From Gaming to Training: A Review of Studies on Fidelity, Immersion, Presence, and Buy-in and Their Effects on Transfer in PC-Based Simulations and Games

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INTRODUCTION

The volatile global security environment has changed warfighting. Battles in the arena of terrorism demand mature judgment, decision-making, and collaboration of warfighters who are often young, and often "part-time" (Reserve or National Guard) soldiers. Traditional methods of training are strained by logistical challenges, geographic distribution of personnel, and limited resources that preclude frequent field training. This situation is changing the way we train warfighters.

Reaching high levels of skill requires novel approaches to training (DoD, 2004) to ensure that training resources are allocated in a cost-effective manner that optimizes skill acquisition and retention (Ricci, Salas, & Cannon-Bowers, 2002). There are two traditional approaches to training in the military. Classroom education provides valuable declarative knowledge to warfighters. Such education is often supplemented today by web-based distance learning courses, for which the Department of Defense has defined the current industry format standards (Advanced Distributed Learning, 2004). However, warfighters also need practice applying the complex skills they study, and practicing them to proficiency. This training is typically delivered in field exercises that expose warfighters to battle environments and stressors, and give them experience interacting in battle environments. However, exercises are expensive, logistically cumbersome, and often dangerous.

Computer-based alternatives to live training have become more common in recent years. These alternatives are simulators, computer-based training systems, and video games. Simulators are systems that emulate visual stimuli and physical controls from the operational environment (Bonk & Dennen, 2005), common examples being flight and driving simulators. Computer-based training systems, sometimes referred to as "lightweight simulations," are web- or PC-based systems designed to provide individual instruction on specific mission skills. These systems represent the physical and behavioral characteristics of military systems with very high fidelity. PC flight simulators such as AirBook® and LiteFlite® are representative examples (SimiGon 2005; SDS International, 2005). These differ slightly from video games, which are also web- or PC-based systems. Video games are most often played using a handheld device or controller, and are designed primarily for entertainment purposes under current usage standards. However, the applications underlying video games may be identical to those used in lightweight simulations.

Lightweight simulators and video games offer a number of benefits for training:

- Video game simulation engines can be readily adapted for training. To the player, a video game consists of a playing environment, characters, tools (e.g., weapons), and missions (or story lines). Many of these elements, such as complex stories or gratuitous violence, are designed to increase entertainment value and sales, <u>not</u> training effectiveness. However, the infrastructure underlying these elements—a simulation engine—can be repurposed for training. MMPGs and lightweight simulators share a common set of enabling technologies (e.g., real-time 3D graphics, artificial intelligence, and networking; Fong, 2004). The military, in fact, has leveraged on these commonalities in developing a number of training games: *Marine Doom* to sharpen teamwork and coordination skills within four-soldier fire teams (Riddell, 1997), *America's Army* to train West Point officers, and *Full Spectrum Warrior* to train squad leaders in urban warfare combat tactics (Reuters, 2003; Roth, 2003). Several commercial off-the-shelf (COTS) games (e.g., *Delta Force 2*, *Steel Beasts*, and *Falcon 4.0*) have also been adapted by various armed forces to address military training requirements (Calvert, 2003; Macedonia, 2002; Zyda & Sheehan, 1997).

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- Gaming technology is often designed for distributed use over the internet or local area network. Thus, military trainees worldwide can use this technology to simultaneously play required training scenarios.
- Gaming technology often provides trainers with control over the scenarios, as do lightweight simulators.
- Like simulators, games have the capacity to emulate the real world, and so provide opportunities to train with some realism, but out of harms way.
- Both game technology and lightweight simulations can be implemented in a low-cost manner and allow for wide usability and private development.
- Research within cognitive psychology supports the use of video games for training, suggesting that playing action-based video games affects cognitive skills related to visual attention (Boot, 2005; Castel, Pratt, & Drummond, 2005; Green & Bavelier, 2003).
- Video games have a wide base of well-trained users. The video game industry is reporting higher earnings than Hollywood box office movies, and is predicted to out-profit both the record industry and home video rentals (Snider, 2002).

The extraordinary technological advances and popularity of the commercial gaming industry have drawn military interest (Defense Advanced Research Projects Agency [DARPA], 2004). This is particularly visible in the DARWARS program (www.darwars.com). DARWARS, funded by DARPA, seeks to provide PC-based experiential training systems in a wide range of domain areas. Of particular focus within DARWARS is multi-person and multi-team training. Massive multiplayer games (MMPGs) have been particularly successful, and we focus on them below. MMPGs involve users (40 – 1000+) interacting virtually toward a set of individual and common goals. This type of technology enables training at both the individual and team level in diverse roles given their utilization of avatars (graphical user images) with disparate abilities, resources and assets with programmer-designed properties, and environments that emulate a variety of real-world conditions.

Massive multiplayer gaming technology could be particularly useful for military training. MMPGs may serve as substitutes for live training for operations that are hazardous or unsafe, where cost reductions in the use of fuel, manpower, or property destruction can be obtained, where participants are distributed, and where a large number of trainees are needed for an exercise. For example, tasks involving non-routine procedures, planning and coordination, teamwork, decision making, and route planning can potentially be trained within an MMPG context.

However, the effectiveness of training with MMPGS, and video games in general, is not well understood. Skills taught and practiced in virtual environments must transfer to the operational environment; the higher the degree of transfer, the more successful a training system/method can be considered to be. As this technology is relatively new, there have been few empirical investigations of skill acquisition in games, and fewer still of skill transfer. **In this review, we examine the potential for technology developed for video games and MMPGs to be used in training.**

It is critical to capitalize on the benefits of video game-based training and transfer the acquired knowledge and skills to the operational environment. We posit that four factors drive training transfer: **fidelity**, **immersion**, **presence**, and **operator buy-in**. Recent scholarship points to the importance of these factors, but the relationships among them are complex. To say that increasing levels of fidelity, immersion, presence, and buy-in will automatically increase transfer may be too simplistic. Below, we define these constructs, explain how they are measured, and discuss the empirical evidence concerning their effects on transfer.

Transfer

Transfer is defined as the application of knowledge, skills and attitudes acquired during training to the environment in which they are normally used (Muchinsky, 1991). Simulator training is only valuable if skills addressed and improved in the virtual environment are required in the operational environment. Several theories attempt to delineate the necessary similarities between simulated and real environments to promote successful transfer. Early transfer research emphasized the theory of elements, which proposed that successful transfer only occurred when the simulated and real tasks had common elements (Thorndike, 1906; Thorndike & Woodworth, 1901). The theory of elements was supported by studies demonstrating specificity of transfer. That is, the simple exclusion of a few common elements between training and operational environments limits training transfer (Chase & Ericsson, 1982; also see encoding specificity, Tulving, 1983). Subsequent work (Singley & Anderson, 1989) has suggested the theory of elements view is too constrained to surface elements, and resolves this issue by proposing that transfer is effective when the two trained skills have similar logical or deep structures (Lehman, Lempert, & Nisbett, 1988). More clearly defined, surface features of training refer to problem-specific or domain-specific features of training examples. In contrast, deep (structural) features refer to the underlying principles imparted in training (see Gick & Holyoak, 1987; Halpern, 1998). For example, learning to fly a particular flight pattern in a Cessna should transfer to a Saab aircraft, given that the pattern shares the same logical and procedural structure in both aircraft.

All training—whether in games, simulators, or real-world settings—entails transfer of lessons learned in the structured environment to the relatively unstructured atmosphere of real-world application. That transfer can be positive, negative, or nil. Positive transfer is said to occur when learning in the training environment improves performance in the target setting. Negative transfer is said to result when learning in the training environment degrades real world performance, typically because trainees apply to the real world behaviors that are appropriate only in the training environment (e.g., actions to "game" a simulator).

The objective of training using games and simulators, of course, is to achieve greater positive transfer than slower, more costly, or more dangerous training methods, often relying on real-world technologies. Comparative tests of transfer measure post-training performance on a real-world task between two groups: an experimental group that trains with the new technology (e.g., an MMPG) and a control group that trains directly in the operational setting (Wickens & Hollands, 2000).

How, specifically, can we compare transfer effects between training environments? Table 1 presents a number of calculations which can be utilized in quantifying and comparing the transfer of training between control and experimental groups. These include the percent transfer and the transfer effectiveness ratio (TER).

Table 1. Transfer of training formulas (Roscoe & Williges, 1980). Y_c = control-group learning time in real-world training; Y_x = experimental-group learning time in real-world training; X = experimental-group learning time in the simulator.

Name	Formula	Definition
Percent Transfer	$\frac{Y_c - Y_x}{Y_c} * 100$	Measures the ratio of time saved in simulator training relative to real-world training.
Transfer Effectiveness Ratio	$\frac{Y_c - Y_x}{X}$	Measures the ratio of time saved in real-world training as a function of time spent in simulator training.

Even when the training technology produces positive transfer, it may do so at the cost of greater time in training. For example, flight simulator training may entail more total time (simulator plus real world flight lessons) than the time required by a group that receives only flight lessons. Positive transfer may also be associated with greater financial costs. The TER value can be used in those cases to determine the cost-effectiveness of specific types of training compared to others, a value referred to as the transfer cost ratio (TCR). In order to accurately evaluate the potential training effectiveness of a novel technology, it is important to consider a variety of transfer measures. The TCR is, of course, only meaningful in circumstances in which real-world training is possible or practical. When alternative training is not possible, the TCR will approach infinity – a clear reflection of the advantage of training in the simulated world.

Gopher and colleagues (Gopher, Weil, & Bareket, 1994) used a variant of the TER in an evaluation of the benefits of a PC-based flight simulator, but did not analyze training time needed as a dependent variable, and therefore did not utilize the calculations in Table 1. This study involved comparing flight performance between a control group of Israeli Air Force cadets and a group training on the game *Space Fortress* (Donchin, Fabiani, & Sanders, 1989). The game required pilots to manually control a spaceship, aim and fire missiles to destroy a space fortress, protect their own ship from damage, and manage resources. The authors argued that training within this game was useful for developing flight-relevant skills, particularly those related to attention management and coping with high mental workload. In testing this hypothesis, the authors compared flight performance scores in actual flight following game-training or no-game-training. Overall flight performance scores of those pilots who trained with *Space Fortress* were significantly better than those pilots in the control group. Upon completion of this study, the game was incorporated into the regular training program of the Israeli Air Force.

It is clear that high, positive transfer is desirable between a training system and real world operations. But how can we increase the amount of transfer? As simulations based on game technology are currently in development, now is the time to implement effective training mechanisms. We argue below that manipulating four factors (or constructs) can increase transfer. These constructs are *fidelity, presence, immersion,* and *operator buy-in*. It is important to note that these constructs are not mutually exclusive in that some of them appear to be functions of the same attributes of computer-mediated environments, and some of them claim to exhibit similar effects. The literature presents conflicting evidence for these constructs and their relations to transfer. The purpose of this review is to make a first step toward deconflicting these constructs. Each of the aforementioned concepts is discussed in the following sections.

Fidelity

Fidelity in this context can be described as the extent to which the virtual environment emulates the real world. Fidelity can be measured on multiple continua, and a large number of subcategories have been described in the literature (e.g., Allen, Hays, & Buffardi, 1986; Hays & Singer, 1989; Lane & Alluisi, 1992; Lintern, Roscoe, Koonce, & Segal, 1990; Rehmann, Mitman, & Reynolds, 1995). For the purposes of this paper, we will focus on physical and functional fidelity in describing the simulation, and psychological fidelity in describing the effects of the simulation on the trainee, acknowledging of course that a further decomposition may be required for any given domain.

Physical fidelity is defined as the degree to which the physical simulation looks, sounds, and feels like the operational environment in terms of the visual displays, controls, and audio as well as the physics models driving each of these variables (Baum, Riedel, Hays, & Mirabella, 1982). Functional fidelity is defined as the degree to which the simulation acts like the operational equipment in reacting to the tasks executed by the trainee (Allen et al., 1986). While expensive simulators can recreate visual cues and precise instrument operation (i.e., physical fidelity), comparatively inexpensive gaming technologies are ideal for recreating interactivity (i.e., functional fidelity) across a range of users in a variety of locations (Lewis & Jacobson, 2002). Psychological fidelity is the degree to which the simulation replicates the psychological factors (i.e., stress, fear) experienced in the real-world environment, engaging the trainee in the same manner as the actual equipment would in the real world (Kaiser & Schroeder, 2003). Psychological fidelity is related to presence, a concept we discuss later.

Physical fidelity encompasses a number of dimensions (visual, auditory, vestibular, olfactory, proprioceptic, etc.). A large literature base exists concerning these different dimensions of physical fidelity (Becker, Warm, Dember, & Hancock; 1995; Borah, Young, & Curry, 1977; McMillan, Cress, & Middendorf, 1990; Rinalducci, 1996), but recent research has focused on the impact of fidelity in the haptic, or tactile, dimension. This work has demonstrated the effectiveness of providing appropriate haptic feedback during simulated tasks, such as in the training and assessment of laparoscopic skills (Rolfsson, Nordgren, Bindzau, Hagstrom, McLaughlin, & Thurfjell, 2002), or F16 aircraft landing procedures (Repperger, Gilkey, Green, LaFleur, & Haas, 2004). Findings have also demonstrated increased autonomic arousal due to action-appropriate haptic feedback in virtual environments relative to those not given haptic feedback, suggesting haptic information can increase fidelity due to a correspondence to the autonomic arousal seen in real environments (Meehan, Insko, Whitton, & Brooks, 2001).

Beyond physical fidelity, *functional fidelity* may also impact the degree of skill or knowledge transfer. In a recent study evaluating the utility of MMPGs as tools for military teamwork training, anecdotal evidence suggested that by incorporating appropriate military command and control hierarchies, trainees were better able to recognize the correspondences between gaming and operational reality (Weil et al., 2005a, 2005b). Although participants interacted in a fantasy themed virtual environment that did not resemble their operational setting, their communications network did resemble a plausible operational communications infrastructure. The use of a Voice-over Internet Protocol (VoIP) communications medium increased the functional fidelity relative to a group of trainees who used only text chat communications. Specifically, interview responses regarding the utility of text chat (relative to VoIP) in MMPGs emphasized the importance of functional fidelity in increasing interest, realism, motivation to perform, and attention to details. In essence, by increasing functional fidelity in the form of a true military communications organization and medium, trainees using an MMPG were better able to potentially benefit from their experiences, irrespective of the fanciful nature of the environment.

A major issue concerning simulated or game-based training involves the absence of the surrounding context in which the trained skills will be used. Many real-world environments evoke levels of stress and arousal that may not be directly replicable in virtual environments. However, for skill learning, it is sometimes critical for these levels of stress and arousal to be comparable in both environments – to therefore have high *psychological fidelity*. Both positive (e.g., entertainment-induced energy and/or motivation) and negative (e.g., conflict-induced fear and/or adverse physiological reactions) types of stress have been shown to enhance skill retention as well as the transfer of training from the simulator to the real world (Mayer & Volanth, 1985; Williams, 1980). Recent studies have examined the effects of adding *contextually-relevant* stress to training paradigms on the improvement and transfer of skills (Driskell, Johnston, & Salas, 2001; Morris, Hancock, & Shirkey, 2004). The primary goal of "stress training," in this sense, is to provide practice under conditions similar to those likely to be encountered in the operational setting. Although it is often difficult to anticipate and simulate specific stress-inducing events, these studies have utilized time pressure, noise, and exposure to violent and distressing events in order to invoke the kind of physiological reaction experienced when exposed to stress in general. In using either time pressure or noise as a stressor, Driskell and colleagues (2001) found that the beneficial effects of stress training on performance were maintained when faced with either a novel stressor or a novel task. Morris and colleagues (2004) compared game-based training and outcome performance between groups exposed to an intense front-line infantry battle on film (i.e., experimental group) or an unstressful video analog (i.e., control group) and found that the experimental group had significantly higher scores on mission success measures such as completing mission objectives, using time skillfully, and avoiding taking fire. Furthermore, individual differences in terms of stress-specific responses accounted for 88% of the variance on mission success, learned tactics, and game adaptation measures combined. More research is needed, however, in examining the relationships between types of stress and skill transfer in general and as influenced by individual differences, and in determining how long the beneficial effects of stress training persist (Morris et al., 2004).

Returning to Thorndike's theory of elements and its successors, one may posit that the appropriate level of fidelity for a training system is dependent on the skills or behaviors that are to be trained. If both the training system and operational setting share properties with regards to the objectives of training, other aspects of the training system could tolerate lower levels of fidelity without compromising training effectiveness. For example, targeted skill training (e.g., learning how to aim and fire a particular type of weapon) and more abstract conceptual learning (e.g., learning the decision making process that precedes weapon use), may be more or less suited to high functional or physical fidelity. It seems a reasonable conjecture that higher levels of physical fidelity are necessary in the former case (aiming and firing a weapon), while higher levels of functional fidelity are necessary in the latter case (making decisions).

Training systems vary in their degree of physical and functional fidelity based on technical feasibility, cost, and training needs. It is believed that trainees tend to demand high physical-fidelity gaming environments for a variety of reasons, including previous exposure to high-fidelity simulators, and concern that performance evaluation in the training accurately reflects anticipated real world performance (Turner, Turner, Dawson, & Munro, 2000). High physical fidelity on the visual, vestibular, and kinesthetic dimensions, however, can be costly, and the added realism does not necessarily add to its TER (Hawkins & Orlady, 1993; Moroney & Moroney, 1999). For example, even inexpensive, visually-simple PC-based simulations can have demonstrable effects for training interactivity. For instance, pilots approved the use of simulations with low physical fidelity for use in aircrew coordination training (Baker, Prince, Shrestha, Oser, & Salas, 1993) and believed that the simulations accurately portrayed changing demands on coordination workload (Bowers, Morgan, Salas, & Prince, 1993). Thus, an important compromise must be made between physical fidelity, related costs, and training effectiveness, such that an adequate match can be made between training and real environmental elements and the logical structure of tasks.

The impact of low physical fidelity on transfer is still not well understood. Applying Thorndike's theory of elements to training in virtual environments, the level of fidelity must be high enough in each dimension for the behavior of interest to be exercised as it would in operational conditions. For example, in a scenario designed to train military long-range snipers, gravitational influences on bullet trajectory may be an important variable to include in the simulation. Conversely, if the same scenario was used to train military medics in finding and treating casualties in an emergency, the gravitational dimension may not be as necessary as environmental metrics or treatment efficacy. Other characteristics, such as resolution and realistic texturing, may be noticed and appreciated by trainees, but they are directly impacted by these variables. However, recent research has drawn useful lessons concerning the physical fidelity of input media (e.g., joysticks) for tasks such as moving through virtual space (Whitton & Brooks, 2005).

To determine the relationship between level of fidelity and training performance, Jentsch and Bowers (1998) stress that simulations are best designed when only the appropriate details are embellished to increase realism. In other words, designers must prioritize the components that need to be realistic and those that do not, based on training requirements. Determining which variables are important to represent realistically can be difficult, especially given the creative opportunities afforded by MMPGs. For example, some argue that it is important to exclude impossible events because they would never be encountered in operational settings (Wray, Laird, Nuxoll, Stokes, & Kerfoot, 2004; Turner, Turner, Dawson, & Munro, 2000). Many games offer the unrealistic ability to immediately transport from one location to the next. While this functionality may improve game play, it drastically differs from the constraints that trainees will face in the real world, and according to some, should be avoided. Others, however, argue that some unrealistic capabilities may minimize or eliminate real-world characteristics that may limit conventional training. For example, providing a bird's-eye view of an environment with a real-time location indicator during wayfinding tasks facilitates route and survey knowledge acquisition, as it limits the cognitive effort necessary for integrating these two information sources during actual navigation (Farrell, Arnold, Pettifer, Adams, Graham, & MacManamen, 2003; Witmer, Sadowski, & Finkelstein, 2002). Similar effects are found by making walls transparent (e.g., visual knowledge generation) and do not rely upon specific path sequences through an environment (Darken & Peterson, 2002). Thus, depending upon the targeted skills of the training system, it is important to consider the potential advantages of introducing additional resources to facilitate learning and transfer of acquired knowledge to real environments.

The relationship between fidelity and transfer is further complicated by the finding that training effectiveness can be increased by adjusting the level of fidelity over a sequence of training experiences (Lathan, Tracey, Sebrechts, Clawson, & Higgins, 2002). For example, in training communications skills to infantrymen, it may not only be necessary to use high-fidelity communications modalities, but military command and control communications hierarchies may also need to be introduced as the training scenario progresses from basic to higher functional and conceptual levels. Fidelity is not a simple high/low dichotomy, rather it is multiple compound continua. There is a relationship between fidelity and transfer, but it is not as simple as 'more is better.' Based on Thorndike's theory of elements, the implications are that if the level of fidelity captures the critical elements/properties of the skills/tasks you wish to teach, that level of fidelity is sufficient *even if* it noticeably deviates from the real world.

Immersion

Immersion refers to the degree to which an individual feels absorbed by or engrossed in a particular experience (Witmer & Singer, 1998). It may contribute to the amount of information acquired, skills developed, and subsequent transfer of knowledge to real environments. Many activities are immersive (e.g., a game of chess, a book, a conversation), but the term is particularly germane to videogames, as evidenced by the rising phenomena of video game addiction (Young, 2004). What is currently not clear is the relationship between an individual's level of immersion in an experience and the degree of skill/behavior/knowledge transfer exhibited by that individual.

Taylor (2002) proposes two types of immersion: *diegetic* (immersion in the act of playing the game) and *situated* (immersion in not only playing the game but in experiencing the illusion of existing within the game space). In terms of video games, diegetic immersion occurs when the player becomes absorbed into the experience of playing the game. Situated immersion goes a step further and is said to occur when the player experiences the game space through the character within that space—not acting upon the game, but within the game (Taylor, 2002). For the purposes of this review, immersion refers to diegetic immersion while presence (discussed in the next section) refers to situated immersion.

Slater and Wilbur (1997) suggest measuring immersion along multiple continua representative of the technology itself. Immersion would therefore be based on the extent to which the visual displays support an illusion of reality that is inclusive (denoting the extent to which physical reality is shut out), extensive (the range of sensory modalities accommodated), surrounding (the size of the field of view), and vivid (the display resolution, richness, and quality). Each of these dimensions may be associated with a scale indicating the extent of its realization. The authors suggest that, based on these scales, immersion can be an objective and quantifiable description of what a video game, MMPG, or simulation provides.

Other factors credited with inducing immersion are levels of control, ease of interaction, video resolution, and social interactions (Sadowski & Stanney, 2002). The greater the control trainees have over their avatar/character and the environment, the higher the self-rated immersion (Witmer & Singer, 1994). User control is largely determined by the naturalness of action-response timing, orientation changes, and environmental manipulation/interactivity (Sheridan, 1992). Finally, immersion is also partly a function of the plot of the game, or story line (Slater & Wilbur, 1997). Plot is essentially the extent to which the game or simulation is self-contained, has its own dynamic, and presents an alternative world to that of the real world.

Presence

While diegetic immersion may be viewed as the objective description of a simulation or game's capability to draw the user in to the act of playing the game, presence – also referred to as situated immersion – refers to the subjective experience of actually existing within the computer-mediated environment even when one is physically situated in another (Slater & Steed, 2000; Witmer & Singer, 1998). The amount of human-computer and avatar-avatar interaction required by many simulations, compounded by high levels of fidelity on a number of dimensions, may lead to a more vivid feeling of presence in the experience. However, it is unclear how this increased presence affects transfer of skills or behaviors, or when increased presence is advantageous. A better understanding of the concept of presence may result in insight to its use as a mechanism for increasing training effectiveness.

A number of factors have been proposed to account for the strength of presence. These are generally categorized as control, sensory, distraction, and realism factors (see Witmer & Singer, 1998 for descriptions of each factor; see Table 2).

Table 2. A Listing of Factors Hypothesized to Contribute to a Sense of Presence (Witmer & Singer, 1998).

Control Factors	Sensory Factors	Distraction Factors	Realism Factors
• Degree of control • Immediacy of control • Anticipation of events • Mode of control • Physical environment modifiability	• Sensory modality • Environmental richness • Multimodal presentation • Consistency of multimodal information • Degree of movement perception • Active search	• Isolation • Selective attention • Interface awareness	• Scene realism • Information consistent with objective world • Meaningfulness of experience • Separation anxiety/disorientation

Heeter (1992) has proposed three types of presence in simulated environments: environmental, social, and personal. *Environmental presence* is not just influenced by the physical fidelity of the simulation, rather it is determined by the extent to which the environment itself appears to acknowledge the user's existence and reacts to it. *Social presence* assumes an interactive multi-player environment; greater interaction and presence of others will lead to higher engagement of the individual with the game and the group. Social presence research indicates increases in the number of avatars interacting (through communication, acknowledgement of presence) within a virtual environment leads to corresponding increases in rated presence (Heeter, 1992). A study of an online gaming community known as Norrath, where social roles are defined through communication with other avatars and social relationships greatly help or hinder progress within the virtual world, found that 20% of users report a feeling of "living in" Norrath (Castronova, 2001). *Personal presence* is the most global type of presence in that it describes the extent of, and the reasons for, a person's *feeling* like he or she is "in" a virtual environment.

Importantly, many of the factors listed in Table 2 can be controlled by the experimenter or training system developer as they determine the physical and functional fidelity of their simulator. These manipulations, in turn, impact the feeling of presence felt by participants. For example, multimodal presentation and scene realism both help determine the existing level of fidelity in the environment (with high levels of either corresponding to high levels of fidelity), but they also influence the amount of perceived presence experienced by the individual. Increasing the correspondence of user control in the virtual world to natural movements in the real world increases the perceived presence within that environment (Billinhurst & Weghorst, 1995). Video resolution and the connectedness and continuity of visual elements are also important for generating perceived presence (Witmer & Singer, 1994).

Presence, by definition, increases engagement with training content. Heightened engagement should increase students' time on training tasks. Time on task is, of course, among the strongest predictors of the acquisition and retention of knowledge and skill. Although systematic research is lacking, there is some suggestion in the literature that presence is valuable in a training tool because it increases motivation and provides a more engaging experience (Lombard & Ditton, 1997). In the case of traditional simulators and MMPGs, research is necessary to elucidate the potential influence of presence on training transfer.

Buy-in

Varying the levels of fidelity or increasing the feelings of presence and immersion are thought to impact the degree of transfer from the simulated environment to the operational setting. However, there is another construct that may influence transfer: user acceptance or "buy-in." In the present context, buy-in refers to the degree to which a person recognizes that an experience or event is useful for training. The conjecture is that higher levels of buy-in imply that the user will invest more effort to extract generalizable lessons from training, and more effort to transfer those lessons to the real world. Transfer is consequently more frequent and successful as a result. There has been limited research on buy-in, although we argue that it warrants investigation in the future.

Three anecdotes illustrate the potential impact of 'buy-in' on transfer. In one study (Carnegie Mellon Entertainment Technology Center et al. 2004; described in Stapleton, 2004), PC game technology was used to construct a training system for fire/rescue teams. When the system was presented to the practitioners, they were unhappy with the 'level of realism' of the system. However, changing the colors of the uniforms and vehicles to correspond to those used by the practitioners improved user acceptance. Taking a Thorndikian approach, it is clear that the amount of transfer should be identical regardless of uniform color, as the essential elements for training are not determined by color. However, transfer is only possible if the intended users use the system, which in turn may be dependent on user identification with the avatars and simulated environment.

Weil et al., (2005a; 2005b) touched on the construct of buy-in during the course of an investigation of the training capacity of MMPGs. Army infantry participants took part in an exploratory study, in which a fantasy-themed virtual environment – based on the video game *Neverwinter Nights* – was used as the platform for a platoon-level C2 and tactical exercise. In this instance, some aspects of the simulation were displayed with low fidelity (e.g., avatar and environmental realism) while others were highly realistic, such as the functional role of the resources (e.g., artillery, ISR resources) and avatar attributes (e.g., strength, speed). In fact, many of the 'fantasy' aspects of the virtual environment were identifiable as analogs to modern military weapons (firebombs = artillery, flying goblins = UAVs, etc). However, participants maintained that the training value of the fantasy-based environment was limited, even when they identified the functional analogies without prompting. They had a difficult time taking the training seriously because a veneer of fantasy was laid over operational capabilities. Consequently, it required substantial experimenter oversight to maintain the atmosphere of training in the experimental sessions, rather than one of game playing.

In a military education setting (Woodman, personal correspondence), two groups of military officers participated in a training exercise in two virtual environments in which aspects of command and control were to be practiced. The first was a realistic WWII-era military environment, while the second environment was based on the modern military. While the underlying training goals and design were the same, participants argued that the WWII environment was not adequate for training because it did not correspond to their experience. Assuming that the resource capabilities and communications apparatus were exact analogs between the two conditions, the identity of the enemy and the characteristics of the avatar uniforms should have no bearing on training impact. Still, these characteristics were important to the participants, and these seemingly small details could prove to be big impediments to training.

In each of these anecdotes, user acceptance increased as participants recognized the relevance of the simulations (avatars, objects, and environments) to their operational experience. We speculate that this acceptance of the simulation as relevant leads to increased learning and greater transfer simply because participants take on a 'training mindset,' a willingness to use the environment to practice the behaviors and actions targeted by their trainer or training instructions. In addition, such acceptance may increase the time spent using the training system. These satisfy a primary condition for the acquisition of expertise – frequent and deliberate (relevant, focused) practice – as identified in studies by Ericsson, Krampe, and Tesch-Romer (1993).

Buy-in is related to the amount of fidelity and perceived realism. Poor fidelity during training may decrease motivation, attention to details, and subsequent transfer of training (Lampton, Bliss, & Morris, 2002). This may be true even if, according to the theory of elements, the level of fidelity is appropriate for the training objectives. There is mounting anecdotal evidence that user acceptance or buy-in will affect transfer from simulation to operation. However, much remains to be studied. There is no empirical evidence that user acceptance improves transfer if the amount of training remains constant. Similarly, the relationships between buy-in and fidelity, immersion, and presence are not well understood. This remains an avenue for fruitful future research.

Key Areas for Further Research

A modest body of research has identified factors that may influence the psychology of "being there" and engaging with games. One would expect that these effects would increase learning and ensure transfer. However, there is precious little research that prove this. We recommend that researchers take on this mission.

The overall goals of simulation-based training are to accelerate learning and ensure transfer of what is learned to real world tasks. It is important to realize that while fidelity, immersion, and presence may influence training transfer, the focus of this article, these three factors must not be considered in isolation. In other words, while presence may be found to have a large influence on learning and transfer, gaming or simulator adjustments to increase presence may have important effects upon fidelity and immersion. These effects may, in turn, have important influences upon learning and transfer. It is therefore critical to determine the potential interactions between these factors, and the cumulative effects upon transfer. The combination of fidelity, immersion, and presence may also have important effects upon levels of buy-in by military audiences.

Based on our literature review, there is high potential for lightweight simulations, particularly those based on MMPG technology, to be effective mechanisms for military training because they can replicate the critical real-world elements. This is especially true for training the cognitive skills required for tasks, the coordination and communication among team members, and the strategic aspects of many tasks. PC-based simulation can support high degrees of functional fidelity, immersion, presence, and buy-in, as evidenced by the findings summarized in this paper, such as:

- The replication of critical aspects of the environment leads to high functional fidelity (Jentsch & Bowers, 1998).
- Popularity indicates a high probability of immersion (Snider, 2002; Young, 2004).
- Avatar schemes and first person perspectives lend to increased presence (Heeter, 1992).
- The ability to tailor the environment to an operator's task may increase buy-in.

However, the ultimate analysis of training impact of PC-based simulation must assess the degree of skill and knowledge transfer from the virtual to the operational environment. To date, there have been few studies that have shown this empirically for either individuals or teams (but see Gopher, Weil, & Bareket, 1994). In the future, it is critical that the extent and nature of transfer be established.

Logistically, MMPGs may contain the necessary architecture to support the large-scale training efforts envisioned by the military, given their potential to facilitate learning by providing training opportunities that are cost- and time-efficient, widely distributable and accessible, as well as cognitively engaging (Weil et al., 2005a; Weil et al., 2005b). However, very little data exists to support the claim that game-based training will be effective in a military setting. While research on simulators provides some guidance on identifying factors that may influence the effectiveness of MMPGs for military training, there are key differences between simulators and games that justify a separate research effort focused on MMPGs. We have identified the following questions as key areas for research.

Q1: What is the impact of fidelity, presence, immersion, and operator buy-in on transfer in MMPGs?

The major advance in MMPG technology is its interactivity; that is to say those features (e.g., client/server architecture) that enable MMPGs to be both massive and multiplayer. To exploit the training potential of MMPGs, it is logical to train skills that are based on interaction. For example, training the decision process for targeting would be more suited to MMPG-based training than would simulated target practice. The emphasis of the former is on communication, sharing information, and drawing conclusions, while the emphasis on the latter is on experiencing the firing of arms. Continuing research should attempt to elucidate the potential interactions between fidelity types and training objectives. For example, in evaluating the training effectiveness of MMPGs, it would be interesting to systematically vary the physical or functional fidelity during the training of task-level and more abstract operational skills.

Q2: What types of interactions exist among the constructs of fidelity, immersion, and presence?

The concepts discussed in this review each seem to relate to the transfer of knowledge of skills. However, the relationships among these concepts remains vague. How do varying the levels of fidelity on a particular dimension impact feelings of immersion and presence? As immersion and presence are highly related concepts, can they be crisply differentiated? Should these constructs be treated independently when designing or assessing training systems, or does a high correlation imply that they should be considered as a bundle?

Q3: How is buy-in affected by functional fidelity, immersion, and presence?

This question lends itself to a bias that exists favoring physical fidelity over functional fidelity among the general public. Indeed, video game designers were pressured by distributors to develop high-fidelity 3D graphics (e.g., Rouse, 1998). Such physical fidelity is readily apparent and immediately gratifying. An appreciation for the analogy between how communications exist in the real world and how they are preserved in a video game is a more abstract concept that is likely to be lost on many trainees, at least initially. Increasing buy-in when functional fidelity is higher than physical fidelity will likely take time as trainees gradually experience their improvement in such domains.

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