Conceptualizing "Games for Good" as Cognitive Technologies

Rudy McDaniel
University of Central Florida

Erik Henry Vick
Rochester Institute of Technology

In this essay we introduce the special issue of *Cognitive Technology* on "Games for Good as Cognitive Technologies". With this special issue we highlight a range of innovative and interdisciplinary research being done within the domain of cognitive technology. This essay introduces the issue and describes the rationale for our focus on *games for good*. The amount of new research focused on this topic is encouraging and exciting and our goal is introduce researchers in cognitive technologies to this important topic. Our hope is that, from this introduction, the field will recognize their promise and engage in a broader collaboration to develop, test, and refine these emerging complex forms of cognitive technology.

KEYWORDS: Video Games, Learning, Training, Technology

An Emerging Body of Research

In recent years, sophisticated video games have emerged as controversial harbingers of a new age of interactive, immersive, and ubiquitous computing. Modern video games are played not only on consoles such as the Playstation 3 and Xbox360, but also on mobile devices, PDAs, cellular phones, and social networking platforms. The proliferation of games and their penetration into so many different areas of contemporary society obviously has profound implications for the entertainment industry, but this phenomenon also presents unique new opportunities for understanding the mechanics of teaching, training, and persuading with networked gaming technologies.

Some researchers, like Steven Johnson (2005) and James Paul Gee (2003), cautiously embrace video games. They note their immersive and engaging characteristics and their capacity to simultaneously challenge, seduce, and frustrate players. They also acknowledge video games' native ability to construct those combinations of complex physical interactions, interesting cognitive problems, and curiosity-piquing narrative scenarios that are appealing to human players. Others are more critical of these new technologies. For example, critics like Maggie Jackson (2009), see video games as nothing more than the latest gadgets in a long line of technologies designed to compete for our precious attention, gadgets that adversely affect important cognitive abilities like focus, judgment, and awareness. Building upon earlier work from critics such as Sven Birkerts (1994), Jackson argues that modern networked technologies are not helping us to become better thinkers and learners, but instead are de-socializing us, distracting us, and leading us to the brink of an impending dark age. Such thinking complements work by cognitive theorists such as Rich Mayer (1999) who have argued for a more human centered approach to the development of learning technologies.

Surely such a polarizing medium has something to offer the domain of cognitive technology. Regardless of which argument one finds more persuasive, it is clear that video games are doing *something* to the way players think and interact with technologies, and that this something may in fact be impactful enough to follow the player outside what Katie Salen and Eric Zimmerman (2004) call the "magic circle" boundaries of the gameworld and into the *real* world, where problems must be solved with real applicability, discussions must be had with real people, and solutions must be crafted in real physical space.

Even without this movement into real space, however, there are interesting things to learn from video games as encapsulated immersive and fantasy-laden environments. For instance, the safe virtual borders of the magic circle offer impressive cognitive and physiological benefits, such as the ability to minimize pain for burn victims or allow people with phobias or post-traumatic stress to safely deal with those issues in virtual environments (Hoffman, 2004; Jackson, 2009). It is the intent of this Special Issue to explore recent research in this area and to begin mapping out some conceptual boundaries for understanding games for good as cognitive technologies.

Video Games and Cognition

Before the recent attention of contemporary advocates and critics alike, video games were studied by scientists

and researchers as a means through which to examine cognitive processes such as spatial aptitude (Dorval & Pepin, 1986), attention (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994), and learning and training (Gopher, Weil, & Bareket, 1994). It was over 20 years ago that cognitive psychology saw one of the first serious attempts to create and use a computer game to examine cognition. *Space Fortress*, developed at the University of Illinois, was one of the first instantiations of a computer game as a cognitive technology for use in experimentation. This game-based technology, both developed and tested by cognitive psychologists, afforded a groundbreaking new way for researchers to observe complex sensory-motor processes (Mané & Donchin, 1989). It helped researchers study, for example, the interaction between skill levels, and the integration of component skill types (e.g., attentional skills, integration of spatial information), and their relation to overall performance (Shebilske, Goettl, & Regian, 1999; Shebilske, Goettl, Corrington, & Day, 1999). The game's utility has continued with revised versions still being developed to improve on its data collection and experimental manipulation capabilities (Shebilske, et al., 2005). It was most recently used in a neuroscientific investigation of the relation of brain volume and learning ability. In this study, Erickson and colleagues found that the size of a participant's striatum was related to their performance on *Space Fortress*, documenting an important connection between cognitive technologies as brain training devices (Erickson et al., 2010).

In addition to the work done with *Space Fortress*, there has been a fair amount of other research using games as cognitive technologies for experimentation and training. For example, in an early examination of transfer of flight training, Gopher and colleagues (1994) found that groups of cadets who received 10 hours of flight training using a computer game were able to perform significantly better on real-world flight tests than cadets who did not receive such video game training. Additional research analyzed the degree to which video games might provide a more valid test of learning. In a study to assess if the video game-based Atari Air Combat Maneuvering Task was a good prospect for a performance test battery for use training tasks conducted under unusual environmental circumstances, Jones, Kennedy, and Bittner (1981) not only found that video games were excellent prospects for such environmental research and training, but also that they displayed similar characteristics to other training methods.

In terms of spatial visualization and attention related research, Gagnon (1985) examined the relationship between spatial aptitude and video game use and found a correlation between scores on video games and spatial aptitude tests. The study also concluded that gender differences existed and that age was negatively correlated to both video game scores and spatial test scores. More recently, researchers determined that game-based training could not only be used to eliminate gender differences in spatial cognition, but also that even short treatment times (10 hours spent playing video games) produced an increase in spatial cognition for all subjects, regardless of gender (Feng, Spence, & Pratt 2007). Similarly, there is a positive correlation to performance on various tests of perceptual functioning in regular players of video games as opposed to individuals who do not play video games (Castel, Pratt & Drummond, 2005; Green & Bavelier, 2003; Green & Bavelier, 2006; Yuji, 1996). This increased performance could not be attributed to a different perceptual processing mechanism, however, leading researchers to hypothesize that the play of video games may lead to faster encoding of stimuli due to a modification of the visual system, thereby allowing for enhanced stimulus-response mapping.

The perceptual and cognitive benefits of video games during complex tasks are also well documented, particularly in the medical field. The Entertainment Software Association (2009) reports on a study from New York's Beth Israel Medical Center in which laparoscopic surgeons who played three hours of video games a week made 37 percent fewer errors than those who did not. Prior work suggests that video game skills can even be used to predict the level of laparoscopic aptitude in beginning surgeons (Rosenberg, Landsittel, & Averch, 2005).

Not all research is entirely supportive of computerized cognitive training, however. Though not exclusively focused on games, recent research from Owen and colleagues (2010) points out a general lack of empirical evidence for the successful use of computerized brain-training programs. In an online study of 11,430 participants, these researchers found no evidence for cognitive improvement after an average of 24.47 training sessions in two experimental groups – one emphasizing reasoning, planning, and problem-solving; the other training a broader array of cognitive functions including short term memory, attention, visiospatial processing, and mathematics. The authors note that these functions

are similar to those found in commercially available brain-training devices. Owen et al. conclude by pointing out that computerized brain trainers have not yet been shown to improve generalized cognitive functioning *beyond those tasks that are actually being trained.* In other words, participants improved on those particular tasks being trained in the experimental conditions, but these improvements did not generalize beyond the boundaries of the test conditions. Such findings echo earlier work by Sims and Mayer (2002) who, in a study with the video game Tetris®, illustrated how spatial expertise gained from game play was quite specific to mental rotation tasks and did not transfer to other measures of spatial ability.

Cognitive Games for Good

These studies, and many others like them, suggest that video games have the potential to significantly affect cognition, though the link of training to transfer is not always supported by research. In the special issue that follows, we focus on additional research-centered types of video games that impact cognition for a particular prosocial purpose — games sometimes characterized as "games for good." By "games for good," we refer to those video games that bring about positive social change in the world. This may or may not be an explicit goal of the designers. Games for good may be developed to promote awareness of nutrition, to examine economic policies and their impact on low SES communities, to educate schoolchildren about history or geography, or to encourage the discussion of public health policy for individuals who might not normally think about this type of problem. Because of the representational and simulated nature of games, the type of good potentially done by these types of games is limited only by the resources and imaginations of the game designers and developers who produce them.

We can better understand the genesis of the games for good movement by tracing recent activity from the academics and independent games developers working in this area. Perhaps the best indicator of video games' rising status in the realm of academic discourse is the emergence of several communities, festivals, and conferences devoted to games for non-entertainment purposes in the early and mid-2000s. One of the earliest gatherings was the Games for Change series of conferences, the first of which was held in New York in 2004. The goal of Games for Change was to "bring together non-profits, foundations, and game developers to explore the use of digital games to advance organizational mission and societal change" (Sawyer, 2004, para. 2). From this initial gathering of technologists and researchers sprung numerous other conferences, festivals, and workshops, each with the goal of advancing the study and practice of game design to move beyond mere entertainment and leisure. The most ambitious groups of individuals were those who wanted to not only teach with games, but also to bring about positive social change through their use. The latest Games for Change festival, held in 2009, boasted an attendance of 430 and included well-known and prolific games scholars such as Henry Jenkins, James Paul Gee, Katie Salen, and Eric Zimmerman (Games for Change). Other prominent conferences devoted to game studies, such as the Games, Learning, and Society Conference—held annually in Madison, WI—generate additional workshops, conference presentations, and research papers devoted to games for good and related topics (Games, Learning, and Society).

This work is particularly important because of the many difficulties inherent in the process of building educational or socially responsible video games. Foreshadowing the current cautionary stance taken by Owen et al. (2010) and previously described above, Squire (2002) warns that educational games must also still prove themselves in terms of both knowledge transfer and the meaningful practice of learned skills outside the game. In his own words, "a skilled *Half-Life* player might develop skills that are useful in playing *Unreal Tournament* (a very similar game), but this does not mean that players necessarily develop generalizable 'strategic thinking' or 'planning' skills" (para. 25). In other words, if a game for good's imparted lessons do not transfer and generalize to the outside world, then they are useful and interesting as new mechanical models for gameplay, but not necessarily as catalysts for behavioral change or expanded awareness.

Although games for good are a subset of educational gaming in general, this broader category paved the way for independent and commercial games for good. Over the past several years, funding agencies and policymakers began paying an increasing amount of attention to video games as tools for teaching, learning, and training (one example is the Game Changers Digital Media and Learning Competition, funded by the MacArthur Foundation). Accordingly, there has been an increase in the amount of critical scholarly analysis applied to games, analysis performed from a variety of disciplinary perspectives. Violence in games, of course,

has always been a favorite topic of the media, and until the early 2000s, much of what was covered by the media was focused on violence and the impact of violent video games. The debate as to the causal relation between violent video games continues and recent meta-analyses have shed light on both problems of publication biases in this area (Ferguson, 2007) as well as evidence that violent video games are a causal risk factor, potentially leading to aggressive behavior and cognition (Anderson et al., 2010; see Ferguson & Kilburn, 2010 for a critique).. More recently, though, academics and practitioners from all disciplines and walks of life began bringing positive example of games into the mainstream media's attention. Initiatives such as the Games-To-Teach project, a partnership between MIT and Microsoft designed to build new gaming prototypes for "interactive educational entertainment," emerged and gained popularity for exploring new teaching strategies for STEM disciplines (MIT, 2001). Additionally, social games designed to explore human values and morality have been produced; several prominent examples of these have surfaced from the NSF-funded Values at Play research project at Dartmouth College (Values at Play, 2007).

Characteristics of Cognitive Games for Good

What is it about games for good that makes them so interesting as examples of cognitive technologies? For one thing, as the research above indicates, games in general are particularly well-suited for exploring and evaluating the complex nature in which we think and make decisions under stress. Additionally, well-designed video games are intrinsically motivating (Malone, 1981), they implement a variety of optimal teaching and learning strategies with immediate feedback (Gee, 2003), and they encourage exploration and identification with virtual avatars in the pursuit of knowledge (Turkle, 1984). Video games also happen to be immensely popular. The average video game player is 35 years old and has been playing games for 12 years; computer or video game systems are installed in 68% of American households (Entertainment Software Association, 2009).

Individuals who play games engage and exercise complex cognitive processes such as metacognition, problem solving, inductive reasoning, and the interpretation of explicit and implicit information (Pillay, Brownlee, & Wilss, 1999). Narrative and fantasy are also an integral part of games which makes them useful for cognitive studies. Humans engage in fictional interactive environments—such as those found in video games—by simulating the events, characters, and other dramatic elements through mental modeling (Tavinor, 2005). This implies that the repetitive nature of video games may allow players to experiment with different behaviors, modes of problem solving, and interaction styles with complete safety (see also Gee's 2003 discussion of the psychosocial moratorium, or safe place for experimentation, provided by video games).

From these initial characteristics, we maintain that video games are useful as tools to explore and assess cognitive and affective processes such as attention, motivation, judgment, memory, decision making, metacognition, and empathy, systems and behaviors that are critical for fostering awareness of social issues or attempting to influence values or behaviors for the betterment of humanity. These goals are lofty, but attainable. When seen against the timeline of representational media, video games are still in their infant phase of development. Only time will tell the true impact of video games as the medium continues to mature and be shaped by new game designers looking to apply interactive gaming technologies for positive social change. This issue begins a dialog on this topic with cognitive technologists that we hope will continue on for many years.

Essays Included in this Special Issue

In this issue, contributing authors report on video games designed for a variety of purposes and examine those characteristics of game design best suited for designing effective games for good as cognitive technologies. Marjee Chmiel discusses game design as a tool for improving public science literacy, while Shlomo Berkovsky and colleagues examine the relationship between real and virtual environments in an attempt to combat the effects of sedentary lifestyles. Matthew Sharritt examines the design techniques used by both commercial and independent games as examples of strategies useful for educational game designers. The remaining two essays in this issue, from Scot Osterweil (MIT Education Arcade) and Jonathan Belman and Mary Flanagan (Values at Play) summarize the research that has grown from these respective initiatives and consider how video games can be designed to accommodate complex psychological tasks involving learning and prosocial behavior.

We bring together these researchers because we believe the complexity and sophistication of today's game-based technologies should be of great interest to cognitive technologists. Our goal is to introduce the research

community to these potentially powerful new tools in the hopes that they will use them to examine complex cognitive processes. In order to truly be effective, however, we must also learn how to transfer the training deployed in these virtual environments to similar situations encountered in the real world. By studying these exciting and emerging forms of cognitive technologies, we can come to a better understanding of learning, memory, problem solving, and decision making in areas of research that have tremendous societal implications.

REFERENCES

Anderson, C.A., Shibuya, A., Ihori, N., Swing, E.L., Bushman, B.J., Sakamoto, A., Rothstein, H.R., Saleem, M., & Barlett, C.P. (2010). Violent video game effects on aggression, empathy, and prosocial behavior in Eastern and Western countries: A meta-analytic review. *Psychological Bulletin, 136, 2,* 151-173.

Birkerts, S. (1994). The Gutenberg Elegies: The fate of reading in an electronic age. Boston: Faber & Faber.

Castel, A.D., Pratt, J., & Drummond, E. (2005). The effects of action video game experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychologica*, *119*, 217-230.

Dorval, M., & Pepin, M. (1986). Effect of playing a video game on a measure of spatial visualization. *Perceptual Motor Skills*, *62*,159-162

Entertainment Software Association. (2009). 2009 Industry Facts. Retrieved December 17, 2009, from http://www.theesa.com/files/2005EssentialFacts.pdf.

Erickson KI, Boot WR, Basak C, Neider MB, Prakash RS, Voss MW, Graybiel AM, Simons DJ, Fabiani M, Gratton G, Kramer AF. (2010). Striatal volume predicts level of video game skill acquisition. Cerebral Cortex. Advance access. Retrieved 1 March, 2010, from http://cercor.oxfordjournals.org/cgi/content/full/bhp293v1.

Ferguson, C. J. (2007). Evidence for publication bias in video game violence effects literature: A meta-analytic review. *Aggression and Violent Behavior, 12*, 470-482.

Ferguson, C. J. & Kilburn, J. (2010). Much Ado About Nothing: The Misestimation and Overinterpretation of Violent Video Game Effects in Eastern and Western Nations: Comment on Anderson et al. (2010). *Psychological Bulletin, 136, 2,* 174-178.

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science*, 18 (10): 850-855

Gagnon, D. (1985). Videogame and spatial skills: An exploratory study. *Educational Communication and Technology Journal*, *33*, 263-275.

Games for Change (G4C) Festival. (2009). The 6th Annual Games for Change Festival. Retrieved November 29, 2009, from http://www.gamesforchange.org/fest2000archive.

Games, Learning, and Society Conference. (2009). The 6th Annual Games, Learning, and Society Conference. Retrieved November 29, 2009, from http://www.glsconference.org/2010/.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. New York: Palgrave Macmillan.

Gopher, D., Weil M., & Bareket, T. (1994). Transfer of skill from a computer game trainer to flight. *Human Factors*, *36* (3), 387-405.

Green, C.S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature 423*, 534-537.

Green, C.S., & Bavelier, D. (2006). Enumeration versus multiple object tracking: the case of action video game players. *Cognition, 101*, 217-245.

Greenfield, P.M., DeWinstanley, P., Kilpatrick, H., & Kaye, D. (1994). Action video games and informal education: effects on strategies for dividing visual attention. *Journal of Applied Developmental Psychology*, *15*, 105-123.

Hoffman, H. (August, 2004). Virtual reality therapy. *Scientific American, 291,* 58-65.

Jackson, M. (2009). Distracted: The erosion of attention and the coming dark age. New York: Prometheus Books.

Johnson, S. (2005). Everything bad is good for you: How today's popular culture is actually making us smarter. New York: Riverhead Books.

Jones, M.B., Kennedy, R.S., & Bittner Jr., A.C. (1981). A video game for performance testing. *American Journal of Psychology, 94* (1), 143-152.

MacArthur Foundation (2010). Digital media and learning competition. Retrieved February 28, 2010, from http://www.dmlcompetition.net.

Malone, T.W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4*, 333-369.

Mané, A.M., & Donchin, E. (1989). The Space Fortress game. Acta Psychologica, 71, 17-22.

Massachusetts Institute of Technology (2001). Games-to-Teach Project: Next generation educational media for math, science, and engineering education. Retrieved November 27, 2009, from http://www.educationarcade.org/gtt/home.html.

Mayer, R.E. (1999). Instructional technology. In F.T. Durso, R.S. Nickerson, R.W. Schvaneveldt, S. T. Dumais, D. S. Lindsay, & M.T.H. Chi (Eds.), *Handbook of applied cognition* (pp. 551-569). Chichester, England: John Wiley & Sons.

Owen, A., Hampshire, A., Grahn, A., Stenton, R., Dajani, S., Burns, A., Howard, R., & Ballard, C. (2010) Putting brain training to the test. *Nature*. Retrieved May 11, 2010, from http://www.nature.com/nature/journal/vnfv/ncurrent/pdf/nature09042.pdf.

Pillay, H., Brownlee, J., & Wilss, L. (1999). Cognition and recreational computer games: Implications for educational technology. *Journal of Research on Computing in Education, 32*(1), 203-216.

Rosenberg, B.H., Landsittel, D., & Averch, T.D. (2005). Can video games be used to predict or improve laparoscopic skills? *Journal of Endourology, 19*(3), 372-376.

Salen, K., & Zimmerman, E. (2004). *Rules of Play: Game Design Fundamentals*. Cambridge, Mass: The MIT Press.

Sawyer, B. (2004). Games for Change. Games for change: Serious issues, serious games, the non-profit perspective.

Retrieved November 26, 2009, from http://www.gamesforchange.org/archives/000036.html.

Shebilske, W.L., Goettl, B.P., Corrington, K., & Day, E.A. (1999). Interlesson spacing and task-related processing during complex skill acquisition. Journal of Experimental Psychology: Applied, 5, 413-437.

Shebilske, W.L., Goettl, B.P., & Regian, J. W. (1999). Executive control of automatic processes as complex skills develop in laboratory and applied settings. In D. Gopher & A. Koriat (Eds.), Attention and performance XVII: Cognitive regulation of performance. Interaction of theory and application (pp. 401-432). Cambridge, MA: MIT Press, Bradford Books.

Shebilske, W.L., Volz, R. A., Gildea, K.M., Workman, J.W., Nanjanath, M., Cao, S,, & Whetzel, J. (2005). Revised Space Fortress: A validation study. Behavior Research Methods, 37, 591-601.

Sims, V.K., & Mayer, R.E. (2002). Domain specificity of spatial expertise: The case of video game players. *Applied Cognitive Psychology, 16,* 97-115.

Squire, K. (2002). Cultural framing of computer/video games. *Game Studies, 2*(1). Retrieved November 1, 2009, from http://gamestudies.org/0102/squire/.

Tavinor, G. (2005). Video games, fiction, and emotion. In Y. Pisan (Ed.), *Proceedings of the second Australasian conference on interactive entertainment* (pp. 201-207). Sydney, Australia: Creativity & Cognition Studios Press.

Turkle, S. (1984). Video games and holding power. In *The Second Self: Computers and the Human Spirit* (pp. 64-92). New York: Simon & Schuster.

Values at Play (2007). Values@Play: Designing social values in computer games. Retrieved November 27, 2009, from http://www.valuesatplay.org/.

Yuji, H. (1996). Computer games and information-processing skills. *Perceptual and Motor Skills*, *83*(2), 643-647.

AUTHOR NOTES

Contact information for Rudy McDaniel, rudy@mail.ucf.edu and for Erik Vick evick@mail.rit.edu. The authors wish to thank the many individuals and anonymous reviewers who made this Special Issue possible. We are especially thankful to Stephen M. Fiore for his advice, enthusiasm, and guidance while organizing and preparing this collection of essays and the University of Central Florida, Department of Philosophy Ethics Center Initiative for its support of this special issue.