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Task Difficulty and Prior Videogame Experience: Their Role in Performance and Motivation in Instructional Videogames

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14. ABSTRACT *(Maximum 200 words)*:

Videogame-based environments are an increasingly popular medium for training Soldiers. This research investigated how various strategies for modifying task difficulty over the progression of an instructional videogame impact learner performance and motivation. Further, the influence of prior videogame experience on these learning outcomes was examined, as well as the role prior experience played in determining the optimal approach for adjusting task difficulty. Participants completed a game-based training task under one of four task difficulty conditions: static, increasing, adaptive-low and adaptive-high. All participants completed an identical pre-training trial, 10 practice trials varying in difficulty level according to condition, and a final performance trial. Results demonstrate that learner performance and motivation significantly improved in all difficulty conditions. Yet, contrary to expectations, no single condition maximized these outcomes relative to others. There was a significant 3-way interaction between performance, condition, and prior videogame experience. Further, prior experience was found to significantly influence these learning outcomes. Learners with greater experience consistently performed better regardless of condition. Experienced gamers also initially reported high task self-efficacy and set higher performance goals for the training task. The results of this research provide information useful to training game developers and instructors utilizing videogames as training tools.

15. SUBJECT TERMS

Games, training, computer games, desktop simulations, task difficulty, challenge, videogame experience, videogame self-efficacy, individual differences, goal setting

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), as part of its Training for Interactive Distributed Environments work package, is investigating the use of training technologies that are effective, affordable, and distributable. This research was part of the LAST ATO (Learning with Adaptive Simulation Technology Army Technology Objective), a collaborative effort between ARI, the Research, Development, Experimentation Command - Simulation and Training Technology Center, the Army Research Lab – Human Research & Engineering Directorate, and the Institute for Creative Technologies. ARI seeks to provide the Army with guidance on how game-based training tools can be used for military training.

The focus of this research effort was to assess how various strategies for modifying task difficulty over the progression of a training game impact learner performance and motivation, and to examine the effect of prior videogame experience. The videogame used in this experiment was *VBS1*™, a first-person-perspective military training game that allows for the creation and modification of military-oriented scenarios. VBS1 provides a set of authoring tools that can be used to modify the game environment to develop specific scenarios. The game scenario developed by the researchers specifically for this experiment was a virtual firing range.

An initial summary of this research was briefed to representatives from the Training and Doctrine Command—Training Development and Analysis Directorate; the Research, Development, Experimentation Command - Simulation and Training Technology Center; the Army Research Lab – Human Research & Engineering Directorate; and the Institute for Creative Technologies in January 2006. Portions of the findings from this research were also presented at the 19th Annual Conference of the Association for Psychological Science in May 2007 and the American Psychological Association Division 19/21 Annual Symposium on Applied Experimental Research in March 2006.

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TASK DIFFICULTY AND PRIOR VIDEOGAME EXPERIENCE:
THEIR ROLE IN PERFORMANCE AND MOTIVATION IN INSTRUCTIONAL VIDEOGAMES

EXECUTIVE SUMMARY

Research Requirement:

Videogames are emerging as an increasingly popular instructional tool in the U. S. Army. Prior research demonstrates that videogame attributes such as level of difficulty affect learning outcomes in game-based learning environments. The research suggests that instructional games that are too easy or too difficult can lead to reduced motivation; and, ultimately, to less time on task and reduced learning. While research has enhanced our understanding of what game attributes influence training effectiveness, little research has investigated how to optimally manipulate such attributes. We sought to help address this gap by focusing on the attribute of task difficulty. The present research examined how various strategies for modifying task difficulty over the progression of a training game impact learner performance and motivation. Further, based on our prior research findings (Orvis, Horn, & Belanich, 2006), we also examined the influence of prior videogame experience on performance and motivation, as well as the role prior experience plays in determining the optimal approach for adjusting task difficulty in game-based training.

Procedure:

Twenty-six participants played a videogame-based training task under one of four task difficulty conditions: static, increasing, adaptive-low and adaptive-high. In a virtual firing range game, all participants completed an identical pre-training trial to establish a baseline performance score, followed by 10 practice trials varying in difficulty level according to condition, and concluding with a final performance trial (with task difficulty equivalent to the pre-training trial).

In the *static* condition, task difficulty remained constant and moderately high across practice trials (equivalent to the pre-training and final performance trials). In the *increasing* condition, task difficulty started low in practice trial 1 and increased one level every two practice trials. The remaining two conditions were learner-centered adaptive difficulty conditions (i.e., increased difficulty after good performance and decreased difficulty after poor performance), with the *adaptive-low* condition starting with low task difficulty (equivalent to the increasing condition) and the *adaptive-high* condition starting with moderately high difficulty (equivalent to the static condition). Participants with both high and low prior videogame experience were represented in each condition.

Findings:

Results indicate that learner performance and motivation significantly improved from the pre-training to final performance trial in all task difficulty conditions. Yet, contrary to expectations, no single condition maximized these outcomes relative to others. There was a significant 3-way interaction between performance, condition, and prior videogame experience. Experienced gamers' performance significantly improved in all conditions at a comparable rate;

however, novice gamers in the increasing condition did not improve substantially, while significantly more improvement occurred in the other conditions.

Additionally, prior experience influenced performance and motivation. Learners with greater experience performed better across all 12 trials regardless of condition. Experienced gamers also initially reported higher task self-efficacy and set higher performance goals for the training task.

Utilization and Dissemination of Findings:

The results of this research provide useful information for training game developers and instructors using videogames as training tools. The results of this research suggest that no single approach to adjusting difficulty level throughout an instructional game is clearly superior in terms of enhancing learner performance and motivation; however, it appears that a forced difficulty level adjustment (i.e., our *increasing* condition) may be less beneficial to novice gamers.

This research also suggests that prior experience may play a more important role in determining learning outcomes than how task difficulty is maintained or modified throughout an instructional game. The good news is that prior videogame experience is a malleable characteristic. Instructors can provide novice gamers with targeted opportunities to gain experience prior to instruction, and thus minimize its impact on performance.

TASK DIFFICULTY AND PRIOR VIDEOGAME EXPERIENCE:
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TASK DIFFICULTY AND PRIOR VIDEOGAME EXPERIENCE: THEIR ROLE IN PERFORMANCE AND MOTIVATION IN INSTRUCTIONAL VIDEOGAMES

INTRODUCTION

Videogame-based environments are an increasingly popular medium for training in the U.S. Army (Hays, 2005). There are a variety of arguments for the adoption of videogame-based training tools. Among these is the potential to capitalize on the motivational draw of game play (Gee, 2003; O'Neil & Fisher, 2004; Prensky, 2001). Knowledge acquisition and transfer of the skills learned in the game to real-world tasks has also been demonstrated (Gopher, Weil, & Bareket, 1994; Knerr, Simutis, & Johnson, 1979). However, the research on videogame-based training is not all positive, with a fair amount of research showing that instructional games do not always lead to the desired motivational properties and instructional gains (Hays, 2005). Given the increasing popularity of using videogames for instructional purposes, research has sought to identify factors that maximize the effectiveness of this instructional medium.

Prior research demonstrates that videogame attributes, such as level of difficulty, realism, and interactivity, affect learning outcomes in game-based learning environments (Belanich, Sibley, & Orvis, 2004; Garris, Ahlers, & Driskell, 2002; Malone & Lepper, 1987). For instance, this prior work suggests that in order to be most effective, instructional games should present an optimal level of difficulty to learners. This optimal range of difficulty can be thought of along the lines of Vygotsky's zone of proximal development - where training should be difficult to the learner, but not beyond his/her capability (Vygotsky, 1978). Instructional games that are too easy or too difficult can lead to reduced motivation and time on task (Malone, 1981; Malone & Lepper, 1987); which, in turn, may ultimately result in less positive learning outcomes, such as diminished knowledge/skill acquisition and retention (Colquitt, LePine, & Noe, 2000; Mathieu, Tannenbaum, & Salas, 1992; Tannenbaum & Yukl, 1992).

While research has enhanced our understanding of what particular game attributes influence training effectiveness, little research has investigated how to optimally integrate or manipulate such attributes in an instructional game. The present research sought to help address this gap by focusing on the attribute of task difficulty. Specifically, we examined how various strategies for modifying task difficulty over the progression of an instructional game impact subsequent learner performance and motivation.

Training Criteria

The current research focused on two specific training criteria: training performance and motivation. Clearly, performance improvement as a result of the instruction provided is an important criterion to consider, as an individual's performance while completing a training program is indicative of the extent to which he/she is acquiring the knowledge/skills being targeted within the instructional content. Further, training research demonstrates that a learner's training performance is positively related to subsequent knowledge/skill transfer (Ford, Smith, Weissbein, Gully, & Salas, 1998; Kozlowski, Gully, Brown, Salas, Smith, & Nason, 2001).

We also focused on the criterion of training motivation. Training motivation reflects the trainee's desire to engage in and learn the content of the training program (Noe, 1986). Research

has consistently found that training motivation influences both cognitive and skill-based learning outcomes across a variety of instructional settings (e.g., Baldwin, Magjuka, & Loher, 1991; Colquitt et al., 2000; Martocchio & Webster, 1992; Noe & Schmitt, 1986; Tannenbaum & Yukl, 1992). An individual's level of training motivation may be particularly relevant to examine in game-based instructional environments, as proponents of instructional videogames argue that a fundamental advantage of using videogames (over other more traditional instructions tools) is the ability to capture and maintain trainee motivation over the course of the instruction. In short, this research sought to understand how to best manipulate task difficulty in a training game so that the game is both engaging and effective as an instructional tool.

Task Difficulty

Task difficulty or challenge of an instructional activity can be defined as the degree to which the activity represents a personally demanding situation requiring a considerable amount of cognitive or physical effort in order to develop the learner's knowledge/skill levels. Individuals are challenged when they encounter a task/situation that demands skills, knowledge, or behaviors beyond their current capabilities (Van Velsor & McCauley, 2004). Additionally, individuals are most motivated by challenging tasks that do not offer certain success or failure, but rather those that provide an intermediate probability of success (Belanich et al., 2004; Malone & Lepper, 1987).

In computer games, the likelihood of success is manipulated by modifying the task difficulty of the game. Typically, videogames get more difficult as the player progresses, such that each game level is more difficult than the previous level. The player will progress until he/she either: a) completes the game or b) reaches a point where the difficulty level surpasses his/her ability (or motivation), at which point the player is likely to stop game play. This is fine for games played for entertainment purposes. However, for training games it is important for trainees to complete the training objectives; and thus, avoid situations where the trainee can not progress to the next "level" of the game. Further, even if a training game can be completed, a trainee who is not appropriately challenged during the game, may not be fully motivated or engaged; and therefore, will likely not receive the full value of the training. Thus, the question of how to appropriately manipulate task difficulty over the progression of an instructional game is of value.

The issue of adjusting game difficulty has been addressed by the commercial, entertainment gaming world. Specifically, many entertainment games deal with this issue by progressively increasing game difficulty regardless of the individual player's ability/performance level. Some games allow players to personally select a level of difficulty in which to play the game (e.g., novice, intermediate, expert). While other games approach this issue by adaptively changing the level of difficulty throughout game play (e.g., the game gets easier when players perform poorly and more difficult when they perform well). To date, to the authors' knowledge, no research has systematically compared different strategies for manipulating task difficulty in videogames used for instructional purposes.

This research was an initial attempt to examine if several different strategies used for modifying difficulty in entertainment games are also effective for modifying level of difficulty in

instructional videogames. Specifically, this research sought to provide initial evidence as to whether a particular strategy is more effective than others in terms of maintaining learner motivation throughout game play and in turn enhancing subsequent training performance.

We examined two different strategies for modifying task difficulty: forced adjustment and learner-centered adaptive adjustment. A forced difficulty level adjustment is where the videogame gradually gets harder regardless of the learner's current performance level; whereas a learner-centered adaptive difficulty adjustment is where the game gets easier when the learner performs poorly and harder when he/she performs well. For comparison purposes, we also examined if the use of a constant difficulty level throughout game play (i.e., static difficulty level) is beneficial for learner performance and motivation. Note that the strategies investigated in the present research are not exhaustive of all possible approaches for manipulating task difficulty; rather, this effort is an initial attempt to discern differences among some of the more common strategies used in entertainment games.

While this research is primarily exploratory in nature, we predicted that trainee performance and motivation may be optimized in a learner-centered adaptive difficulty condition because the difficulty level would match the learner's performance/ability, as compared to a forced difficulty level adjustment condition or static condition. In the forced difficulty level adjustment condition, task difficulty may increase faster than participants' skill level increases; and thus, it could be counterproductive, leading to inferior test performance. Similarly, a lack of increased difficulty over time in the static condition is also expected to result in a mismatch between the game level and learner skill level, as the learner's skill may surpass the "set" level over time. In turn, learner motivation and performance may be negatively impacted.

Prior Videogame Experience

Prior research on training games has found that trainee characteristics, and in particular, a trainee's prior experience with videogames, influences various trainee outcomes in videogame-based instructional environments. For instance, research has found that an individual's prior videogame experience (i.e., frequency of videogame use) is predictive of his/her future performance in videogame-based environments (Gagnon, 1985; Orvis et al., 2006; Young, Broach, & Farmer, 1997). Further, videogame experience has also been found to significantly predict several affective and motivational learning outcomes, such as training motivation, satisfaction, perceived ease in using the training game interface, and time spent engaging in an instructional game (Orvis et al., 2006; Orvis, Orvis, Belanich, & Mullin, in press).

Based on this prior research, the present research also examined the influence of prior videogame experience on performance and motivation in videogame-based instructional environments. Additionally, we explored the impact prior experience may have on determining the optimal approach for adjusting difficulty level.

METHOD

Participants

Twenty-six participants completed a 12-trial training game task under one of four task

difficulty conditions. The mean age of participants was 25.96 years (SD = 5.30 years). All participants were employed adults working part-time to full-time in a research organization. Participants were recruited via email. Participation was voluntary and was not compensated.

Experimental Design

A single-factor experiment, with repeated measures, was conducted to test the effects of different task difficulty manipulations on trainee performance and motivation. Participants were randomly assigned, counterbalancing for gender, to one of four task difficulty conditions: static, increasing, adaptive-low, or adaptive-high. The manipulations are described below. Participants with both high and low prior videogame experience were represented in each condition.

Game

The videogame used in this experiment was *VBS1™ (Virtual Battlespace version 1)*, a first-person-perspective military training game that allows for the creation and modification of military-oriented scenarios. VBS1 is a multi-player, three-dimensional, fully interactive PC-based gaming environment created in 2001 by Bohemia Interactive (www.bistudio.com). VBS1 has been used by the U.S. Army and Marine Corps for training and research purposes.

VBS1 provides a set of authoring tools that can be used to modify the game environment to develop specific scenarios. The game scenario developed by the researchers specifically for this experiment was a virtual firing range. In this scenario, the participant played the role of a Soldier who was training at a firing range in order to improve the accuracy of his/her marksmanship skills using an M16 semi-automatic rifle from the prone unsupported position. The firing range consisted of 15 target positions arranged in three rows of five each. The rows were 100, 200, and 300 meters away from the participant's position in the virtual world. One trial of the scenario consisted of a sequence of 20 standard silhouette-shaped targets, each appearing in one of the 15 positions. (Note that *all* 15 positions were not necessarily used in any given trial.) Each target would remain visible for a few seconds (the exact time varied as described in the next section) or until the participant successfully shot it, whichever came first. Each trial started with the participant loading a 30-round magazine and continued until either all 20 targets had been shown or the ammunition was exhausted, at which time the participant was given feedback indicating how many targets were successfully hit. The participant controlled the game character's actions by using a PC mouse and keyboard. The participant completed a *pre-training* trial to establish a baseline performance score, followed by 10 *practice/training* trials, and concluding with a final *performance* trial.

The game was run on a 3.2 Ghz Pentium 4 computer running Microsoft Windows XP with 1GB of RAM using a 23 inch (19 inch x 12 inch) LCD monitor set to a resolution of 1920 x 1200. Participants sat at a comfortable distance from the monitor (typically about 24 inches) and were free to adjust their position.

Manipulations

Task difficulty was manipulated based on two factors: the distribution of target distances and target display time. As task difficulty increased, a greater proportion of targets appeared in

the more distant rows, and targets were visible for shorter durations. At each difficulty level, more distant targets were visible for longer durations than closer targets. Target distances and durations for each level are shown in Table 1. Pilot testing was used to set the levels of experimental difficulty levels. Eleven difficulty levels were created ranging from 0 (extremely easy) to 10 (extremely difficult); however, no participant reached level 10 in the two adaptive conditions.

Table 1. *Distances and display durations for targets by task difficulty level*

	Percentage of Targets and Display Duration (in seconds)		
Difficulty Level	100m	200m	300m
0	100% (3.19)	0% (n/a)	0% (n/a)
1	75% (3.12)	25% (3.67)	0% (n/a)
2	50% (3.05)	50% (3.58)	0% (n/a)
3	25% (2.96)	75% (3.50)	0% (n/a)
4	33% (2.90)	42% (3.41)	25% (4.10)
5	25% (2.83)	50% (3.33)	25% (4.00)
6	5% (2.76)	70% (3.25)	25% (3.90)
7	5% (2.69)	45% (3.17)	50% (3.80)
8	5% (2.62)	20% (3.08)	75% (3.70)
9	5% (2.55)	5% (3.00)	90% (3.60)

Four task difficulty experimental conditions were created: static, increasing, adaptive-low, and adaptive-high. For all four conditions, the pre-training and final performance trials were set at a difficulty level of 5 (i.e., moderately high difficulty, selected to prevent floor or ceiling effects). In the *static* condition, task difficulty was set equal to the pre-training and performance trials; in this condition, task difficulty remained constant and moderately high (i.e., level 5) across practice trials. In the *increasing* condition (i.e., a forced difficulty level adjustment condition), task difficulty started low in practice trial 1 (i.e., level 2) and increased one level after every two practice trials. The highest level was for practice trial 10 at level of 6. The remaining two conditions were learner-centered adaptive difficulty conditions. In the *adaptive-low* condition, task difficulty started low (i.e., level 2), the same level as the increasing condition, and changed dynamically based on participants' performance. In the *adaptive-high* condition, task difficulty started at a moderately high level (i.e., level 5), the same level as the static condition, and changed based on participants' performance. In the learner-centered adaptive conditions, task difficulty was increased one level for a given practice trial after participants performed well in the previous practice trial (i.e., hitting ≥ 15 targets) and decreased one level after poor trial performance (i.e., hitting ≤ 10 targets). Task difficulty remained at the same level if the participant hit between 11 and 14 targets in the previous trial.

Procedure

Participants were informed that the objective of the game was to hit as many targets as possible out of 20 in a trial. Participants were told that their performance would be tested at the end of the training session, and that they would have an opportunity to complete several practice trials before the final performance trial. Participants were provided instructions on how to move in the virtual environment, how to position their character, how to reload their weapon, and how to successfully aim and hit a target. Three sample targets, one at each distance, were presented on which to practice these skills. All participants were required to successfully hit each of these

three targets before continuing in the experiment – each target remained visible until it was hit. An experimenter observed each participant throughout this instructional period, ensuring that participants understood the controls and the task. Additionally, the experimenter ensured that each participant was firing in single-shot rather than burst (3-shot) mode.

Participants then answered a series of questions assessing their prior videogame experience and other personal characteristics. Next, they completed a *pre-training* trial with 20 targets at difficulty level five to establish a baseline performance score, followed by a short questionnaire assessing various trainee motivational variables including: pre-training motivation, performance goal level for the final performance trial, and task self-efficacy. Next, participants completed 10 *practice/training* trials, followed by a short questionnaire assessing the participant's performance goal level and task self-efficacy with regard to the final performance trial (i.e., the upcoming trial). Participants then completed the final *performance* trial with 20 targets at difficulty level five and completed a few questions assessing their post-training level of motivation. Time in the training environment averaged 41.7 minutes (SD = 3.18).

Measures

Prior videogame experience. Prior game experience was assessed using one open-ended item modified from Orvis et al. (2006). The item appeared as follows: "In a typical week, how many hours do you play videogames?"

Pre-training/post-training motivation. Training motivation for the game-based training program was assessed using a five-item scale adapted from Noe and Schmitt (1986). Items were modified slightly to fit the game environment. Sample items include "I am motivated to learn the skills emphasized in this game" and "I plan to exert a lot of mental effort to do well in this game." Possible responses ranged from 1 (strongly disagree) to 5 (strongly agree). The coefficient alpha for the pre-training motivation and post-training motivation scale was .80 and .77, respectively.

Task self-efficacy. Self-efficacy is a task-specific construct as it relates to the performance of specific tasks/behaviors (Bandura, 1986); thus, measures of self-efficacy should be tailored to fit the relevant domain. Our measure of task-specific self-efficacy was assessed using a two-item scale adapted from Phillips and Gully (1997). The items include "I am confident in my ability to perform well on this task (on the qualification test)" and "I will succeed at this task (the qualification test) even if it becomes more difficult." Task self-efficacy was assessed immediately after the pre-training trial and prior to the final performance trial. The coefficient alpha for task self-efficacy after the pre-training trial and for the final performance trial was .91 and .92, respectively.

Performance goal level. Personal performance goal level was assessed using one item, "What is your personal goal for the total number of targets hit in the qualification test?" The participants' personal performance goal level was assessed immediately after the pre-training trial and prior to the final performance trial.

Training performance. Training game performance was operationalized as the number of targets hit, out of 20, for the given trial.

RESULTS

Descriptive Statistics

Intercorrelations between the study variables and the variable means and standard deviations for the total sample, as well as for each task difficulty condition and level of videogame experience, are displayed in Table 2. For efficiency in reporting in this table, practice performance was averaged across the 10 practice trials. Note that the variable of prior videogame experience was dichotomized into inexperienced and experienced gamers, with inexperienced gamers reporting that they typically do not play videogames at all during a given week and experienced gamers reporting that they typically play videogames for at least one hour a week. Across the experienced gamers, videogame usage ranged from 1 to 8 hours of game play per week ($M = 4.17$, $SD = 2.55$).

Table 2. *Intercorrelations of Variables, Means, and Standard Deviations*

Variable		1	2	3	4	5	6	7	8	9	10
1. Videogame experience		--									
2. Pre-training motivation		.30	--								
3. Post-training motivation		.18	.73**	--							
4. Goal level (T1)		.37+	.08	-.08	--						
5. Goal level (T2)		.28	.04	.17	.44*	--					
6. Task self-efficacy (T1)		.52**	.64**	.54**	.37+	.32	--				
7. Task self-efficacy (T2)		.23	.37+	.45**	.24	.65**	.62**	--			
8. Pre-training trial performance		.63**	-.17	-.13	.47*	.13	.38*	-.01	--		
9. Practice trial performance		.44**	-.11	-.06	.31	.65**	.22	.17	.52**	--	
10. Final trial performance		.55**	-.16	-.19	.28	.41*	.30	.18	.53**	.64**	--
Total Sample	*M*		3.75	4.03	13.27	16.44	3.35	3.44	5.96	12.60	14.19
	SD		.56	.65	5.09	3.58	1.03	1.09	3.96	2.90	3.85
Static condition	*M*		3.70	4.07	13.17	17.60	3.50	3.75	6.67	13.58	15.00
($n = 6$)	*SD*		.43	.47	3.76	.89	.84	.99	3.50	2.29	2.28
Increasing condition	*M*		4.12	4.08	13.40	13.40	3.70	2.90	6.20	10.82	12.60
($n = 5$)	*SD*		.59	.64	4.16	5.27	.97	1.52	3.03	5.53	6.54
Adaptive-low condition	*M*		3.56	4.01	13.43	18.00	2.86	3.50	4.14	13.46	13.14
($n = 7$)	*SD*		.26	.58	5.65	3.22	.99	.87	3.02	1.40	3.85
Adaptive-high condition	*M*		3.73	3.98	13.13	16.25	3.44	3.50	6.88	12.23	15.50
($n = 8$)	*SD*		.78	.92	6.71	2.96	1.24	1.13	5.41	1.80	2.56
Low experience group	*M*		3.60	3.92	11.57	15.57	2.86	3.21	3.71	11.43	12.29
($n = 14$)	*SD*		.49	.81	5.80	4.07	1.00	1.07	2.49	3.27	4.05
High experience group	*M*		3.93	4.15	15.25	17.55	3.92	3.71	8.58	13.97	16.42
($n = 12$)	*SD*		.61	.41	3.33	2.62	.63	1.10	3.78	1.66	2.07

Note. For goal level and task self-efficacy, time 1 (T1) was assessed immediately after the pre-training trial and time 2 (T2) was assessed prior to the final performance trial. $^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$ (two-tailed).

Task Difficulty Modifications

The impact of various strategies for modifying task difficulty over the progression of a training game was assessed using repeated-measures analysis of variance in SPSS. Results indicated that learner performance and motivation significantly improved from the pre-training to final performance trial in all task difficulty conditions; a significant main effect was detected for both learner performance, $F(1, 18) = 138.84^{**}$, $\eta^2 = .89$, and motivation, $F(1, 18) = 8.79^{**}$, $\eta^2 = .33$ (see Table 3 and 4). We expected that trainee performance and motivation may be optimized in a learner-centered adaptive difficulty condition, as compared to a forced difficulty level adjustment condition. Yet, contrary to expectations, no single condition maximized these outcomes relative to others. There was, however, a significant 3-way interaction detected between performance, condition, and prior videogame experience, $F(3, 18) = 4.00^{*}$, $\eta^2 = .40$. As depicted in Figure 1, experienced gamers' performance significantly improved from the pre-training to final performance trial in all conditions at a comparable rate. For inexperienced gamers, performance improvement occurred at about the same rate for three of the four conditions; however, performance did not improve as substantially in the increasing condition (i.e., the forced difficulty level adjustment condition).

Table 3. *Analysis of variance for the effects of task difficulty condition on performance and the interactive effects of condition and videogame experience on performance*

Source	*df*	*F*	η^2	*p*
		Between subjects		
Condition (C)	3	.85	.12	.48
Videogame Experience (VE)	1	17.38	.49	.00
C x VE	3	.62	.09	.61
Error	18	(13.87)		
		Within subjects		
Performance (P)	1	138.84	.89	.00
P x C	3	1.25	.17	.32
P x VE	1	.04	.00	.85
P x C x VE	3	4.00	.40	.02
Error	18	(5.52)		

Note. Values in parentheses represent mean square errors.

Table 4. *Analysis of variance for the effects of task difficulty condition on motivation and the interactive effects of condition and videogame experience on motivation*

Source	*df*	*F*	η^2	*p*
		Between subjects		
Condition (C)	3	.34	.05	.80
Videogame Experience (VE)	1	1.01	.05	.33
C x VE	3	.42	.07	.74
Error	18	(.75)		
		Within subjects		
Motivation (M)	1	8.79	.33	.01
M x C	3	.98	.14	.42
M x VE	1	.05	.00	.83
M x C x VE	3	.85	.12	.49
Error	18	(.11)		

Note. Values in parentheses represent mean square errors.

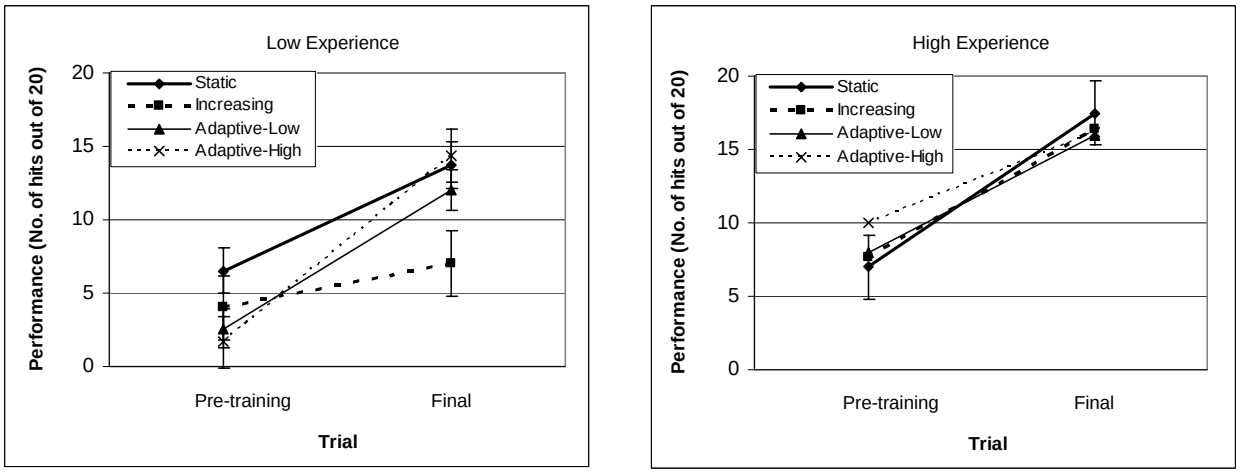

Figure 1. Left Panel: Condition by low videogame experience interaction effects on performance. Right Panel: Condition by high experience interaction effects on performance.

Videogame Experience

The direct influence of prior videogame experience on performance and motivation was also examined. We expected prior videogame experience to have a positive impact on these criteria. When examined across all 12 trials (pre-training, practice, and final performance test trials), a significant between-subjects main effect was observed for performance, $F(1, 24) = 8.67^{**}$, $\eta^2 = .27$, as well as a significant Performance X Experience interaction, $F(11, 264) = 2.47^{**}$, $\eta^2 = .09$, supporting our expectation (see Table 5). As depicted in Figure 2, performance improvement was demonstrated for all learners. Additionally, across task difficulty conditions and trials, learners with greater prior experience performed better overall compared to the inexperienced group. The inexperienced group did, however, appear to improve their personal performance level to a greater degree than the experienced group, demonstrating the Performance X Experience interaction.

Table 5. *Analysis of variance for the effects of videogame experience on performance*

Source	*df*	*F*	η^2	*p*
		Between subjects		
Videogame Experience (VE)	1	8.67	.27	.01
Error	24	(73.46)		
		Within subjects		
Performance (P)	11	14.93	.38	.00
P X VE	11	2.47	.09	.00
Error	264	(9.02)		

Note. Values in parentheses represent mean square errors.

With respect to training motivation, the inexperienced and experienced gamers did not significantly differ in the more global construct of pre-training motivation ($t(24) = -1.56$, $p = .13$). However, at the start of the game, inexperienced and experienced gamers did significantly

differ in their task self-efficacy and self-set performance goal for the training task approached significance (for self-efficacy - $t(21.61) = -3.13$, $p = .01$; for goal level - $t(24) = -1.94$, $p = .06$). Self-efficacy and personal goals represent two specific motivational constructs according to the social cognitive theory (see Bandura, 1986). Further, we found that by the final performance trial, the observed differences between inexperienced and experienced gamers in these two more specific motivational constructs became nonsignificant (for self-efficacy - $t(24) = -1.16$, $p = .26$; for goal level - $t(22.28) = -1.47$, $p = .16$). The implications of this particular finding will be highlighted in the Discussion section.

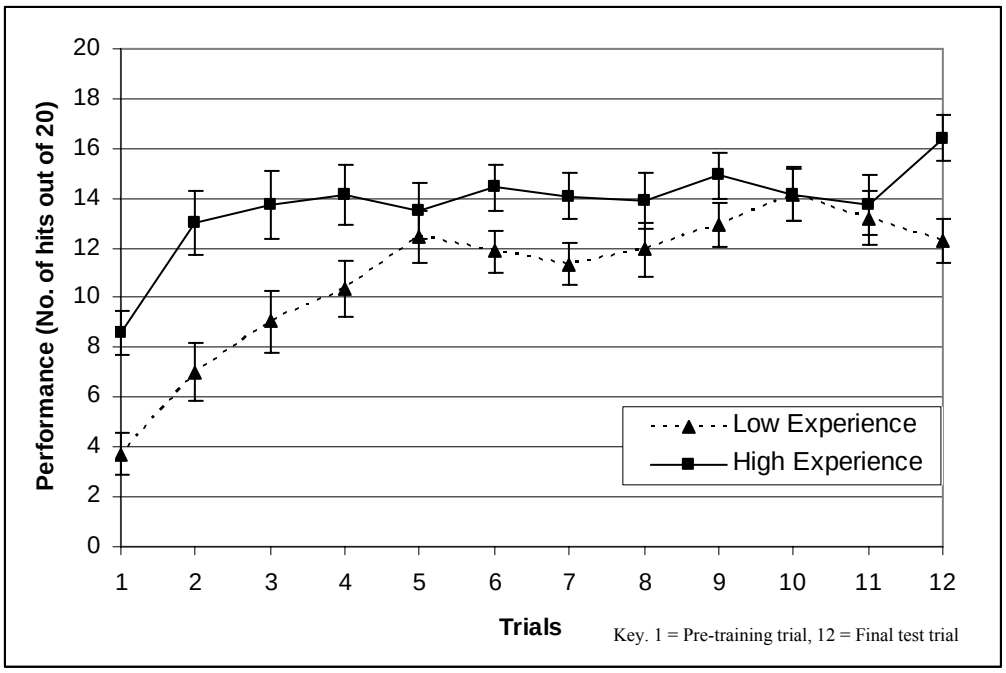

Figure 2. Interactive effect of videogame experience on learner performance

DISCUSSION

To date, there has been no research on task difficulty manipulation of videogame-based training environments and its influence on training outcomes. This research was an initial attempt to advance our understanding of how different strategies for modifying task difficulty over the progression of a training game impact the training outcomes of learner performance and motivation. Because experience and skill level are determinants of the relative level of difficulty of a task for a specific person, we also sought to understand the influence of a trainee's level of prior videogame experience on these outcomes. Our findings in relation to task difficulty modifications and videogame experience are discussed below. In addition, practical implications of this research and future research directions are provided.

Task Difficulty Modifications

Results indicated that across all difficulty level conditions, completion of the instructional game resulted in improvement in performance and motivation. Contrary to expectation, no single approach to adjusting difficulty level was clearly superior in terms of enhancing these criteria. We had predicted that these criteria may be optimized in a learner-centered adaptive difficulty condition (i.e., the adaptive-low and adaptive-high conditions) because the difficulty level would match the learner's ability. Whereas, in the forced difficulty level adjustment condition (i.e., the increasing condition), task difficulty may have increased at a faster/slower rate than increases in some participants' skill level; and thus, it might not optimize the training experience, leading to inferior performance. With the static condition, it was expected that a lack of increasing difficulty across trials would not match a learner's increasing skill level as the training progressed.

We did find, however, that the forced difficulty level adjustment condition was less beneficial for learners who had little prior experience with videogames. Inexperienced gamers in this particular condition demonstrated the lowest level of performance in the final performance trial of the game, as compared to inexperienced gamers in the other conditions and the experienced gamers in all four conditions. This interaction between task difficulty condition and experience suggests that for some learners the method used to manipulate task difficulty will influence training outcomes. In addition, this suggests that prior experience plays a role in determining the optimal approach for adjusting task difficulty in an instructional videogame.

This effect may have occurred for the inexperienced gamers because the task difficulty quickly surpassed the participants' skill levels; further, this gap between the participants' skill level and the skill level required to perform well on a trial was intensified after each subsequent practice trial. This finding may also be due, in part, to the phenomenon of learned helplessness (see Abramson, Seligman, & Teasdale, 1978; Milkulincer, 1988; 1989). Specifically, inexperienced gamers in this condition were aware of their poor performance, as all participants were informed of the number of targets they successfully hit after each trial. As the trials progressed, inexperienced gamers may have perceived their performance level to be markedly below a desirable standard and may have significantly doubted their ability to improve; thus, they may have eventually abandoned their performance goals (Bandura & Cervone, 1983; Milkulincer, 1988).

Videogame Experience

Our results also suggest that prior videogame experience has an important influence on performance and motivation, consistent with our prior research findings (see Orvis et al., 2006; Orvis et al., 2005). We found that, overall, learners with greater videogame experience performed better across the 12 trials regardless of task difficulty condition. Experienced gamers also initially reported higher task self-efficacy and set higher personal performance goals for the training task than inexperienced gamers. Such differences in self-efficacy and self-set goals are of great consequence because prior research suggests that these motivation-based cognitions impact learner choices during training, as well as subsequent performance and affect-based learning outcomes (Bandura & Cervone, 1986; Colquitt et al., 2000; Mathieu, Martineau, & Tannenbaum, 1993).

Practical Implications

This research suggests that prior experience may play a more important role in determining learning outcomes than how task difficulty is maintained/modified throughout an instructional game. The good news is that prior videogame experience is a malleable characteristic that can be compensated for fairly easily. We suggest that instructors utilizing instructional videogames should assess trainees' prior game experiences in order to identify those who lack the prerequisite game experience. Instructors could then provide these novice gamers with targeted opportunities to gain the necessary experience prior to instruction. Further, to facilitate instructors in providing the appropriate amount of preparatory practice for a given learner's needs, game developers should incorporate a feature within the instructional game that enables the instructor to select the desired amount and content of trainee orientation and practice.

Providing such prerequisite experience also has the potential to enhance a learner's motivation-based cognition (e.g., self-efficacy; Bandura, 1977). When inexperienced trainees are provided with additional practice opportunities with a relevant videogame, it is also likely that trainees will feel more confident in their capability to successfully learn and perform well in a training environment which incorporates a comparable game. And, in fact, we observed this in the current research. Inexperienced gamers initially reported lower task self-efficacy and set lower performance goals in the game. However, after exposure to the game through several practice trials, by the end of the instructional game, the observed differences between novice and experienced gamers in these motivation-based cognitions became nonsignificant. While the initial discrepancy was eliminated over the course of this particular training scenario, it is important to keep in mind that the scenario used for this research provided instruction on a relatively straightforward skill. For training games designed to teach more complex skills, such as decision making or adaptability, a more extensive practice session prior to the learning segment of the training (i.e., when learners are acquiring the new knowledge/skills taught in the game) may be necessary in order to successfully reduce initial differences among novice and experienced gamers.

It is often assumed that most junior Soldiers who grew up in the digital age would have a great deal of experience with videogames; accordingly, additional orientation and practice with videogames would be unnecessary. Our research has consistently shown that the assumption that most young Soldiers are gamers is overly optimistic. For instance, in a series of research studies, we found that many Soldiers have limited or no videogame experience (Moore, Orvis, Belanich, Solberg, & Horn, 2007; Orvis et al., 2006; Orvis et al., 2005). Specifically, in Moore et al. (2007), we found that fewer than 32% of over 10,000 U.S. Army Soldiers surveyed across various ranks play videogames at least once a week. Even for the ranks with the expected highest frequency (E2-E4), only about 50-58% reported playing traditional, commercial videogames on at least a weekly basis. Moreover, 43% of Soldiers, across all ranks, reported that they never play videogames, and over 24% of junior Soldiers (i.e., E2-E4) reported never playing games. The present research, as well as our prior work, does not imply that videogames should be avoided as training tools due to the lower than expected frequencies of Soldiers playing videogames. We believe that instructional games hold promise as effective instructional tools, and that Soldiers without videogame experience should not be neglected. We do believe that continuing to act on the "Soldier = gamer" assumption can be troublesome unless certain precautions are taken, such as providing preparatory practice with games. If introductory/pre-

training is not provided, over 50% of learners may be at a considerable and persistent disadvantage due to their lack of experience.

Future Research Directions

The current research is just the first step in understanding how to best match videogame difficulty to a learner's optimal level of challenge in order to maximize training performance and motivation. While no single strategy for optimally modifying task difficulty was clearly observed in the current research, there are several other explanations which may account for our findings. One explanation may be that the learner-centered adaptive difficulty conditions did not change aggressively enough across practice trials. For example, the scheme only adjusted up or down one level every trial, instead of adjusting two or three levels for a given trial. So, it may not have been adaptive enough for either very low or very high performers to provide the most appropriate level of challenge needed at given points in the training. We suggest that future research use a more aggressive adaptation scheme to more efficiently accommodate trainee performance. Additionally, future research could explore other methods for manipulating task difficulty, such as: a) a combination of forced increase and adaptive methods (e.g., if a learner performs well the next trial is harder, but if the performance does not improve after three consecutive trials the next trial is a "forced" higher level of difficulty) or b) a within trial manipulation (e.g., if a learner performs an action correctly the next time it is more difficult, or if he/she performs a single action poorly the next time it is easier).

Second, the constraints of the particular training environment used - a marksmanship task - may have led to a ceiling effect that diminished the possible range of scores during the final performance test. Because there may have been a ceiling effect that limited progression to higher task difficulty, future research could include a second Static condition at a low level of task difficulty (e.g., level 2). This condition would also show if completing the training task solely at an easier difficulty level would lead to performance improvements on the final performance test (which has a higher level of difficulty). Third, our small sample size may have also contributed to our non-significant finding. Additionally, we suggest that future research examine task difficulty modification effects for instructional games which seek to provide instruction on other types of skills (e.g., decision-making, pattern recognition, adaptability). It is possible that particular task difficulty effects or how one should best modify task difficulty varies according to the type of instructional game and its instructional objectives.

Further, given the importance of prior videogame experience on learner performance and motivation in instructional videogames, we suggest that future research examine the effect of providing preparatory videogame experiences on novice videogame player's subsequent training-relevant cognitions and performance. It is important to determine whether such preparatory experiences can actually level the "playing field" (or at least reduce the discrepancy) for novice and experienced gamers in game-based instructional environments. It could be that experienced videogame players differ from inexperienced players in other ways (beyond mere exposure or experience levels) which may affect task performance. Further, it is possible that these other differences may not be easily overcome by providing videogame orientation to non-gamers. For instance, in a recent study, Green and Bavelier (2007) compared experienced gamers (with the "action" videogame genre) to individuals who lacked such gaming experience

and found that experienced gamers demonstrated superior levels of visual acuity and spatial resolution. In an attempt to understand if level of game experience was the primary cause of these observed differences, Green and Bavelier provided a group of non-gamers with 30 hours of action game playing experience. Providing this experience resulted in significant performance improvement in the non-gamers' spatial resolution; yet, this preparatory experience had no impact on visual acuity performance. This suggests that some differences between experienced and inexperienced gamers may not be a direct result of game playing. That being said, the skill-based differences between the two groups in our research are more likely to be due to gaming experience than differences in visual acuity, which are essentially physiological processes. Future research is warranted in this area. Finally, if such preparatory experiences are found to be beneficial, what may be the threshold for the amount (and/or content) of experiences necessary in order to significantly enhance novice gamers' future training performance?

Summary

Recent technological advances in the videogaming world have been leveraged by the U.S. Army for training purposes (Beal, 2005; Herz & Macedonia, 2002). Instructional videogames can be motivating to use (Malone, 1981; Prensky, 2001) and skills learned in game-based training environments can transfer to real-life situations (Gopher et al., 1994; Knerr et al., 1979). While some positive examples of game-based training have been demonstrated, it is not entirely clear why some game-based learning environments are successful while others are not (Hays, 2005). Prior training game research demonstrates that videogame attributes such as task difficulty affect performance and other learning outcomes in videogame-based instructional environments (Belanich et al., 2004; Garris et al., 2002). To date, little research has investigated how to optimally manipulate such attributes.

The present research sought to help address this gap by examining different strategies for modifying task difficulty in instructional videogames, as well as the effect of prior videogame experience. We found that learner performance and motivation significantly improved in all task difficulty conditions. Further, prior experience significantly influenced these learning outcomes and a three-way interaction was detected between performance, task difficulty condition, and prior experience, which suggest that for some participants (i.e., inexperienced gamers) the method used to manipulate difficulty level will influence training performance. These findings have implications for our Soldiers' training performance and motivation in videogame-based training environments. Maximizing these training outcomes should ultimately result in enhanced operational capabilities.

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