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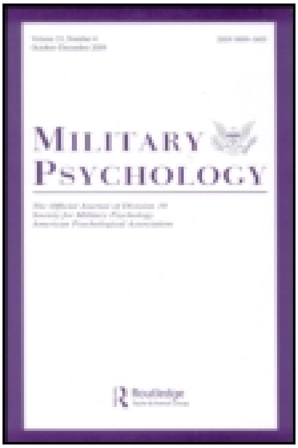

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While videogames can easily be tailored to provide "adaptive training," little research exists examining whether this benefit enhances training outcomes. The current study investigated three task difficulty manipulations and the moderating role of personality. Participants engaged in six 7-minute missions in a videogame-based training task. Openness to experience and neuroticism, but not conscientiousness, interacted with task difficulty condition such that trainees higher in these traits performed better over the course of training in the adaptive condition. These results suggest that adaptive training can result in the greatest performance improvement when the trainee's personality is suited to the instructional environment.

With the shift to technology-delivered training, videogames have captured the attention of training professionals and educators (see O'Neil & Perez, 2008) and have emerged as a popular training tool in the military (Bourge & McGonigle, 2006; Orvis, Horn, & Belanich, 2009). As opposed to the more traditional, lecture-based training, videogames can easily be designed to provide "adaptive training"—training content that is tailored to suit each trainee. For example, the

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level of difficulty of the training content can be modified to best suit the trainee's current skill levels and personal progression across the training (Wexley & Latham, 1991).

Prior work has proposed that to maximize the effectiveness of game-based training, the trainee must experience an optimal level of difficulty (Orvis, Horn, & Belanich, 2008). Consistent with Vygotsky's (1978) zone of proximal development, the training should be difficult enough to increase trainee motivation and performance, but not beyond the given trainee's capability (Belanich, Sibley, & Orvis, 2004). Thus, one would assume that learner-centered adaptive difficulty adjustments would be more advantageous than non-tailored adjustments (e.g., a forced increase in difficulty over time), as the difficulty level would appropriately match the trainee's current skill/performance level. Although work in the broader literature is supportive (e.g., Metzler-Baddeley & Baddeley, 2009; Mihalca, Salden, Corbalan, Paas, & Miclea, 2011; Shute & Towle, 2003; Vandewaetere, Desmet, & Clarebout, 2011; Wilson et al., 2009), little research to date has empirically examined whether adaptive difficulty is indeed better for learning in a game-based training environment. Because videogames represent an emerging training delivery method, it is important to investigate the effectiveness of adaptive training in this context. One prior study that examined different strategies for modifying task difficulty during a training game failed to find support for this assumption. Specifically, Orvis et al. (2008) found that performance at the end of training, across all trainees, was not significantly different across learner-centered adaptive and forced increase difficulty conditions.

Recent research in the e-learning literature suggests that the impact of adaptive training may depend on the personality characteristics of the trainee. Orvis, Brusso, Wasserman, and Fisher (2011) found that learner-centered adaptive training (i.e., high learner control in their study) was not universally better for all trainees in terms of learning. For example, they found that trainees high in openness to experience excelled in learner-centered training, whereas trainees low in this trait learned more in an e-learning environment with a low level of learner-centered adaptation. The extant training research has been supportive of the value of identifying and understanding the influence of such attribute-treatment interactions (ATIs) in training effectiveness (Gully & Chen, 2010; Gully, Payne, Koles, & Whiteman, 2002).

The important role of personality has also been acknowledged throughout the broader training literature (i.e., the traditional classroom-based training literature). Prior research in military settings (Driskell, Hogan, Salas, & Hoskin, 1994) and meta-analytic studies have demonstrated aggregate positive relationships between the Big Five personality traits of openness to experience and conscientiousness with training outcomes (e.g., Barrick & Mount, 1991; Barrick, Mount, & Judge, 2001). Moreover, primary research has demonstrated that the Big Five trait of neuroticism is also influential on training outcomes in more complex and challenging training environments (e.g., Herold, Davis, Fedor, & Parsons, 2002).

Thus, the purpose of this study is to investigate whether the optimal strategy for modifying task difficulty throughout a training videogame *depends* on trainees' openness to experience, conscientiousness, and neuroticism. We seek to better understand under what conditions (i.e., for which trainees) the investment in adaptive training is most fruitful and may reap the expected benefit of accelerated learning over the course of training.

Task Difficulty

Task difficulty of a learning activity refers to "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 and skill levels" (Orvis et al., 2008, p. 2417). Trainees should find a task difficult when it requires the use of knowledge/skills they have not yet mastered. Given that individuals come to training with differences in pre-existing knowledge, skills, motivation, and other individual characteristics (Shute & Towle, 2003), this definition implies that difficulty is trainee-specific. In other words, what one trainee finds difficult, another trainee may find rather simple because of differences in their present knowledge/skill levels. Thus, the capability to modify task difficulty to match a trainee's needs is paramount.

One of the reasons that adaptive training is proposed to be beneficial is due to the idea that it fosters "manageable" challenge. Based on prior theoretical work in the e-learning and gaming literatures (e.g., Shute & Towle, 2003; Vandewaetere et al., 2011; Wilson et al., 2009), it is expected that learner-centered adaptive training—where the training content gets easier when the learner performs poorly and harder when he/she performs well—is most effective at enhancing training outcomes. In contrast, non-tailored adjustment, such as a forced increase in difficulty (i.e., the training content gets harder regardless of the learner's current performance), is sub-optimal. For example, Shute and Towle (2003) argued for improved efficiency, effectiveness, and enjoyment of training as possible payoffs of adaptive e-learning environments. Likewise, in the gaming literature, Wilson and colleagues (2009) noted that challenge is an important game attribute linked to training outcomes. They proposed that rudimentary challenges lead to boredom, while excessive difficulty leads to frustration. Thus, challenge should match the trainees' capability.

Recent empirical research on computer-based instruction has supported the idea that adaptive training enhances performance. Metzler-Baddeley and Baddeley (2009) examined the effects of adaptive training on memory and retention of Spanish vocabulary in a sample of non-Spanish-speaking undergraduates. They found that students in adaptive training had higher immediate recall and retention rates. Additionally, Mihalca et al. (2011) found that students learned more about college genetics in an adaptive compared to a non-adaptive condition.

With respect to the training game literature, to the authors' knowledge, Orvis et al. (2008) is the only empirical study examining the effectiveness of adaptive training compared to other task difficulty modifications. In contrast to the aforementioned computer-based instruction research, Orvis et al. did not find adaptive training to be a superior strategy for modifying task difficulty over the course of a training game, as compared to a forced increase or static condition. However, they found interaction effects such that trainees with greater levels of prior videogame experience improved their training performance at the same rate in all task difficulty conditions, whereas novice gamers experienced less performance improvement in the forced increase condition. This work suggests that the impact of task difficulty modifications may depend on trainees' prior gaming experience and perhaps other individual differences as well.

Personality

As mentioned earlier, recent e-learning research suggests that whether adaptive training reaps the expected benefits may depend on a trainee's Big Five personality (Orvis et al., 2011). Accordingly, we describe the hypothesized moderating role of openness to experience, conscientiousness, and neuroticism in determining when adaptive training is the optimal strategy.

Openness to Experience

Individuals who are high in openness to experience are intellectually curious, creative, and enjoy new experiences for their own sake (Costa & McCrae, 1992; Goldberg, 1993). Meta-analytic work has demonstrated that openness to experience is positively related to success in training (Barrick & Mount, 1991; Barrick, et al., 2001). Gully and Chen (2010) noted that highly open individuals are receptive to learning new things, and are therefore more likely to stay focused and motivated during training.

Although no prior work has specifically examined the interaction between openness and adaptive videogame-based training, Orvis et al. (2011) did demonstrate that open trainees performed better in an e-learning program with high learner control (which is comparable to adaptive training, as both are implemented in order to tailor training to the given trainee), whereas a low learner control program was optimal for trainees low in this trait. Likewise, we expect that highly open trainees will also perform better in an adaptive game-based training environment. The adaptive context would provide open trainees with the best opportunity to explore and be creative, which represents their optimal learning environment.

On the other hand, if trainees low in openness to experience are placed in an adaptive environment where the difficulty level depends on personal performance, their performance improvement over time may be hampered. Because such individuals are not receptive to learning new things and do not seek out challenge (Gully & Chen, 2010), they may be prone to underperform, remain in a low difficulty level, and thus learn less over time. In contrast, because the difficulty level is pre-determined to be challenging in the non-tailored, forced increased and static conditions, trainees with low openness would be required to stretch their current skills/performance level, despite their own tendency to avoid challenge. Thus, less open trainees' performance over time will be greater in the non-tailored conditions.

Hypothesis 1: Openness to experience will moderate the relationship between task difficulty condition and performance such that trainees higher in openness to experience will perform better over time in the adaptive training.

Conscientiousness

Individuals high in conscientiousness are persistent, dutiful, organized, and strive for personal achievement (Costa & McCrae, 1992; Goldberg, 1993). Meta-analytic work has demonstrated that conscientiousness is related to training success (Barrick & Mount, 1991; Barrick, et al., 2001). Trainees higher in conscientiousness have been found to put forth more effort (Yeo & Neal, 2004), set higher goals (Hollenbeck & Klein, 1987), and be more self-efficacious (Martocchio & Judge, 1997).

It is expected that trainees lower in conscientiousness will perform better in learner-centered adaptive training. In a challenging training environment, such as the training game in this study, persistence is paramount to successful performance. When faced with poor performance earlier in training, persistent trainees are more likely to continue trying hard to do better in the later components of the training. Thus, highly conscientious trainees should put forth effort and persist in the face of challenge irrespective of whether the training content is adapting to their current performance level. In contrast, we expect that trainees lower in this trait would benefit from completing training with a tailored level of challenge, as they are more likely to give up in the face of failure/challenge. Therefore, adaptive training may be optimal for these trainees because they would be more likely to experience "small wins" over the course of training, which in turn would boost their self-efficacy for the training task and enhance the effort they put forth to perform well during the training (Bandura, 1977).

Hypothesis 2: Conscientiousness will moderate the relationship between task difficulty condition and performance such that trainees lower in conscientiousness will perform better over time in the adaptive training.

Neuroticism

Individuals who are high in neuroticism are prone to psychological distress, have higher levels of anxiety, are more self-conscious, and tend to react to frustration with anger (Costa & McCrae, 1992; Goldberg, 1993), whereas low neuroticism reflects positive psychological adjustment (Herold et al., 2002). Meta-analytic work has found weak but negative relationships between neuroticism and training performance (Barrick & Mount, 1991; Barrick et al., 2001). Gully and Chen (2010) noted that neuroticism is negatively related to training success because highly neurotic trainees are more anxious and less focused. Indeed, prior research has found that anxiety is negatively related to training outcomes (Martocchio, 1994).

Prior research has also suggested that neuroticism is an especially important trait to consider in more complex training (Herold et al., 2002). Accordingly, we expect neuroticism to play an important role in performance in a complex/challenging videogame-based training environment. Specifically, the anxiety experienced by trainees with high neuroticism will be exacerbated when task difficulty is predetermined to be challenging, as in the forced increased and static conditions, because the training may be more difficult than they can effectively cope with. However, with learner-centered adaptation, highly neurotic trainees should feel more comfortable and less anxious, as the difficulty level meets their current performance/ability levels. This reduction in anxiety should allow such trainees to focus attention and effort toward performance, and thus, have higher performance over the course of training (Brown, 2001). However, trainees low in neuroticism do not experience anxiety and negative self-reactions in challenging environments and should do well in training regardless of whether it is adaptive.

> Hypothesis 3: Neuroticism will moderate the relationship between task difficulty condition and performance such that trainees higher in neuroticism will perform better over time in the adaptive training.

METHOD

Participants

Participants were 139 students from a southeastern university, who received course credit or extra credit for participation. The mean age of participants was 20.96 (*SD* = 4.54), and 58% were female. The majority of participants were White (64.7%); 20.2% were Black, 6.5% were Hispanic, 4.3% were Asian, and 4.3% were of another race.

Training Simulation

The simulation used for this study, *Game-Distributed Interactive Simulation* (*G-DIS*), is a modification of the commercial first-person-perspective videogame *Half-Life. G-DIS* was designed by the U.S. Army Research Institute and Research Networks Incorporated to support military training exercises and to serve as a game-based training research test bed (Lampton, Bliss, Orvis, Kring, & Martin, 2009). The gaming environment is a small town surrounded by a wooded area. Participants and experimenters were engaged in the training game environment on separate computers in different physical locations; they communicated via headsets.

The programming platform and interface of *G-DIS* allows for manipulation of the training environment to create a novel and controlled training scenario. There were six training missions, in which trainees assumed the role of an armed field Soldier in search of 14 pieces of intelligence (Intel), placed throughout the town. While searching for the Intel, trainees encountered innocent civilians and enemy soldiers that engaged them. They were informed that points were awarded for Intel found and deducted for civilian fatalities and being killed by an enemy soldier. Missions were developed to ensure equivalence (relative to a given difficulty level) while eliminating carry-over effects across missions. For example, Intel placement varied across missions. Trainees were also unable to anticipate enemy or civilian locations, as their placement varied across missions and their movements were dynamic. Experiential learning was required both within a mission and across missions. Similar to other game-based training research (e.g., Orvis et al., 2009), our design necessitated that trainees engage in/practice strategy development and adaptation of their tactics in order to maximize their mission performance.

Manipulations

Three experimental conditions were created for this study. These conditions (increasing, adaptive, and static) manipulated the degree of task difficulty experienced during the six training missions. In all conditions, participants completed the same Mission 1 and 6 (set at moderate difficulty to prevent ceiling or floor effects). In the increasing difficulty condition, difficulty increased across Missions 2–5, such that Mission 2 was set at low, Missions 3 and 4 were set at moderate, and Mission 5 was set at high. In the adaptive condition, the difficulty level of Missions 2–5 changed dynamically based on the participant's performance score in the prior mission. Specifically, difficulty level increased when participants scored between 9 and 14 points, decreased when scoring 3 or fewer points, and remained the same when scoring between 4 and 8 points. These thresholds of performance were determined via pilot-testing. Finally, for comparison purposes, we also examined the effect of a constant difficulty level (i.e., the static condition), where the difficulty remained moderate for all six missions.

Task difficulty per mission was manipulated by varying the enemies' weapon type and firing accuracy. Three difficulty levels were created: low, moderate, and high. In missions with a *low* level of difficulty, enemy soldiers possessed a weapon that did not significantly hurt the life of the trainee and had a low level of firing accuracy. In the *moderate* difficulty level, approximately half of the enemy soldiers were equipped with the same weapon as the low difficulty level, while the other half possessed a more powerful weapon. All enemy soldiers possessed a moderate degree of firing accuracy. In missions with *high* difficulty, all enemy soldiers possessed the more powerful weapon and a high degree of firing accuracy.

Procedure

Participants completed a questionnaire assessing their personality, prior videogame experience, and other basic demographics. They were also randomly assigned to one of the three difficulty conditions. Then, all participants engaged in a 12-minute experimenter-led (via voice communication using the headset) pre-training tutorial designed to familiarize participants with *G-DIS*. This tutorial included an overview of the keyboard and mouse functionality (e.g., how to move your avatar, aim and fire your weapon, enter a building), and practice using these controls. The experimenter also explained the purpose/objectives of the upcoming training missions and performance scoring rules. After this tutorial, participants completed six 7-minute missions. After each mission, participants were informed of their mission score, including pieces of Intel found, avatar deaths, civilian kills, and total score. Average completion time for the study was 2 hours.

Measures

Performance

Mission performance was calculated based on the number of Intel located during the mission, the number of times the participant was killed by an enemy solider, and the number of civilians killed by the participant. For each mission, there were a total of 14 pieces of Intel, worth 1 point each. Each participant and civilian fatality resulted in a 1 point deduction. Therefore, the maximum performance score was 14. Due to the experimental manipulation, participants in the three conditions experienced different difficulty levels during Missions 2–5. In order to make performance scores comparable across conditions for these four missions, mission performance was adjusted such that 1 point was subtracted from the mission score for participants in a low difficulty mission and 1 point was added to the mission score for participants in a high difficulty mission. This measurement approach is consistent with prior game-based training research (Orvis et al., 2008). Finally, we focused on predicting performance improvement over time across the six training missions.

Personality

The Big Five traits were assessed using Saucier's (1994) Mini-Markers, which consists of eight adjectives per Big Five trait. Participants responded to how accurately each adjective described them on a 9-point scale ranging from 1 (*extremely inaccurate*) to 9 (*extremely accurate*). Sample items include: *creative* for openness to experience, *systematic* for conscientiousness, and *fretful* for neuroticism. Openness, conscientiousness, and neuroticism were all adequately reliable, with coefficient alphas of .72, .76, and .79, respectively.

Videogame Experience

Prior first-person-perspective videogame experience was used as a study covariate, as research has demonstrated that prior genre-specific videogame experience is significantly related to videogame-based training outcomes (Orvis et al., 2009). Prior experience and Mission 1 performance were significantly correlated in this study ($r = .51$). Prior experience was assessed using Orvis et al.'s (2008) 1-item scale: "In a typical week, about how many hours per week do you play first-person-perspective video/computer games (for example, Battlefield 1942, James Bond 007, Medal of Honor, Half-life 2)?" Possible responses included 0–20 hours per week (increasing by increments of 1 hour) with an added option of "more than 20" hours.

RESULTS

Hierarchical linear modeling was used to test the study hypotheses. All models were run with both restricted and full maximum likelihood estimation techniques. Deviance statistics are reported from models using full maximum likelihood estimation, while all other parameters are reported based on restricted maximum likelihood estimation with robust standard errors. Although restricted maximum likelihood produces less biased parameter estimates, deviance statistics from these models cannot be compared. Thus, both techniques were used. The random effects ANOVA model was run first, allowing for the calculation of the ICC(1) coefficient. ICC(1) was .22 and the deviance statistic was 4,039.50. The ICC(1) indicates that 22% of the variance in performance was between individuals, whereas 78% was within individuals.

Next, time was entered into the model as a random effect in order to determine the degree of performance improvement across the six missions. The results of this model suggested that time did not randomly vary, $\tau_{11} = .002$, $X^2 = 86.60$, $p > .500$. Therefore, time was entered as a fixed effect (see Model 1 in Table 1). The results demonstrated that trainee performance significantly improved .70 points per mission, $t(832) = 20.45$, $p < .001$. A separate model for each personality variable was run to test the hypotheses. In each model, prior experience was entered as a covariate predicting initial performance (i.e., Mission 1), and all other variables were entered to predict degree of performance improvement across the training. All continuous variables were centered, and task difficulty condition was dummy coded with adaptive difficulty as the referent. For each hypothesis, two interaction terms (referred to as the static and increasing interactions) were created to reflect the comparison between the adaptive condition and the static and increasing condition, respectively. Interactions were computed by multiplying the centered personality variable and each dummy code.

Hypothesis 1 predicted that trainees higher in openness to experience would perform better over time in adaptive training. In support of this, the static interaction term was significant, and the increasing interaction term approached significance, $\beta_{14} = -.15$, $t(826) = -2.15$, $p = .032$ and $\beta_{15} = -.13$, $t(826) = -1.76$, $p = .079$, respectively. As shown in Figure 1, open trainees performed better in the adaptive difficulty condition, whereas those lower in this trait performed better in non-tailored adjustments (i.e., the forced increase and static conditions). Hypothesis 2, predicting that trainees lower in conscientiousness would perform better in adaptive training, was not supported. Neither interaction term was significantly related to degree of performance improvement. Hypothesis 3 predicted that trainees higher in neuroticism would perform better over time in adaptive training. The static interaction term was significant, $\beta_{14} = -.14$, $t(826) = -2.34$, $p = .020$, but the increasing interaction term was not, $\beta_{15} = -.04$, $t(826) = -0.69$, $p = .493$. Trainees higher in neuroticism performed better in the adaptive difficulty condition compared to the static difficulty condition, whereas, surprisingly, the opposite was true for trainees lower in neuroticism (see Figure 2). There were no performance differences in the increasing difficulty condition. This suggests partial support for Hypothesis 3.

DISCUSSION

The purpose of this study was to examine whether the optimal strategy for adapting task difficulty in videogame-based training *depended* on trainees' openness to experience, conscientiousness, and neuroticism. The extant training research has supported the value of identifying such ATIs in training effectiveness (Gully &

TABLE 1
Linear Growth Model Predicting Training Performance

	Model 1			*Model 2 Openness to Experience*			*Model 2 Conscientiousness*			*Model 2 Neuroticism*		
Fixed Effect	*Parameter*	*SE*	*df*	*Parameter*	*SE*	*df*	*Parameter*	*SE*	*df*	*Parameter*	*SE*	*df*
Intercept, π_0												
Intercept, β_{00}	2.11**	0.16	138	2.11**	0.15	137	2.11**	0.15	137	2.11**	0.15	137
Videogame Experience, β_{01}				0.19**	0.05	137	0.18**	0.05	137	0.18**	0.05	137
Mission, π_1												
Intercept, β_{10}	0.70**	0.03	832	0.70**	0.06	826	0.70**	0.06	826	0.70**	0.06	826
Personality, β_{11}				0.07	0.05	826	−0.02	0.05	826	0.07	0.05	826
Static, β_{12}				−0.04	0.08	826	−0.04	0.08	826	−0.04	0.08	826
Increasing, β_{13}				0.03	0.08	826	0.03	0.08	826	0.03	0.08	826
P X Static, β_{14}				−0.15*	0.07	826	0.02	0.06	826	−0.14**	0.06	826
P X Increasing, β_{15}				−0.13†	0.08	826	0.03	0.08	826	−0.04	0.06	826
Deviance[a]	3818.29			3805.53			3809.20			3804.27		
Random Effect	*Variance Component*	*df*	X^2	*Variance Component*	*df*	X^2	*Variance Component*	*df*	X^2	*Variance Component*	*df*	X^2
Intercept	2.06	138	508.24**	1.93	137	475.40**	1.93	137	474.30**	1.88	137	465.56**
Level-1 error	4.60			4.60			4.62			4.60		

Note. Mission = time with Mission 1 coded as the intercept; P = personality; personality refers to the construct labeled in the Model heading; Static is the comparison between static difficulty and adaptive difficulty; Increasing is the comparison between increasing difficulty and adaptive difficulty.

[a]Deviance is reported from full maximum likelihood estimation so that they can be compared. The parameters are from models using restricted maximum likelihood estimation.

†$p < .10$. *$p < .05$. **$p < .01$.

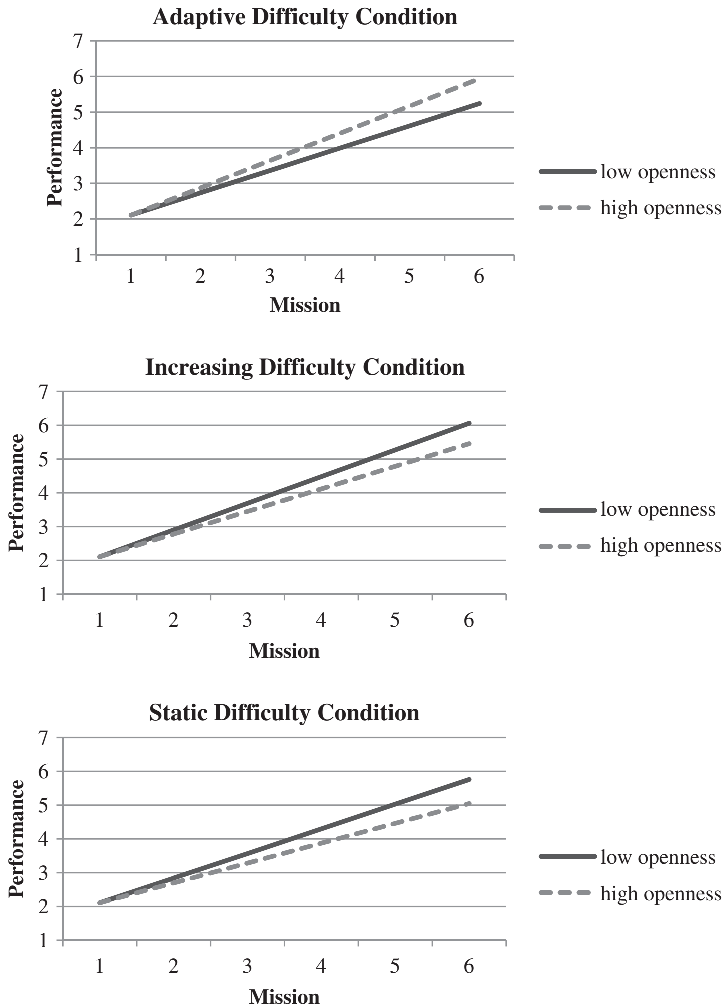

FIGURE 1 Interaction between openness to experience and task difficulty condition.

Chen, 2010; Shute & Towle, 2003). The results of the current study extend this work, demonstrating that both openness to experience and neuroticism interacted with task difficulty condition to predict performance improvement across a training program. These results may be due to the fact that (a) trainees with higher openness to experience benefit from adaptive training because they are better able to explore and be creative while learning; and (b) trainees with higher neuroticism benefit from adaptive training due to a reduction in stress and anxiety.

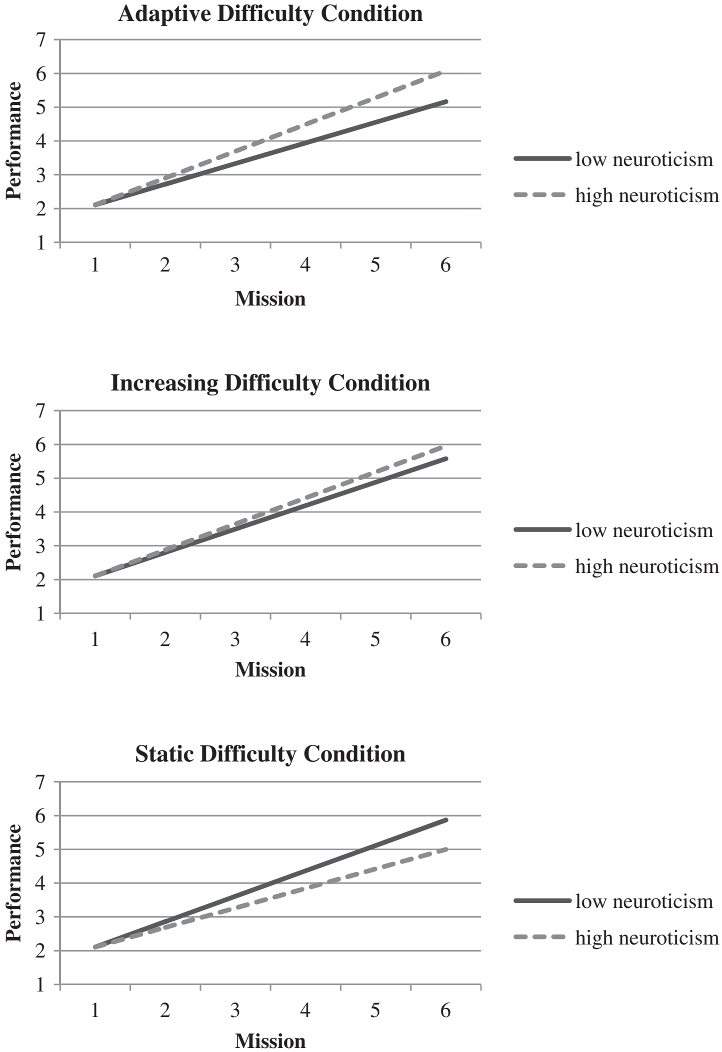

FIGURE 2 Interaction between neuroticism and task difficulty condition.

Contrary to our hypothesis, conscientiousness did not interact with difficulty. Although we did not expect to observe any difference for trainees higher in conscientiousness, we did expect that those lower in conscientiousness would be better served in adaptive training. This finding may suggest that adaptive training is equally effective for trainees with any level of conscientiousness. On the other hand, the context of our training program may not have adequately allowed for the detection of differences across the task difficulty modification strategies. Prior research suggests that the effect of context is important specifically when examining performance-based personality traits like conscientiousness (Barrick & Mount, 1993). Accordingly, failure to detect a difference for low conscientious trainees may possibly be due to the short duration of the training, which limited the degree to which conscientiousness could negatively impact training performance in the non-tailored conditions. Additional research is needed to determine if this interaction would materialize with a more complex, lengthy training program.

We do acknowledge that the magnitude of the significant interaction effects found were small. Yet, it is important to note that the training missions used in the present study were likely more straightforward than training games designed to teach more complex skills to Soldiers (e.g., see Ratwani, Orvis, and Knerr [2010], and Topolski et al. [2010] for an example of a more complex military training game). Thus, it is probable that the present results may be amplified in military applications.

Study Limitations and Directions for Future Research

One potential limitation of the present study may be the way in which training performance was adjusted to reflect mission difficulty. As mentioned earlier, an adjustment was necessary to make performance comparable in Missions 2–5 across experimental conditions, as trainees encountered different difficulty levels at the same point in training depending on their assigned condition. We chose to adjust performance by adding one point to their overall mission score for trainees in a *high* difficulty mission and subtracting one point from the overall mission score for those in a *low* difficulty mission (those in *moderate* difficulty received no adjustment). We chose to use $+/-1$ point because when comparing the means of Mission 2 performance between individuals in the static condition (i.e., in *moderate* difficulty) and the increasing condition (i.e., in *low* difficulty) the difference was approximately 1 ($M = 3.22$ and $M = 4.35$, respectively). Recall that *moderate* difficulty comprised an equal mix of elements from both the *low* and *high* difficulty conditions. Although other strategies for adjustment are possible, we suggest that this adjustment was appropriate given the observed score differences between trainees in the different difficulty levels early in training.

A second limitation is that the mediating processes through which personality interacts with task difficulty condition to impact performance over time were not empirically captured. It is possible that successful matching between trainee personality and difficulty condition leads to higher performance via enhanced motivation and self-efficacy, or reduced anxiety. In fact, prior research has demonstrated the importance of these constructs for training success (Martocchio, 1994; Noe & Schimtt, 1986; Orvis et al., 2008). Although our theoretical arguments for the examined personality traits suggest such mediating processes, they were not directly tested.

Accordingly, an important next step for future research is to empirically identify the underlying processes that explain the observed ATI effects on the degree of performance improvement over the course of training. For example, one could examine trainee anxiety as an important mediator of the influence of neuroticism and task difficulty condition on training performance. Additionally, investigating other dispositional variables beyond the Big Five could prove valuable. For example, goal orientation could moderate the effect that adaptive versus forced increase conditions have on training performance. Individuals with high performance avoid goal orientation tend to decrease effort and experience negative emotions in response to negative feedback and challenging learning tasks (Cron, Slocum, VandeWalle, & Fu, 2005; VandeWalle, Cron, & Slocum, 2001). Thus, if placed in a game-based training environment that is not matched to their current performance level, similar interactions may be observed as with highly neurotic trainees.

Practical Implications and Conclusions

Videogames are increasingly used for military training domains (Bourge & McGonigle, 2006). A key advantage of using videogames for instructional purposes is that they can be designed to provide adaptive training, tailored to suit each trainee's current skill/performance level. To date, little research has empirically examined the assumption that learner-centered adaptive difficulty is better for learning in a game-based training environment. Our findings suggest that trainees with higher openness to experience and neuroticism are better positioned for training success in adaptive training, whereas those lower in these traits are better suited for non-tailored training environments (i.e., training that employs forced increase or static difficulty). Our study also supports prior research that found that individuals' prior gaming experience is an important influence on their future performance in videogame-based environments (Orvis et al., 2008; 2009; Young, Broach, & Farmer, 1997). For instance, Orvis et al. (2009) found that U.S. Military Academy cadets' first-person-perspective game experience positively predicted their performance in a subsequent training game.

Practical implications of this research are related to military training game design and implementation. These findings suggest that the military may benefit from developing game-based training programs with different options for varying task difficulty across the training, as well as maintaining Soldiers' profiles on a personality assessment. The record of a Soldier's personality assessment could be used to place individual trainees into the appropriate game-based training program, maximizing the military's return on investment. Further, as suggested by Orvis, Moore, Belanich, Murphy, and Horn (2010), Soldiers' prior game experience should be assessed prior to training, and those lacking game experience should be provided with opportunities to gain the prerequisite experience either before or during the training. To facilitate instructors in providing this prerequisite experience, Orvis and colleagues suggest that training game developers "incorporate a feature within training games that enables the instructor to select the desired amount and content of trainee orientation and practice" (p. 154).

In conclusion, this study suggests that adaptive training has the potential to result in the greatest performance improvement, relative to non-tailored adjustment, over the course of training as long as the trainee is suited for such an instructional environment, based on their personality. Ensuring that such military trainee differences are matched with the strategy used to modify task difficulty across a training game may maximize the level of training effectiveness across all trainees. Clearly, understanding when and how to best use adaptive game-based training is deserving of further study.

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