

ONLINE VIDEO GAME THERAPY FOR MENTAL HEALTH CONCERNS: A REVIEW

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ABSTRACT

Background: There has been research on the use of offline video games for therapeutic purposes but online video game therapy is still fairly under-researched. Online therapeutic interventions have only recently included a gaming component. Hence, this review represents a timely first step toward taking advantage of these recent technological and cultural innovations, particularly for the treatment of special-needs groups such as the young, the elderly and people with various conditions such as ADHD, anxiety and autism spectrum disorders.

Material: A review integrating research findings on two technological advances was conducted: the home computer boom of the 1980s, which triggered a flood of research on therapeutic video games for the treatment of various mental health conditions; and the rise of the internet in the 1990s, which caused computers to be seen as conduits for therapeutic interaction rather than replacements for the therapist.

Discussion: We discuss how video games and the internet can now be combined in therapeutic interventions, as attested by a consideration of pioneering studies.

Conclusion: Future research into online video game therapy for mental health concerns might focus on two broad types of game: simple society games, which are accessible and enjoyable to players of all ages, and online worlds, which offer a unique opportunity for narrative content and immersive remote interaction with therapists and fellow patients. Both genres might be used for assessment and training purposes, and provide an unlimited platform for social interaction. The mental health community can benefit from more collaborative efforts between therapists and engineers, making such innovations a reality.

Key words: online video games, therapy, mental health, review

INTRODUCTION

Despite the growing recognition of mental health professionals that video games can make their therapeutic offerings more engaging, there has been little study as yet of the therapeutic opportunities afforded by the emerging medium of online video games. During the first wave of research into video game interventions in the 1980s, computers were presumed to suffer from therapeutic limitations that the online revolution has now overcome, by placing real people rather than cold artificial

intelligence (AI) behind the computer screen, and demonstrating the possibility of rich computer-mediated communication. This review of current assets for online video game therapy represents a timely first step toward taking advantage of these recent technological and cultural innovations, particularly for the treatment of special-needs groups such as the young, the elderly and people with various conditions such as ADHD, anxiety and autism spectrum disorders.

We begin with a historical survey of findings and forecasts from early video game literature. Then we outline how online developments have expanded the possibilities for video game therapy beyond their predicted bounds. Research into online video game therapy must build on findings from two domains, which we document in turn: offline video game therapies and online non-game therapies. We conclude by identifying the few interventions that have pioneered the integration of video game-based and online therapeutic tools, and by proposing avenues for future research.

This review was restricted to studies published in peer-reviewed journal articles, books and book chapters. Studies were identified through online databases including Web of Science, EBSCOHost, ScienceDirect, PsycINFO, ERIC and ACM Digital Library. Key words used include combinations of 'computer games', 'video games', 'online games intervention', 'therapy', 'treatment' and 'mental health'. Peer-reviewed papers could be qualitative or quantitative in nature and unpublished doctoral and master's dissertations were excluded.

ONLINE REVOLUTION: CHANGING HORIZONS FOR THERAPEUTIC VIDEO GAMES, 1980s – PRESENT

The first video gaming boom occurred in the late 1970s to early 1980s, simultaneous with the appearance of a variety of accessible, low-cost home computer systems (e.g. Atari, Apple). Children especially were drawn to the new medium and researchers also explored how this attraction might be employed for therapeutic ends. Malone (1981) argued that video games satisfy children's need for challenge, fantasy and curiosity, making them a model for intrinsically motivating instruction. While cognitive benefits associated with video game use in and of itself have been documented, Hume (1984) voices a cautious response from the therapeutic community, noting that the widespread adoption of computers in occupational therapy departments will be impeded by factors such as low computer literacy, lack of literature and information on software, and limited time available for therapists to develop applications.

At this time case studies also began to appear suggesting that, under certain circumstances, interventions incorporating computer games may prove as effective as human therapists. The overriding professional opinion at this time, however, was that therapists would never be replaced by even the most sophisticated computers. In an early review of the use of computers for psychological problems, Lawrence (1986) asks whether machines will ever be able to 'talk' with patients, and so satisfy the conditions for a full therapeutic relationship. After discussing extant research on computer communication, Lawrence concludes that computers can neither reproduce the superficial signals of non-verbal communication, nor vehicle the intimacy that might underlie these forms of communication.

While the last 20 years have brought video games no closer to generating intimate contact of their own, the online revolution has nevertheless made them a medium for human intimacy to an extent unimaginable in the 1980s. The computer is no longer envisioned as an automated

replacement for the therapist, but as a conduit for faithfully transmitting the therapeutic interactions of humans. The computer-as-replacement model of the 1980s can be seen, for example, in a study by Delclos and Kulewicz (1986), which demonstrates that an educational video game can improve sixth-graders' problem-solving skills up to a point, but that live teacher intervention is required to advance them past this plateau. Rather than explore possible synergy between facilitator and computer, the authors conclude that through greater understanding of human compensation for computer shortcomings, intelligent programs may yet come to take on the role played by the human teacher in this study. Since the rise of the internet in the mid 1990s, however, mental health research has turned increasingly toward the computer-as-conduit model, in which processing power is harnessed precisely to transmit facilitator and user communications. Recent studies have concentrated on technical and cognitive requirements for creating the illusion of virtual therapist presence (Riva *et al.*, 2002) or immersive user presence in a virtual world (Ravaja *et al.*, 2004). Improved graphics and processing speed enable real-time animation of on-screen interlocutors, allowing users to interact with the inhabitants of projected narrative worlds both verbally and physically (e.g. Charles *et al.*, 2001).

In the 1980s computer game therapy required that both the client and unfamiliar equipment be brought to the office. The exceptional effort was justified by a promise that computers might someday lighten much of the therapist's load. Today computers may well make therapy easier, though not by taking the therapist out of the picture. Rather, the ability to meet with clients in limitless virtual spaces can put therapists into whatever picture they deem most constructive. Online video game worlds, in particular, offer the dual benefit of intrinsically motivating challenges and rules tailored to the client's specific needs. Hume's (1984) concern about low computer literacy appears increasingly anachronistic in today's wired societies, and Lawrence's (1986) caveat about poor therapeutic computer communication could not foresee the extent to which computers would become a medium for human-to-human communication instead. The other doubts that Hume raises, however, remain disappointingly current: therapists continue to lack the time to develop innovative applications, and as a result the profession still enjoys little literature and information on promising software (Coyle *et al.*, 2007). Given the continuing rarity of research into therapeutic online video games, the following section summarizes generalizable findings from the field of offline video games.

OFFLINE VIDEO GAME THERAPIES

Although the 1980s saw a variety of controlled experiments on the effectiveness of video games in therapy, mental health research on video games in the 1990s came to be dominated by their adverse effects, and only in the 2000s does the argument for video game therapy reappear with frequency. In the 1980s Larose *et al.*, (1989) reported significantly improved spatial abilities of adolescents with minimal brain damage or attention problems by means of a modified Atari game. Although Larose *et al.* conclude that this would only be the beginning of research into computerized re-education exercises, none of these reports generated much follow-up. Instead, during the following decade video games were increasingly studied as medical and psychosocial hazards (Griffiths, 1996) or addictive threats (Griffiths & Hunt, 1998). Recent reviews of the positive advances in video game therapy (Griffiths, 2004; Saloni-Pasternak & Gelfond, 2005) consistently respond

to this preconception by opening on a defensive note. Despite this diversion of attention, video game therapy has been applied to a wide range of mental health concerns, all of which might now be extended by taking treatment online.

Aggression

Given the trend to view video game violence as a factor in aggression, and the extensive literature devoted to this topic (e.g. Griffiths, 1998), it is interesting to note the handful of researchers who have opted to explore an alternate viewpoint whereby video games might play an active role in curbing aggressive behavior. One team has pursued the long-term development of a multimedia program called SMART Talk (Bosworth *et al.*, 2000), which incorporates video games and simulations as part of a computer-based intervention that significantly diminishes middle-school students' beliefs that are supportive of violence and increases their intentions to use non-violent strategies. While it is unclear how much of the effect is attributable to the video game component of the intervention, a starting assumption of the project is that adolescents' engagement with such interactive multimedia will contribute to the success of the program.

Anxiety disorders

Inquiries into 2D video games for anxiety treatment can be found, alongside a variety of graded exposure therapies using virtual reality. Sharry *et al.*, (2003) propose Relax to Win, a biofeedback-based 2D game for the treatment of children with general anxiety problems. Two on-screen dragons race faster the more players relax, as measured by their galvanic skin response. The authors outline how this incentive to learn relaxation techniques can be integrated into a wider treatment format. Video games also prove realistic enough to generate successful graded exposure trials against phobias of spiders (Bouchard *et al.*, 2006) and heights or enclosed spaces (Robillard *et al.*, 2003). Fear of driving after an accident can be comparably reduced by virtual reality driving games, or their 2D equivalents (Walshe *et al.*, 2003).

Graded exposure by virtual reality has been applied to fear of flying (Rothbaum *et al.*, 2000) and fear of heights (Emmelkamp *et al.*, 2002). Despite this flurry of interest in a new technology, however, certain studies indicate that virtual reality treatments may not be as effective as traditional approaches. For example, Dewis *et al.* (2001) demonstrates that while computer-aided vicarious exposure is superior to the control, live graded exposure remains superior to both. Choi *et al.* (2005) compared a traditional 12-session panic control program to a shortened experimental treatment using virtual exposure, and found that the results of the experimental treatment have fallen significantly behind at six months.

Attention deficit hyperactivity disorder

Video game therapy for children with ADHD has elicited a relatively large amount of scholarly attention, because many children who do not inhibit their hyperactivity in other contexts will do so when playing intrinsically motivating video games. Lawrence *et al.* (2002) highlighted that 6–12-year-old boys with ADHD perform beneath a normally developing control group when playing a cognitively demanding adventure video game, and even more so on a route task outside the laboratory, but perform equally well on a motor-skill targeting game that does not involve high working memory or distractor loads. This engagement makes video games ripe for therapeutic applications.

One natural application is as a platform for ADHD assessment tools. Assessment video games vary in their ability to detect a difference between the performance of children with and without ADHD, which may be due to differences in demands on working memory, as highlighted by Lawrence *et al.* (2002). For instance, Saldana and Neuringer's (1998) video game-based test of response variability found no difference between groups, and simply involves pressing one of two buttons when an animated snake crosses a target area on the screen. The CyberCruiser program (Kerns & Price, 2001), on the other hand, asks children to exercise prospective memory in checking their fuel gauge while weaving a virtual car through traffic, and children with ADHD demonstrate significantly more difficulty on this task than does the control group. Shaw *et al.*, (2005) show that 6–13-year-olds with ADHD perform more poorly when compared to a control group on a conventional Conners' Continuous Performance Test II (Conners, 2000), but perform equally well when the same test is administered as a video game. When children with ADHD interact with an immersive virtual reality simulation of a busy road crossing, they act more dangerously and experience twice as many collisions as controls (Clancy *et al.*, 2006), which may suggest a method not only of identifying but safely shaping the behaviour of children at greater risk of injury in hazardous situations.

There is some evidence that video games can contribute to reducing ADHD symptoms. The first therapeutic video game for children with ADHD was by Pope and Bogart (1996), whose Extended Attention Span Training (EAST) system modifies a NASA program that assesses the engagement of pilots using automated flight management systems. Pope and Palsson (2001) further develop this NASA patent as an ADHD intervention that decreases players' control over off-the-shelf PlayStation games when their EEG reports lower attention, measured as higher theta-to-beta wave ratio. The effectiveness of this adaptive training system was equal to that of conventional, non-game visual biofeedback in reducing 9–13-year-olds' inattention and hyperactivity, and the participants reported it to be much more enjoyable. In a recent review, Heinrich *et al.*, (2007) provided evidence across studies that children with ADHD improved on behavioural and cognitive variables after frequency (theta/beta) training and/or slow cortical potential (SCP) training. Such biofeedback training can be run as a computer game and thus principally attractive for children.

Autism

Therapeutic computer games are of special interest for autism, since their rules-based environments present a safe, appealing vehicle for interventions to improve socialization. Bolstering the case for video games as therapy for autism is evidence that video modelling results in greater motivation, generalization and cost-effectiveness than *in vivo* modelling among autistic children ages 7–11 (Charlop-Christy *et al.*, 2000). More recently, it has been demonstrated that 13–18-year-olds with autistic spectrum disorder interact with virtual environments on a par with control groups, although some are more likely to walk between other characters in the simulation, suggesting a potential for virtual environments to serve as a medium for education about social conventions (Parsons *et al.*, 2004, 2005); the same researchers report lessons that such adolescents have found useful from guided interaction with virtual simulations of café and bus environments (Parsons *et al.*, 2006).

Several researchers have worked on therapeutic video games for autistic children. Tanaka and colleagues are developing Let's Face It, a suite of games designed to teach ability-appropriate distinctions between faces and objects, and recognition and labelling of facial expressions (Tanaka *et al.*, 2005). Whalen *et al.*, (2006) developed a rigorously tested computer-assisted instructional

program called TeachTown, which uses a suite of game-like tests and professionally designed visual reinforcers to make a demonstrated positive impact on receptive language, social understanding, self-help, attention, memory, auditory processing and early academic skills for children with autism and other developmental delays.

Personality and psychotic disorders

Scattered efforts have been made to bring video games to bear on the most challenging personality and psychotic disorders. On one end of the spectrum are Sieswerda *et al.*, (2005), who employ the simplest of ‘worm’ and ‘tennis’ games not for any therapeutic content, but to tease out responses involving potential differences in dichotomous evaluations among subjects with border-line personality disorder, subjects with cluster or antisocial personality disorders, and a control group with no diagnosed personality disorder. On the other end is Shrimpton and Hurworth’s (2005) account detailing the development of an elaborate adventure game to educate young people who have experienced their first psychotic episode. An interdisciplinary panel of experts is convened to study the prototype, and they demand substantial redevelopment in order to make the intervention an effective aid in young people’s recovery from psychosis. Studies of video games applied to schizophrenia include Crookes and Moran (2003), who prepared a simple joystick-controlled game in order to assess how quickly subjects of different ages and genders can find cheese hidden on a 4 × 4 grid according to certain classical conditioning rules that healthy adults naturally filter out, but that schizophrenics do not; and Da Costa and De Carvalho (2004), who established that a group of medicated schizophrenics respond positively to completing cognitive tasks in virtual reality, suggesting a new medium for therapeutic interventions.

Children and the elderly

It is evident from the foregoing that children and adolescents have been the primary targets of therapeutic video games. While adults are comfortable with direct face-to-face dialogue, many children struggle to express themselves with words alone and use of therapeutic channels such as video games and other means provide children with an avenue for indirect communication (Coyle *et al.*, 2007; Coyle *et al.*, 2005). Several comprehensive overviews of the literature for this entire age range have appeared (e.g. Goh *et al.*, in press; Griffiths, 2003; Saloni-Pasternak & Gelfond, 2005), and beyond these, several reports on subgroups can be found. Kokish (1994) presents the first recommendations on materials for computer play with preschoolers, and Aymard (2002) discusses a computer drawing game for projective use, to stimulate catharsis and affective expression in preschoolers and school-age children. Reaching at-risk youth by means of video games is also a recurring theme. For example, Resnick (1994) reports on BUSTED, a computerized game to promote reflection on antisocial behaviour in young offenders, and Sherer (1994) reports a controlled study of the effects of a moral development game on youth in distress. Dominic Interactive is an example of a DSM-IV-based diagnostic tool for children aged 6–12, in which a series of yes/no questions aim to give children greater scope for self-expression via a format akin to a video game. It has undergone validity testing in the US (Valla *et al.*, 1997) and other countries (Valla *et al.*, 2002).

The elderly represent another demographic that has received its share of attention from therapeutic video game developers. Counting for Goblins is a computerized version of the Counting Span task, which older subjects found more interesting than the offline equivalent, and which features

automatic measurement of accuracy and response times (Ryan, 1994). More recently, Barnes *et al.* (2006) tested a randomized controlled trial of computer-based cognitive therapy in older adults with mild cognitive impairment. Elderly patients (mean age of 75 years) were randomly assigned to either the intervention ($n = 22$) or control ($n = 23$) groups. The intervention group performed a series of computer-based, progressive listening exercises that were designed to enhance learning and memory for 100 minutes/day, five days/week for about six weeks. The control group read online newspapers and listened to audio books for comparable amounts of time. Measures of verbal memory consistently favored the intervention group. The researchers concluded that computer-based cognitive therapy may improve cognitive function in elderly patients with mild cognitive impairment but larger trials with greater statistical power are needed.

ONLINE NON-GAME THERAPIES

Bremer and Beresin (2000) is typical of current reviews of computer use in mental health and throughout the health sciences, in that it divides 'Internet Socializing' and 'Computer Games' into separate headings under 'Patient's Computer Use', a classification that admits no overlap between the two domains, and mitigates against research into the benefits of synergy between them. Since most examples of remote computer therapy have developed in just such a silo, we must devote a section to the field of non-game online therapeutic applications before considering interventions that merge the two. Any mental health practitioners who use a cell phone or email as part of their work have an understanding of the communicative possibilities the wired world can open up, but for the brief history that follows, we will focus on online therapeutic services with a computer-automated component.

Before the internet revolution, the telephone was the main point of entry to automated therapeutic services. In the 1980s Schneider (1986) launched a five-week, 24-hour-a-day system to stop smoking, coupled with an early dial-up electronic bulletin board to keep clients in touch with fellow and former smokers, as well as clinicians. Trials confirmed that smokers in the full program made repeat visits to the system and smoked progressively less over the six-month follow-up (Schneider *et al.*, 1990).

Despite the spread of the internet and email during the 1990s, telephone-access systems such as interactive voice recognition (IVR) remained central to online therapeutic offerings. IVR systems were set up to test automated assessments for OCD (Baer *et al.*, 1993) and depression (Baer *et al.*, 1995). These systems showed good interrater reliability with assessments performed by clinicians via live phone interviews, and client response was not negative, but interest waned in the face of preference for human communication. IVR was also applied to a new smoking cessation program (Schneider *et al.*, 1995), in which success correlated with the number of calls clients made to the system, but remained below the level of face-to-face interventions; and to an automated OCD self-treatment service known as BT STEPS (Marks *et al.*, 1998), which with regular use produced results comparable to SSRI therapy. Marks (1999) contextualizes these experiments against the decade's use of computers in mental health generally, and discusses the potential advantages of computerized self-treatments from the perspectives of patients, practitioners and researchers.

Recent years have seen new directions in experimentation with evolving online technologies. A service such as Health Hero (O'Connell & Cherry, 2000) explicitly roots itself in the previous

successes of IVR, and especially its cost-effective management of high-risk, chronically ill patients. Meanwhile, researchers such as Popescu *et al.*, (2000) are exploring home virtual reality systems for orthopaedic rehabilitation, which take advantage of transparent, automated data collection to transmit feedback from a haptic glove directly to a central database.

VIDEO GAMES GO ONLINE: FUTURE INTEGRATIONS

A decade ago, Barker *et al.*, (1995) tested a computer intervention for adolescent children of divorce that involved a trip to the lab to play a therapeutic video game, a mail-out of a post-test one week later, and a 10-minute telephone interview one week after that. Today it is easy to imagine a streamlined version of this program: if the subject were still to visit the lab, it might be for deeper face-to-face interaction, since the video game could be played anywhere, before or after, and the results instantly shared with the lab. Instant, convenient email has all but eclipsed the traditional postal service, and follow-up interviews can take many other remote-communication forms. Once the relationship is established, researcher and subject might meet anywhere, perhaps even in a new, self-expressive virtual space that the subject has created as part of the reflection on the intervention. Many practitioners will prefer the immediate warmth of the traditional face-to-face encounter, for its associations and its proven benefits, but as we shall see, certain researchers have begun to explore such alternate virtual spaces as well. The entire community stands to gain from this growing wealth of therapeutic options.

In the field of health psychology, a private intranet initiative called STARBRIGHT World (Bush *et al.*, 2002) proposes a rich communicative platform of chatrooms, instant messaging, bulletin boards, art activities, contests and more to support the quality of life, socialization and locus of control of chronically hospitalized children in Canada and the US. Research indicates that users show decreased loneliness and withdrawal, and increased willingness to return to the hospital (Battles & Weiner, 2002).

With Zora, Bers (2001) takes the concept of the interactive online forum and expands it into a virtual city for the exploration of identity and moral development. Whether applied to hospitalized 7–18-year-olds undergoing dialysis (Bers *et al.*, 2001) or to 11–15-year-olds selected for a naturalistic experiment in diversity (Bers, 2001), the rules of the Zora world encourage constructivist learning about personal values by requiring that all objects and spaces that participants create also be associated with an explicit value. As Bers *et al.*, note, not only are dialysis patients able to distract themselves from their machines and move as freely as they like through the virtual spaces they help shape, but this creative use of their free time helps them explore aspects of their identity that are usually underplayed during treatment. Bers (2006) continues to theorize on means by which such 'identity construction environments' can promote positive youth development.

Cheng *et al.*, (2003) are adapting the open-ended online social model for children with Asperger's syndrome, and their very different needs. They hope that online play therapy will provide four advantages in helping these children learn conversational skills, that it will offer a safe role-playing environment, reduce anxiety via indirect interactions, offer a means for generalization of skills learned face to face, and facilitate affiliation with peers and others.

To furnish the participants with increased conversational structure, their conventional chat application, KidTalk, is supplemented with scripts that offer a choice of roles for a given situation (e.g. 'host' and 'guests' at a birthday party). Clear visual feedback is also offered as to how effectively each user is participating in the chat: the less a user speaks, the farther from the centre of a conversational circle that user's avatar becomes.

One interesting application of online capability to therapeutic video games is the research by Jimison *et al.*, (2004) into programs that automatically furnish a central location with feedback about the cognitive abilities of elderly game players, enabling either automated assistive scripts or human intervention should difficulties arise. The authors devise a series of algorithms that infer users' cognitive performance by tracking success on a game such as FreeCell, as well as psychomotor measurements associated with keyboard entry and mouse movement. The proposed software can also provide user feedback by modifying the difficulty of a game to maintain an optimum level of challenge for ageing players.

Throughout this review, advances in therapeutic 2D video games have been considered alongside those in 3D virtual reality. In the final analysis, however, we would argue that online 2D games are currently a more compelling research prospect than virtual reality therapies. The continued high cost and inaccessibility of the equipment involved will ensure that virtual reality remains a niche domain for some time to come. As long as virtual reality equipment must be employed at the mental health professional's laboratory, the world will naturally turn to universally available 2D screens as its gateway to easily accessible alternative worlds. Because there is little barrier to exploring the potential of online video game therapies, any creative, effective therapeutic application in this field will likely gain wide acceptance.

Nearly three decades after the first home computer explosion, we can see that the mental health community's early concerns about low computer literacy and poor computer communication have turned out not to pose the expected barriers to therapeutic use. While the immense appeal of video games went on to cause a backlash among scholars who saw harm to their players, pioneering researchers have now harnessed the intrinsic motivation that they elicit to help treat ADHD, anxiety, and other psychiatric conditions. A second sea change arrived with the advent of the internet, causing computers to be seen less as potential replacements for the therapist and more as conduits for therapeutic interaction. The research and clinical potential for combining video games and the communicative possibilities of the internet are immense. Future research into online video game therapy for mental health concerns might focus on two broad types of game: simple society games such as cards or chess, online versions of which are freely available, and elaborate online worlds such as massively multiplayer online role-playing games (MMORPGs), whose worldwide membership numbers in the millions. Both genres might be used for assessment and training purposes, and with an online chat component, both provide a limitless platform for social interaction that could be incorporated as part of the intervention program. Society games present the advantage of being accessible and enjoyable to players of all ages, while online worlds offer a unique opportunity for narrative content and immersive remote interaction with therapists and fellow patients. We echo Coyle *et al.*'s (2007) call for more collaborative efforts between therapists and engineers, making such innovations more widely used.

REFERENCES

- Aymard, L.L. (2002) 'Funny Face': Shareware for child counseling and play therapy. *Journal of Technology in Human Services*, 20, 11–29.
- Baer, L., Brown-Beasley, M.W., Sorce, J. & Henriques, A.I. (1993) Computer-assisted telephone administration of a structured interview for obsessive-compulsive disorder. *American Journal of Psychiatry*, 150, 1737–1738.
- Baer, L., Jacobs, D.G., Cukor, P., O'Laughlen, J., Coyle, J.T. & Magruder, K.M. (1995) Automated telephone screening survey for depression. *Journal of the American Medical Association*, 273, 1943–1944.
- Barker, J., Brinkman, L. & Deardorff, M. (1995) Computer intervention for adolescent children of divorce. *Journal of Divorce and Remarriage*, 23, 197–213.
- Barnes, D.E., Yaffe, K., Belfor, N., Reed, B., Jagust, W., Decarli, C. & Kramer, J. (2006) Computer-based cognitive therapy for mild cognitive impairment: results of a pilot, randomized, controlled trial. *Alzheimer's and Dementia*, 2(Suppl 1), 508–509.
- Battles, H.B. & Weiner, L.S. (2002) Starbright World: Effects of an electronic network on the social environment of children with life-threatening illnesses. *Children's Health Care*, 31, 47–68.
- Bers, M.U. (2001) Identity construction environments: Developing personal and moral values through the design of a virtual city. *Journal of the Learning Sciences*, 10, 365–415.
- Bers, M.U. (2006) The role of new technologies to foster positive youth development. *Applied Developmental Science*, 10, 200–219.
- Bers, M.U., Gonzalez-Heydrich, J. & DeMaso, D.R. (2001) Identity construction environments: Supporting a virtual therapeutic community of pediatric patients undergoing dialysis. *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*, 3, 380–387.
- Bosworth, K., Espelage, D., DuBay, T., Daytner, G. & Karageorge, K. (2000) Preliminary evaluation of a multimedia violence prevention program for adolescents. *American Journal of Health Behavior*, 24, 268–280.
- Bouchard, S., Côté, S., Saint-Jacques, J., Robillard, G. & Renaud, P. (2006) Effectiveness of virtual reality exposure in the treatment of arachnophobia using 3D games. *Technology and Health Care*, 14, 19–27.
- Bremer, J. & Beresin, E.V. (2000) Computers in psychiatry today. *Academic Psychiatry*, 24, 168–172.
- Bush, J.P., Huchital, J.R. & Simonian, S.J. (2002) An introduction to program and research initiatives of the Starbright Foundation. *Children's Health Care*, 31, 1–10.
- Charles, F., Mead, S.J. & Cavazza, M. (2001) User intervention in virtual interactive storytelling. Paper presented at Virtual Reality International Conference, Laval, France.
- Charlop-Christy, M.H., Le, L. & Freeman, K.A. (2000) A comparison of video modeling with *in vivo* modeling for teaching children with autism. *Journal of Autism and Developmental Disorders*, 30, 537–552.
- Cheng, L., Kimberly, G. & Orlich, F. (2003) KidTalk: Online therapy for Asperger's syndrome (Technical Report No. MSR-TR-2002–08). Redmond, WA: Microsoft Research.
- Choi, Y.-H., Vincelli, F., Riva, G., Wiederhold, B.K., Lee, J.-H. & Park, K.-H. (2005) Effects of group experiential cognitive therapy for the treatment of panic disorder with agoraphobia. *Cyberpsychology and Behavior*, 8, 387–393.
- Clancy, T.A., Rucklidge, J.J. & Owen, D. (2006) Road-crossing safety in virtual reality: A comparison of adolescents with and without ADHD. *Journal of Clinical Child and Adolescent Psychology*, 35, 203–215.
- Connors, C.K. (2000) The Connors' Continuous Performance Test II (Version II). North Tonawanda, NY: MultiHealth Systems.
- Coyle, D., Doherty, G., Matthews, M. & Sharry, J. (2007) Computers in talk-based mental health interventions. *Interacting with Computers*, 19, 545–562.
- Coyle, D., Matthews, M., Sharry, J., Nisbet, A. & Doherty, G. (2005) Personal investigator: A therapeutic 3D game for adolescent psychotherapy. *International Journal of Interactive Technology and Smart Education*, 2, 73–88.
- Crookes, A.E. & Moran, P.M. (2003) An investigation into age and gender differences in human kamin blocking, using a computerized task. *Developmental Neuropsychology*, 24, 461–477.
- Da Costa, R.M.E.M. & De Carvalho, L.A.V. (2004) The acceptance of virtual reality devices for cognitive rehabilitation: A report of positive results with schizophrenia. *Computer Methods and Programs in Biomedicine*, 73, 173–182.
- Delclos, V.R. & Kulewicz, S.J. (1986) Improving computer-based problem solving training: The role of the teacher as mediator. *Computers in Human Behavior*, 2, 135–146.

- Dewis, L.M., Kirkby, K.C., Martin, F., Daniels, B.A., Gilroy, L.J. & Menzies, R.G. (2001) Computer-aided vicarious exposure versus live graded exposure for spider phobia in children. *Journal of Behavior Therapy and Experimental Psychiatry*, 32, 17–27.
- Emmelkamp, P.M.G., Krijn, M., Hulsbosch, A.M., De Vries, S., Schuemie, M.J. & Van Der Mast, C.A.P.G. (2002) Virtual reality treatment versus exposure *in vivo*: A comparative evaluation in acrophobia. *Behaviour Research and Therapy*, 40, 509–516.
- Goh, D.H., Ang, R.P., Tan, H.C. (in press) Strategies for designing effective psychotherapeutic gaming interventions for children and adolescents. *Computers in Human Behavior*.
- Griffiths, M.D. (1996) Computer game playing in children and adolescents: A review of the literature. In *Electronic children: How children are responding to the information revolution* (ed. T. Gill), pp.41–58. London: National Children's Bureau.
- Griffiths, M.D. (1998) Video games and aggression: A review of the literature. *Aggression and Violent Behavior*, 4, 203–212.
- Griffiths, M.D. (2003) The therapeutic use of videogames in childhood and adolescence. *Clinical Child Psychology and Psychiatry*, 8, 547–554.
- Griffiths, M.D. (2004) Can videogames be good for your health? *Journal of Health Psychology*, 9, 339–344.
- Griffiths, M.D. & Hunt, N. (1998) Dependence on computer game playing by adolescents. *Psychological Reports*, 82, 475–480.
- Heinrich, H., Gevensleben, H. & Strehl, U. (2007) Annotation: Neurofeedback – train your brain to train behavior. *Journal of Child Psychology and Psychiatry*, 48, 3–16.
- Hume, C. (1984) Microcomputers in occupational therapy departments: The therapeutic application. *British Journal of Occupational Therapy*, 41, 175.
- Jimison, H., Pavel, M., McKanna, J. & Pavel, J. (2004) Unobtrusive monitoring of computer interactions to detect cognitive status in elders. *IEEE Transactions on Information Technology in Biomedicine*, 8, 248–252.
- Kerns, K.A. & Price, K.J. (2001) An investigation of prospective memory in children with ADHD. *Child Neuropsychology*, 7, 162–171.
- Kokish, R. (1994) Experiences using a PC in play therapy with children. *Computers in Human Services*, 11, 141–150.
- Larose, S., Gagnon, S., Ferland, C. & Pépin, M. (1989) Psychology of computers: Cognitive rehabilitation through computer games. *Perceptual and Motor Skills*, 69, 851–858.
- Lawrence, G.H. (1986) Using computers for the treatment of psychological problems. *Computers in Human Behavior*, 2, 43–62.
- Lawrence, V., Houghton, S., Tannock, R., Douglas, G., Durkin, K. & Whiting, K. (2002) ADHD outside the laboratory: Boys' executive function performance on tasks in videogame play and on a visit to the zoo. *Journal of Abnormal Child Psychology*, 30, 447–462.
- Malone, T.W. (1981) Toward a theory of intrinsically motivating instruction. *Cognitive Science*, 4, 333–369.
- Marks, I.M. (1999) Computer aids to mental health care. *Canadian Journal of Psychiatry*, 44, 548–556.
- Marks, I.M., Baer, L., Greist, J.H., Park, J.M., Bachofen, M., Nakagawa, A. *et al.* (1998) Home self-assessment of obsessive-compulsive disorder: Use of a manual and a computer-conducted telephone interview, two UK-US studies. *British Journal of Psychiatry*, 172, 406–412.
- O'Connell, M.A. & Cherry, J.C. (2000) The Health Hero® online service: A new internet-based communications platform for disease management, case management and performance measurement. *Disease Management and Health Outcomes*, 7, 149–161.
- Parsons, S., Leonard, A. & Mitchell, P. (2006) Virtual environments for social skills training: Comments from two adolescents with autistic spectrum disorder. *Computers and Education*, 47, 186–206.
- Parsons, S., Mitchell, P. & Leonard, A. (2004) The use and understanding of virtual environments by adolescents with autistic spectrum disorders. *Journal of Autism and Developmental Disorders*, 34, 449–466.
- Parsons, S., Mitchell, P. & Leonard, A. (2005) Do adolescents with autistic spectrum disorders adhere to social conventions in virtual environments? *Autism*, 9, 95–117.
- Pope, A.T. & Bogart, E.H. (1996) Extended attention span training system: Video game neurotherapy for attention deficit disorder. *Child Study Journal*, 26, 39–51.
- Pope, A.T. & Palsson, O.S. (2001, October). Helping video games 'Rewire Our Minds'. Paper presented at Playing by the Rules Conference, University of Chicago Cultural Policy Center, Chicago, IL.

- Popescu, V.G., Burdea, G.C., Bouzit, M. & Hentz, V.R. (2000) A virtual-reality-based telerehabilitation system with force feedback. *IEEE Transactions on Information Technology in Biomedicine*, 4, 45–51.
- Ravaja, N., Salminen, M., Holopainen, J., Saari, T., Laami, J. & Järvinen, A. (2004) Emotional response patterns and sense of presence during video games: Potential criterion variables for game design. *ACM International Conference Proceeding Series: Proceedings of the third Nordic conference on human-computer interaction*, 82, 339–347.
- Resnick, H. (1994) Electronic technology and rehabilitation: A computerized simulation game for youthful offenders. *Computers in Human Services*, 11, 61–67.
- Riva, G., Molinari, E. & Vincelli, F. (2002) Interaction and presence in the clinical relationship: Virtual reality (VR) as communicative medium between patient and therapist. *IEEE Transactions on Information Technology in Biomedicine*, 6, 198–205.
- Robillard, G., Bouchard, S., Fournier, T. & Renaud, P. (2003) Anxiety and presence during VR immersion: A comparative study of the reactions of phobic and non-phobic participants in therapeutic virtual environments derived from computer games. *Cyberpsychology and Behavior*, 6, 467–476.
- Rothbaum, B.O., Hodges, L., Smith, S. & Lee, J.H. (2000) A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting and Clinical Psychology*, 68, 1020–1026.
- Ryan, E.B. (1994). 'Memory for Goblins': A computer game for assessing and training working memory skill. *Computers in Human Services*, 11, 213–217.
- Saldana, L. & Neuringer, A. (1998) Is instrumental variability abnormally high in children exhibiting ADHD and aggressive behavior? *Behavioral Brain Research*, 94, 51–59.
- Salonius-Pasternak, D.E. & Gelfond, H.S. (2005) The next level of research on electronic play: Potential benefits and contextual influences for children and adolescents. *Human Technology*, 1, 5–22.
- Schneider, S.J. (1986) Trial of an on-line behavioral smoking cessation program. *Computers in Human Behavior*, 2, 277–286.
- Schneider, S.J., Schwartz, M.D. & Fast, J. (1995) Computerized, telephone-based health promotion: Smoking cessation program. *Computers in Human Behavior*, 11, 135–148.
- Schneider, S.J., Walker, R. & O'Donnell, R. (1990) Computerized communication as a medium for behavioral smoking cessation treatment: Controlled evaluation. *Computers in Human Behavior*, 6, 141–151.
- Sharry, J., McDermott, M. & Condon, J. (2003) Relax To Win: Treating children with anxiety problems with a biofeedback video game. *Eisteach*, 2, 22–26.
- Shaw, R., Grayson, A. & Lewis, V. (2005) Inhibition, ADHD, and computer games: The inhibitory performance of children with ADHD on computerized tasks and games. *Journal of Attention Disorders*, 8, 160–168.
- Sherer, M. (1994) The effect of computerized simulation games on the moral development of youth in distress. *Computers in Human Services*, 11, 81–95.
- Shrimpton, B. & Hurworth, R. (2005) Adventures in evaluation: Reviewing a CD-ROM based adventure game designed for young people recovering from psychosis. *Journal of Educational Multimedia and Hypermedia*, 14, 273–290.
- Sieswerda, S., Arntz, A. & Wolfis, M. (2005) Evaluations of emotional noninterpersonal situations by patients with borderline personality disorder. *Journal of Behavior Therapy and Experimental Psychiatry*, 36, 209–225.
- Tanaka, J., Klaiman, C., Koenig, K. & Schultz, R.T. (2005, May) Plasticity of the neural mechanisms underlying face processing in children with ASD: Behavioral improvements following perceptual training on faces. Poster presented at the International Meeting for Autism Research, Boston, MA.
- Valla, J.P., Bergeron, L., Saint-Georges, M. & Gaudet, N. (1997) Reliability of the Dominic-R: A young child mental health questionnaire combining visual and auditory stimuli. *Journal of Child Psychology and Psychiatry*, 38, 717–724.
- Valla, J.P., Kovess, V., Chan-Chee, C., Berthiaume, C., Vantalon, V., Piquet, C. et al. (2002) A French study of the Dominic interactive. *Social Psychiatry and Psychiatric Epidemiology*, 37, 441–448.
- Walshe, D.G., Lewis, E.J., Kim, S.I., O'Sullivan, K. & Wiederhold, B.K. (2003) Exploring the use of computer games and virtual reality in exposure therapy for fear of driving following a motor vehicle accident. *Cyberpsychology and Behavior*, 6, 329–334.
- Whalen, C., Liden, L., Ingersoll, B., Dallaire, E. & Liden, S. (2006) Behavioral improvements associated with computer-assisted instruction for children with developmental disabilities. *Journal of Speech and Language Pathology – Applied Behavior Analysis*, 1, 11–26.

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