behave in predetermined ways, though sometimes not predictably when intelligent software is used to determine their evolving response patterns. Particular personality traits are said to be programmable (Poznanski & Thagard, 2005), though it would be reassuring to know that the models of personality used in such work have been checked out with personality researchers in psychology.

Avatars are most commonly used in games, though research has been carried out in an educational context using Active Worlds software by Bailey and Moar (2003) who attempted in their VERTEX project to give children (who represented themselves as avatars) the experience of creating 3-D objects and interacting in shared virtual worlds with children in other schools - inner city schools in north London, UK and a school in a small coastal town on a Scottish island (Orkney), groups of pupils that would usually not meet one another. This was found to be highly motivating for all children, developing their collaborative and communication skills as they shared stories about each other's lives, cultures and experiences, but especially so for children who previously showed low classroom motivation, were disruptive or had learning difficulties. These benefits were attributed to the game-like qualities of virtual worlds.

This type of usage of programmable people in VEs has particular potential for psychology, in areas such as interpersonal skill development and training, particularly since it may be necessary for training purposes to have a virtual character who becomes quickly aggressive and hostile, or withdrawn, as required. Developments in the computing field, that enable the programming of emotion-driven "Believable Agents" whose "… behaviors change in psychologically plausible ways" have been adopted in areas such as human-machine interfaces, electronic advertising, and electronic entertainment, but also have applications in areas related to interactive therapy. Wang, Wang, Meng, Teng, and Xie (2006) comment that incorporating emotion into virtual humans has gained increasing attention recently within academia and industry. Cyber sex has been a regular topic of interest in the press, though (to the author's knowledge) no system is currently available that provides realistic sexual intimacy with simulated characters, although Renaud, Rouleau, Granger, Barsetti, and Bouchard (2002) used participants' interactions with naked virtual models as a means of probing sexual preferences, and other "intimate" applications may prove useful in clinical practice in future. The availability of virtual sexual trainers could be of special value in an area that is ethically difficult, and in which some individuals may be desperate to retain their privacy. In unpublished studies, the attachment behaviour of romantic couples has been assessed in 3-D virtual environments adapted from standard computer games (see below; Lischke & Frey, 2004).

Moreover, the availability of alternative, parallel virtual worlds and virtual cities has allowed the development of experimental societies and a range of social interactions that would not otherwise be possible (Rothblum & Sablove, 2005; see a review by Pearlman, 2007). Gaggioli, Mantovani, Castelnuovo, Wiederhold, and Riva (2003) pointed out that the majority of experimental studies in 2003 had at that point involved virtual navigation and interaction with experimental virtual objects, rather than using inhabited spaces. That may still be so within psychological research but the entertainment business has moved rapidly, and many hundreds of thousands of users now regularly log on to shared environments such as Second Life. Gaggioli et al. (2003) were right to point out that a number of factors needed to be addressed within the area of human-simulated human interaction (such as appearance, structure, autonomy) for effective simulation to be achieved. Few studies have been conducted to assess the quality of interaction between a patient and a virtual human in a situation designed to be of therapeutic benefit, for example. Indeed, it should be noted that such uses of technology are not without their critics, who argue that VEs may often have an alienating effect on their users (O'Neill, 2005). Nevertheless, virtual city environments can be applied to specific training, for example in training small teams for urban combat, emphasising the practice of command and control skills (Lampton, Clark, & Knerr, 2003), also in organizational/industrial psychology (Pierce & Aguinis, 1997); identity construction environments can be designed to promote positive youth development (Bers, 2006).

Social psychology

Where social behaviours and social cognition research is concerned, Groom, Sherman, and Conrey (2002) argued that, despite potential benefits, insufficient was known about behaviours in VEs to be able to use them reliably in social cognition research. However, interpersonal social behaviours have been effectively investigated using immersive VEs. Bailenson, Blascovich, Beall, and Loomis (2003) used an immersive VR system to examine the behaviours of participants as they crossed a virtual room, encountering a virtual human on the way. The characteristics of the virtual human were varied – gender, gaze behaviour and whether they were allegedly avatars or computer-controlled. It was found that greater distance was maintained when approaching the virtual human from the front rather than the back, and participants gave more personal space to virtual humans who engaged them in mutual gaze. Social influence due to mimicry has also been investigated in a VE (Bailenson & Yee, 2005). A simulated person programmed to mimic the head movements of a participant (with a 4-second delay) while presenting an argument was found to be more persuasive and received more positive trait ratings from the participant than a non-mimicking character. Within undergraduate teaching, VE simulations have been proposed for use in psychodrama exercises (Whitman, 1996). Shapiro and McDonald (1992) commented on the likely future importance of VR for investigations in communications and social psychology. Arguments concerning the potential benefits and limitations of VE use in social psychology can be found in Volume 13 (2002) of the journal *Psychological Enquiry*, in particular by Blascovich et al. (2002), Groom et al. (2002), and Rizzo and Schultheis (2002). Collaborative uses of VEs and the usage of space in social interaction, of interest within occupational and other, wider spheres, is discussed by Nova (2005), and Carnagey et al. (2007) discuss violent gaming (see previous section) in the context of antisocial and prosocial behaviours.

Psychological treatments and cybertherapy

Botella (2005) and Botella et al. (2006) point out that there have been an increasing number of studies in the clinical therapeutic field, mainly concerning exposure treatments for anxiety and phobic states, including fear of flying, social phobia, agoraphobia, claustrophobia and arachnophobia (cf. Wiederhold & Wiederhold, 2000). The number has spiralled since the publication of the first case study using VE techniques around 1995, so that rather than being a promise of the future, virtual reality should be regarded as a present reality (Botella, 2005). The particular benefits of using VEs in treating anxiety and post-traumatic stress disorder have been documented for several years (see also Gershon et al., 2002). Patients can access treatment remotely, particularly since portable and shared VR systems are available (Galimberti & Belloni, 2003), inexpensively and, perhaps importantly in some cases, with a high level of anonymity. Compared with "in vivo" exposure, VR exposure to fear-provoking stimuli has the advantages that it can be used in a consulting room, in privacy and comfort, it can involve the use of carefully graded exposure to feared stimuli and more intense exposures that might be excessively frightening in reality; it can be used with patients who have difficulty visualising scenes and with those patients who are too phobic to experience the real equivalent situations (Wiederhold & Wiederhold, 2005). Attempts have been made to desensitise schizophrenic patients to their hallucinations by presenting them with virtual representations of those hallucinations (Tarr & Warren, 2002). This approach is not without its potential dangers; studies have yet to be conducted to determine whether at least some patients with psychotic conditions who have difficulty separating the real world from their imagination may not be disadvantaged by exposure to surrealistic virtual images.

Among studies concerned with anxiety-based neurotic conditions, in a study of fear of flying (Muhlberger, Petrusek, Herrmann, & Pauli, 2005), patients and controls were given four virtual flights while their heart rates and skin conductance were recorded. Results suggested that this VE exposure was authentic insofar as the flight phobics showed enhanced subjective and physiological fear reactions, so that the authors concluded that virtual flights do activate the same fear networks that are responsible for fear of flying in reality. Indeed, VE exposure was argued to be useful clinically for the diagnosis of flight phobia, and treatment outcome could be predicted from the physiological and subjective responses of the participants during virtual exposure. Wiederhold and Wiederhold (2005) have applied the same logic to fear of driving, a clinical condition that is frequently experienced by people recovering from traffic accidents, or as one aspect of a more general agoraphobia. They can be provided with driving exposure in the safety of a therapist's office, and challenged with increasingly demanding tasks at the wheel (an example of VRGET, virtual reality graded exposure therapy). A particular advantage to the use of VEs in this context is that reactions can be precisely measured and observed, so that changes in behaviour can be accurately monitored. New developments will undoubtedly make VEs increasingly available. Riva et al. (2007) describe NeuroVR, based on open source software, and using user-friendly interfaces, it allows clinical practitioners to create or adapt virtual environments for use in therapy sessions.

Huber (2006) points out that using VEs in "clinical cyber psychology" is especially beneficial because a high level of control can be exerted over stimulus presentation and patient interactivity, no other form of training having the reproducibility aspect that characterises VEs. This feature of VEs was utilised by Freeman et al. (2005) in a study in which participants were introduced to a VE populated by five computer characters that had been programmed to behave in a neutral fashion. The greater participants felt "present" in the VE, the greater the likelihood that they experienced persecutory ideation and paranoic thoughts about the computer characters. This type of social VE may have future benefits since many areas of clinical psychological practice involve more subtle or broader interactions than simple object-directed phobias, as Andrews (2005) points out (on behalf of the clinical Division of a professional Society). Clinical psychologists work with individuals, couples, families and organizations, though it is not impossible to envisage that VEs may be beneficial in these areas as well, as environments become more social and complex, as Andrews (2005) acknowledges. Such work will benefit from the vast amount of effort that has been devoted recently to the role of emotion in the design of virtual humans (Gratch & Marsella, 2005), which, interestingly, draws together several specialisms (in computing and technology, and psychology), requiring effective interaction between disciplines. Psychologists have long debated the nature of emotional states (Gray, 1971; Smith, 1998). That work now informs those who want to model the subtle processes involved in the subjective and expressive aspects of emotion (cf. Poznanski & Thagard, 2005) but new paradigms using virtual models can, in turn, potentially enhance the research field by enabling the controlled testing of theories. Training in clinical psychology using VEs is covered below.

Stress, exercise and VEs

The UK government has been keen to promote children's activity and exercise, for example in getting to and from school. There is a substantial and growing proportion of children in UK schools whose body mass indices (BMIs) place them in the overweight and obese categories. In part this may have a dietary cause, but may also be due to the fact that parents have increasingly thought it safer and convenient to transport children between home and school. This has negative effects in several domains: companionship is lost, exploration and deviations from regular routes are reduced so that spatial experience is limited. Can VEs help? Recently, Thomson et al. (2005), psychologists who advise on road safety training, have successfully used VEs to provide children with safe virtual roadside experience. Roadside crossing judgements (avoiding risky crossings, while still crossing efficiently and quickly) were found to improve in 7-11 year-olds after 4 sessions of 30-40 minutes of VE training. Using a VE as a test environment, Clancy, Rucklidge, and Owen (2006) found that participants with ADHD (attention deficit-hyperactivity disorder), in a hazardous road-crossing environment, showed more unsafe road-crossing behaviour than controls, in particular underutilizing the available gaps in on-coming traffic. The authors recommend the use of VEs as a training medium in such cases. Clearly, there is a potential danger that children participating in such studies may be given a false sense of security in risky situations by virtue of being tested in a safe laboratory or classroom. The behaviours observed in VEs may not reflect real world behaviours. According to the risk homeostasis model (Wilde, 2001), the safety of the VE might provoke more risky behaviour during road crossing exercises, though there is evidence of positive transfer; virtual training reportedly leads to safer and not riskier crossing behaviours (Thomson et al., 2005).

The promotion of fitness and exercise can also be assisted by VEs. Those who exercise regularly (run or cycle) will know that the kilometres disappear more rapidly when there is a friend to chat to, or music to listen to. In addition, VEs can provide interesting scenery as a backdrop to exercise. The experience of running or cycling through a novel terrain such as along virtual Pyrenees mountain paths (perhaps with suitable aromas) can engage the exerciser and allow them to undertake lengthier and more strenuous exercise. Plante et al. (2003) and Plante, Cage, Clements, and Stover (2006), in developing a VE system to assist stress management, found that participants who exercised while experiencing a virtual environment were more relaxed, and they experienced less tension, than those who either took a brisk walk outside or viewed the virtual experience without exercising.

In promoting recovery from painful conditions, VEs may also have adjunctive uses (Hoffman, 1998), in engaging attention effectively, such as in the distraction of adolescent burn victims from burn pain by placing them in "Snow World" which "… depicts an icy 3-D virtual canyon with a river and waterfalls" in which participants can "… [shoot] snowballs at snowmen and igloos" (Hoffman et al., 2003).

VEs in the teaching of psychology

Undergraduate courses and modules

The virtual learning environment

It is not impossible to imagine that in 50 years' time, much school and university undergraduate material could be delivered as electronic modules, perhaps from a limited range of sources or even a single source. Some of the didactic university experiences of undergraduate students might be acquired by downloading virtual lecture theatres, virtual lecturers and virtual seminar rooms. Of course, acquiring information in this way is not the whole university "experience" and many other activities that constitute the "student experience", such as social bonding, promoted by direct personal proximity, are probably not substitutable. There are practical difficulties with virtual education which should not be underestimated, though these apply to all subjects and not only to psychology. First, there is the need to regularly up-date teaching materials. This is easy enough when additional PowerPoint slides need to be inserted into a presentation but not when the reprogramming of a virtual lecture is required. Also, emphases, emotion, and the spontaneous instructive asides that characterise a good lecture would often not be represented within a virtual presentation. Moreover, in the learning context, progressive elaboration of knowledge by personal activity is central to current theories of learning (Howe, 1998). It remains to be seen whether virtual environments can help to provide such activity as part of distance learning programs. Technological developments in education have sometimes been regarded as gimmicks and have not always delivered the benefits originally expected, perhaps because they have usually lacked a crucial e.g.,. social) learning component (see Tolmie & Balbieri, 1997). On the other hand, experience with an environmental science training package has suggested that depth of learning is enhanced in students when they interact with a virtual trainer compared with the conventional learning from on-screen text and illustrations (Moreno, Mayer, Spires, & Lester, 2001). Moreno and Mayer (2004) took a further innovative step in examining student interaction with virtual agents in the learning of a multimedia educational design game, comparing head immersion and desktop formats. Students reported a higher level of presence in the head immersion conditions, but this was unrelated to learning. However, personalised speech messages produced consistently better levels of learning on retention and problem-solving transfer tests. The data qualified those of Moreno et al. (2001), indicating that deeper learning is best achieved when a virtual training agent speaks to learners in a personalised style. The Moreno studies were conducted using science materials e.g. botany) but the same principles are likely to apply to learning by psychology students.

An enthusiastic proponent of 3-D virtual reality systems for the promotion of empowerment and engagement, used in Botswana with developmental psychology students among others, is Losike (2006) who argues that multimedia, simulations and virtual reality may bring teaching to life by providing students with experiential learning. According to Losike, “students can experience past events, current trends, and future possibilities and also interact with each other” and that “through interactive participation… multimedia software [permits] logical thinking, problem solving, hypothesis testing, inference and many activities of higher order thinking”. An important point that Losike makes is that “… virtual reality has the potential to transport the minds of students into a given set of experiences. Students felt that they were actually in the experience they were watching on the screen”.

Such a concept has driven work on chronological thinking which can impact on teaching of the history of psychology as well as chronology in other disciplines. Testing primary school children, junior school children and university undergraduates, Foreman, Boyd-Davis, Moar, Korallo, and Chappell (2007) attempted to enhance the learning of historical chronology by having participants fly through a series of events depicted in a VE as a series of screens. It was hoped that by representing the events as “places” encountered sequentially (rather like a familiar row of shops), spatial memory would be engaged, and thus items would be remembered more effectively and in the correct order. There was indeed a benefit for VE use compared with PowerPoint and paper-based text versions of information, but this was largely in undergraduate participants. It appeared that the younger primary children were overawed by the experience and the interest in the presentation medium suppressed memory for some items. The familiar effect seen in memory research in psychology, the serial position effect, was observed in the learning of the historical items, and where there were benefits from using a VE, this tended to happen because intermediate list items were better remembered than when other media were used. Foreman, Korallo, Newson, and Sarantos (2008) have found that using a game format in which scores appear on the screen, and sequences of information (works of art, painter and date) have to be anticipated by the participant, the usual loss of information in intermediate list positions was avoided and learning of a sequence could be trained to perfection. Procedures such as this could thus be used to illustrate the development of theory and ideas within psychology, but could be useful in many other academic spheres having a strong chronological-historical component. An alternative to a linear time-line is the representation of events within a larger and broader space, which could be explored for familiarisation, perhaps over an extended period of time and progressively elaborated (perhaps by students themselves). Such a representation has been used to illustrate the history of photography by Kullberg (1995).

The virtual experimental psychological laboratory

Much of the discussion above centred on uses of VEs in research areas, but the teaching of research skills in undergraduate laboratories can also benefit. A number of authors have pointed out the potential for the development of teaching laboratories in psychology based upon VEs. As early as 1998, this potential was anticipated by Hoffman (1998), who suggested virtual laboratory work in cognitive psychology (perception and memory). Kahan and Mathis (2007) have used a virtual on-line demonstration to enhance comprehension among psychology students of the Sternberg short-term memory scanning task, using a form that required rapidly searching under virtual cups for a ball. When later tested on an on-line quiz, the group having had the virtual demonstration understood the concepts and the paradigm better, outperforming controls.

Adapting game environments for use in the virtual experimental psychological laboratory

Technologies have long been regarded as useful adjuncts to therapies, especially therapies requiring repetitive training or exercise movements (see Krichevets, Sirotkina, Yevsecheva, & Zeldin, 1995), and 3-D video game-based exercises have been used successfully in improving dynamic balance control in patients with brain injuries (Betker, Szturm, Moussavi, & Nett, 2006). Virtual 3-D environments based on games such as Half Life© and Unreal Tournament© have been used clinically in the treatment of arachnophobia (fear of spiders), acrophobia (fear of heights) and claustrophobia (fear of enclosed spaces) (Robillard, Bouchard, Fournier, & Renaud, 2003). However, standard computer games can also be modified as a general resource in the experimental psychological laboratory. They are engaging and realistic, particularly since the games industry (along with the military) have vastly greater resources to develop environments than humble experimenters working in psychological laboratories. Moreover, the use of standard formats can reduce inter-laboratory variation in experimental settings. Games such as Half Life©and Quake III Arena©, are modifiable because the manufacturers publish parts of the games' source codes, explicitly allowing software modifications. In psychology, this allows the game to be adapted according to the research objectives, so that independent variables can be manipulated. Hartig, Frey, and Ketzel (2003) and Frey, Hartig, Ketzel, Zinkernagel, and Moosbrugger (2007) were specifically interested in knowing whether individual differences in game experience prior to participation could be overcome by using suitable training regimes, also whether cybersickness (Stanney & Salvendy, 1998) might produce artificial differences among more or less prone participant groups. Frey et al. (2007) modified the game Quake III Arena© and tested 85 participants aged between 19 and 53 years for their ability to navigate in experimental conditions in three VEs, presented on a monitor screen. These were divided into groups of non-gamers, inexperienced gamers, and experienced gamers. The experimenters concluded that low complexity virtual environments appear to be most suitable for psychological studies. Inexperienced gamers were indeed found to benefit most from 15 minutes of prior training, though significant group differences still remained afterwards. Perhaps surprisingly, in view of the association of cybersickness with immersive head-mounted displays (Stanney & Salvendy, 1998) and elderly participants, some 10% of participants in this study, viewing a monitor screen experienced significant nausea, most having to abort testing prematurely. They found that female participants over 31 years who were not used to playing 3-D computer games were the most susceptible, one third of this group exhibiting the phenomenon. Clearly, prior experience of gaming and computer use can influence spatial performance in VEs (Waller et al., 2001), and this may apply especially to games which are frequently used in the general population when adapted for psychological laboratory work.

Comparative psychology: Teaching and VEs

Just as human participants can be tested in standard animal paradigms using VEs (see previous section), the use of virtual technologies has allowed a further animal-related issue to be addressed. In the past three decades, the use of animals in psychological experiments has reduced greatly, with many university courses advertising that they teach "human psychology", and emphasising that animals do not feature in their research or taught modules. This may please animal rights activists, but it means that undergraduate students can miss out on highly instructive activities, such as the observation of laboratory behaviour, bar-pressing, learning, operant conditioning and superstitious behaviour seen in rats or pigeons during Skinner box training. In UK Psychology departments, this was a controversial but popular feature of the curriculum. However, using a virtual animal laboratory, there is no need to buy and keep expensive animals, ensure their humane housing and treatment, face objections from animal rights activists, or to clean faeces from cages. Sniffy the virtual rat features in a form that can be used to illustrate training and reinforcement schedules;

Sniffy scratches, rears up and in most respects behaves like a real animal subject. Quite sophisticated learning studies can be conducted by students using Sniffy as their subject, reviewing cumulative records under different schedules of reinforcement, for example. Compared with standard study, the use of this virtual laboratory significantly increased students' comprehension of concepts, raising their comprehension scores from 63% to 76% (Venneman & Knowles, 2005).

Teaching of spatially-related skills

Students in the author's university often choose to take modules in cognitive neuropsychology, for which a comprehensive text by Neil Martin (Martin, 2006) is recommended, yet their knowledge of brain structure and anatomy we often find to be limited. In a study elsewhere involving 240, 1st year psychology students, Levinson, Weaver, Garside, McGinn, and Norman (2007) used a virtual reality brain model to teach brain surface anatomy. In particular, they were interested to know whether learner control of views would enhance learning, and whether there was any effect of restricting participants' experiences to a subset of key views. The best test performance was obtained from participants in the low learner control/restriction to key views condition. Experiencing multiple views impeded learning, especially in those participants who were assessed as having poor spatial ability. This result is reminiscent of Sandamas' and Foreman's (2007) finding (see previous section), that operating an input device to explore a model can have an adverse effect on spatial learning, arguably due to the overloading of spatial working memory by input device control. Studies of working memory have often used concurrent spatial tasks to impair spatial learning (see Garden, Cornoldi, & Logie, 2002), and in the context of virtual learning situations, use of input devices and autonomous choice of displacements must be regarded as the equivalent of a concurrent spatial task. During VE exploration, activity can subtract cognitive capacity, leaving less available for information processing for the primary spatial task, though this can apparently be overcome via suitable training in input device use (Sandamas et al., 2009).

Postgraduate training

Clinical psychology students and trainees may in the future benefit from experiences of virtual training. Realistic virtual interactions can be experienced and reviewed over and over again as necessary, allowing direct training of therapeutic practices and strategies, but in the Psychology classroom. Tichon, Loh, and King (2004) have provided virtual demonstration models of phenomena commonly seen in schizophrenia, such as delusions, hallucinations and thought disorder. A Psychology Virtual Teaching Laboratory has been used to develop dissemination programs that promote the use of VEs in rehabilitation (Cardenas, Munoz, Gonzalez, & Uribarren, 2006). Vally (2006) has recommended that "cyber-practice" ought to be incorporated as part of all graduate psychology programs, and like Cardenas et al. (2006), points out the particular value of distance therapies (including use of VR) in countries where accessing therapy can be difficult and/or non-affordable. This becomes increasingly feasible, since improvements in system usability have developed in parallel with reductions in the costs of purchasing and implementing VE technology, and the development of many innovative uses and applications.

VEs in cognate areas

The "space" defined by VEs can be regarded as a new anthropological space, arguably "… throwing commonsensical images of individual psychology into question" for those engaged in psychodynamic psychology (Parker, 2007). Whether psychoanalytic concepts can be portrayed and represented better, given the freedom of expression within 3-D environments, than through textual accounts remains to be seen. Clinical psychologists have long asked whether fantasies and terrifying experiences of hallucinating or paranoid patients might be represented in VEs in order both to convey the experience to the therapist and enable the patient to better cope with it. A difficulty here has been the absence of good self-authoring packages for non-expert users, although self-authoring might be improved in the future. Archaeologists have used VEs to allow an individual to "fly through" the evolution of an archaeological site, to provide "first hand" experience of the changes through which it has passed, perhaps over millennia, and in medicine, virtual training for minimally invasive surgery is now commonplace, at least as one element of training (Gallagher et al., 2005).

The future: Potential uses within psychology education

The above review has highlighted particular areas in which the use of VEs can illuminate and demonstrate phenomena in psychology, rendering verbal descriptions more understandable to undergraduate students, such as allowing participation by students in animal paradigms, and developing the interpersonal skills of clinical trainees. Though not specifically covered, these same advantages can be applied in many areas of the subject, including spheres such as educational, health and organisational psychology. It is likely that the use of intelligent agents in teaching processes will become more common, just as web based experiments and software that allows students to test themselves as participants in laboratory experiments have made a significant contribution to experimental psychology teaching. The use of VEs arguably allows students opportunities to safely carry out experiments with any number of virtual agents, and conduct more elaborate experiments that might illustrate principles such as the relationship between N size and statistical power and significance. VEs may make assessment more individual and valid. It is as yet unclear what the ultimate impact of realistic VEs might be on teaching. At one level one could imagine virtual lecture theatres, in which students and lecturer can interact via input devices and headsets; all materials can be accessed remotely, dominating the teaching process and making university access more available to a wider section of the community. However, in relation to higher education in particular, Howe (1998) has pointed out that "Quite a lot is at stake … in deciding how to divide responsibilities between persons and computers".

Conclusions

The development of VEs in psychology has largely benefited research in the past (especially in areas that have strong spatial components), though they are being used more frequently now in clinical and other forms of virtual training, as well as in undergraduate teaching where they can enliven the syllabus and render lectured materials more memorable. They might also promote educational integration by providing training in spatially mapping (new) school environments and provide authentic distance learning experience to increase participation rates among disadvantaged groups. Uses in clinical training could be extended in the future, with improvements in the programming of emotions and sophisticated "evolving" personalities, such that simulated people can be programmed to behave in neutral, aggressive or happy ways. In many studies reviewed above, head immersion VR has been said to create a greater feeling of presence than desk-top presentation, although VEs can be effective when programmed using relatively cheap software (Botella, 2005) and presented on a cheap monitor. Some of the barriers to VE use are the unreliability of software companies, compatibility difficulties, technology up-grading costs, and technical support availability. There is always a need to update created environments to ensure currency. Nevertheless, research is consistently demonstrating new benefits.

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