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Adaptive Guidance: Effects On Self-Regulated Learning In Technology-Based Training

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Abstract

Guidance provides trainees with the information necessary to make effective use of the learner control inherent in technology-based training, but also allows them to retain a sense of control over their learning (Bell & Kozlowski, 2002). One challenge, however, is determining how much learner control, or autonomy, to build into the guidance strategy. We examined the effects of alternative forms of guidance (autonomy supportive vs. controlling) on trainees' learning and performance, and examined trainees' cognitive ability and motivation to learn as potential moderators of these effects. Consistent with our hypotheses, trainees receiving adaptive guidance had higher levels of knowledge and performance than trainees in a learner control guidance. Controlling guidance had the most consistent positive impact on the learning outcomes, while autonomy supportive guidance demonstrated utility for more strategic outcomes. In addition, guidance was generally more effective for trainees with higher levels of cognitive ability and autonomy guidance served to enhance the positive effects of motivation to learn on the training outcomes.

Keywords

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Comments

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Abstract

Guidance provides trainees with the information necessary to make effective use of the learner control inherent in technology-based training, but also allows them to retain a sense of control over their learning (Bell & Kozlowski, 2002). One challenge, however, is determining how much learner control, or autonomy, to build into the guidance strategy. We examined the effects of alternative forms of guidance (autonomy supportive vs. controlling) on trainees' learning and performance, and examined trainees' cognitive ability and motivation to learn as potential moderators of these effects. Consistent with our hypotheses, trainees receiving adaptive guidance had higher levels of knowledge and performance than trainees in a learner control guidance. Controlling guidance had the most consistent positive impact on the learning outcomes, while autonomy supportive guidance demonstrated utility for more strategic outcomes. In addition, guidance was generally more effective for trainees with higher levels of cognitive ability and autonomy guidance served to enhance the positive effects of motivation to learn on the training outcomes.

Adaptive Guidance:
Effects On Self-Regulated Learning In Technology-Based Training

Technological advances such as the widespread availability of the internet have led organizations to increasingly adopt e-learning programs. One of the important implications of e-learning is that it gives learners greater control over their learning (DeRouin, Fritzsche, & Salas, 2004). Although learner-control carries many potential benefits, such as more personalized and efficient instruction, research suggests that learners do not always make good use of the control they are given (Bell & Kozlowski, 2002; Reeves, 1993). As a result, researchers have called for strategies to help learners make effective decisions in learner-controlled, online environments (DeRouin et al., 2004).

One strategy that has been shown to have potential for aiding trainees' decisions during e-learning is adaptive guidance (Bell & Kozlowski, 2002). Adaptive guidance provides trainees with diagnostic, future-oriented information that can help them make appropriate decisions about what and how much to study and practice during training. Bell and Kozlowski (2002) found that providing trainees with guidance while learning a complex radar control task improved their study and practice, self-regulation, knowledge acquired, and performance. Although this preliminary research suggests that adaptive guidance may be a valuable tool in technology-based training environments, additional research is needed to further validate and refine the strategy.

One issue that warrants research attention concerns how to design adaptive guidance to maximize trainees' learning and performance. Adaptive guidance is based on the idea that optimal learning occurs when instruction leverages the advantages of both program and learner control. To this end, adaptive guidance provides the information trainees need to make effective decisions about how to deploy their attentional resources and allocate their effort during learning, but also allows trainees to retain a sense of control over their learning (Bell & Kozlowski, 2002). One challenge, however, is determining how much learner control, or autonomy, to build into the guidance strategy. On the one hand, research on self-determination theory has provided evidence that learning contexts that are framed as autonomy supportive enhance autonomous motivation and lead to higher levels of learning and performance than those that are more controlling (e.g., Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004). However, too much autonomy may lead to lower levels of compliance with the guidance information, which ultimately may result in poor learning decisions and hurt learning and performance. One goal of the current study, therefore, was to examine the effects of framing guidance as more autonomy supportive or controlling on trainees' learning and performance.

A second issue examined in this study concerns the potential for aptitude treatment interactions (ATIs) in which guidance has differential effects depending on specific trainee characteristics. Past research has provided evidence that certain trainees benefit more from learner control than others (DeRouin et al., 2004). However, this research has focused on differences across learner control and program control conditions, and it is less clear how individual differences will interact with adaptive guidance, which blends program and learner control. In the current study, therefore, we examine cognitive ability and motivation to learn as two individual differences that may interact with adaptive guidance to influence trainees' learning and performance.

The goal of the current paper, therefore, is to extend the findings of Bell and Kozlowski (2002) by not only examining the effects of alternative guidance frames (autonomy supportive vs. controlling) on trainees' learning and performance but also investigating cognitive ability and motivation to learn as two individual differences that may potentially moderate these effects. A better understanding of how training design and ATIs influence the effectiveness of adaptive guidance can not only aid in theory building but also be used to design guidance strategies that maximize training outcomes and meet the needs of different trainees. In the next section we provide an overview of adaptive guidance and then consider the potential implications of guidance that is autonomy supportive or controlling. We then turn attention to how cognitive ability and motivation to learn may interact with these guidance strategies to influence knowledge and performance outcomes.

Adaptive Guidance

In a learner-control environment, learners often do not make good decisions and often fail to perform at the same level as participants in program-controlled environments. Thus, trainers need strategies that maintain the benefits of learner-control but also enhance participants' knowledge and performance. Adaptive guidance is one technique that helps trainees to make good use of the control that they are given in a learner-control environment (Bell & Kozlowski, 2002). Adaptive guidance analyzes learners' performance to provide them with information regarding future decisions that could assist them in their training. Adaptive guidance is different than feedback in that it is future-oriented, while feedback is past-oriented. Adaptive guidance does not replace feedback, but rather supplements it with additional information that trainees need to make effective decisions about how best to deploy their attentional resources and allocate their effort (Bell & Kozlowski, 2002). Guidance information describes what trainees should think about and the behaviors trainees should engage in while studying and practicing. Thus, future-oriented guidance can help learners to make decisions in their learning and helps guide their self-regulation.

Adaptive guidance is designed to enhance trainees' self-regulation in several ways (Bell & Kozlowski, 2002). First, adaptive guidance influences self-monitoring by providing suggestions for what trainees should study and practice, based on progress, which should direct their attention to existing knowledge and performance deficiencies. In addition, as they acquire basic knowledge and skills, adaptive guidance shifts trainees' monitoring to more advanced or strategic aspects of the task. This promotes a learning sequence in which more strategic competencies are built on fundamental knowledge and skills. Second, adaptive guidance influences trainees' self-evaluation by helping them to calibrate their progress towards task mastery, which should influence the amount of effort they put into the training. This may be particularly important later in training when research has shown that trainees in learner control conditions often overestimate their competence and withdraw effort before having fully mastered the task. Finally, adaptive guidance is designed to influence trainees' self-reactions in the form of self-efficacy. Specifically, guidance helps to build self-efficacy by providing information on how individuals can overcome their performance deficiencies, which leads to an improved sense of capability to deal with future task demands and challenge (Bell & Kozlowski, 2002). In summary, by helping trainees to interpret their current progress and to sequence their learning activities, adaptive guidance is designed to focus trainee attention and effort to promote more effective learning.

Bell and Kozlowski (2002) found strong support that adaptive guidance helps learners to make better learning decisions in a learner-control environment. Learners who received guidance studied and practiced the material in a more appropriate sequence than those who received no guidance. Guidance also had a positive effect on trainees' self-efficacy early in training. The result was that learners who received adaptive guidance exhibited higher levels of basic and strategic knowledge and performance and were better able to transfer their skills than those in a pure learner control condition. In this study, we attempt to replicate the positive effects of guidance on trainees' learning and performance. Thus, we expect that trainees who receive adaptive guidance will exhibit higher levels of basic and strategic knowledge and performance relative to trainees in a learner control condition.

Hypothesis 1: Adaptive guidance will have a positive impact on trainees' basic and strategic knowledge and performance

Autonomous versus Controlling Adaptive Guidance

One of the features that distinguishes adaptive guidance from program control is that it assists trainees in making effective learning decisions, but allows them to retain a sense of control over their learning (Bell & Kozlowski, 2002). Research has shown that these feelings of control can enhance individuals' attitudes toward training (Park & Tennyson, 1983; Tennyson &

Buttrey, 1980). A recent study by Vansteenkiste et al. (2004) provides additional evidence that feelings of control, or autonomy, during training may have important motivational implications. In their study, the authors tested the self-determination theory hypotheses that autonomy-supportive learning climates (vs. controlling climates) would improve students' learning, performance, and persistence. In their study, the different climates were manipulated through the wording of task instructions to reflect either autonomous conditions (e.g., "you might") or controlling conditions (e.g., "you must"). Vansteenkiste et al. (2004) found that, relative to the controlling context, the autonomy-supportive context led to higher levels of autonomous motivation, which in turn facilitated deeper processing as well as higher test performance and more free-choice persistence. These findings suggest that guidance that is framed as autonomy supportive should enhance motivation and, therefore, learning and performance.

Research on learner control conducted over the past three decades, however, has typically failed to provide support for this motivational hypothesis (Steinberg, 1989**)**. Instead, research suggests that while trainees may be more motivated when given greater autonomy, their effort is often misdirected. For example, studies have shown that individuals given learner control often use poor learning strategies and skip over important learning opportunities (Brown, 2001; Mayer, 2004). Thus, while greater autonomy or control may enhance individuals' attitudes toward training, it may also lead to poor learning decisions which ultimately inhibit learning and performance. Accordingly, these findings from the learner control literature suggest that guidance which is framed as more controlling should be more effective for focusing trainee attention and effort and promoting learning.

It may be possible to reconcile the inconsistencies in the findings of these two literatures by considering the role of task complexity. In relatively simple, static, and straightforward learning tasks, individuals are able to quickly develop declarative representations of the task, which reduces demands on the attentional system (Kanfer & Ackerman, 1989). In addition, the sequence of learning is often less critical because simple tasks do not possess a logical, hierarchical organization of material (Bell & Kozlowski, 2002). The result is that on simple learning tasks differences in performance are primarily a function of motivation (Terborg, 1977), or of how much one studies and practices. This suggests that on simple learning tasks autonomy supportive guidance would be most effective for driving trainees' learning and performance because of its capacity to enhance trainee motivation. Indeed, the study reviewed earlier by Vansteenkiste et al. (2004) utilized a relatively simple reading comprehension task, which may help explain the positive relationship between the autonomy supportive context and students' learning and performance.

In the current study, however, we are interested in the effects of guidance in a cognitively complex and dynamic training environment, which may make it more difficult for trainees to effectively utilize learner control (Bell & Kozlowski, 2002). Complex learning tasks place significant demands on the attentional system (Kanfer & Ackerman, 1989). In addition, complex tasks require not only the encoding of information but also the sequencing of task content to promote the integration of concepts and the development of task strategies. The result is that on more complex learning tasks performance is driven primarily by the quality of learning, or how individuals deploy their attentional resources and allocate their effort (Bell & Kozlowski, 2002). Guidance that is more controlling increases the likelihood that trainees will comply with the guidance information and, therefore, make effective learning choices. Motivation levels may not be as high as in the autonomy-supportive context, but ultimately effort-learning function will be stronger in the controlling guidance condition. Based on this rationale, we predict that on more complex tasks that controlling guidance will lead to higher levels of knowledge and performance than autonomy supportive guidance.

Hypothesis 2: Trainees who receive controlling guidance will exhibit higher levels of knowledge and performance than trainees who receive autonomy-supportive guidance

Guidance and Cognitive Ability

To date, research on adaptive guidance and other advisement strategies has not given much consideration to the potential for aptitude-treatment interactions. Yet, prior research suggests that several individual differences may moderate the effects of adaptive guidance, one of which is cognitive ability. Although self-regulation often aids learning and performance, the engagement of self-regulatory processes (e.g., self-monitoring, self-evaluation) also demands attentional resources (Kanfer & Ackerman, 1989). The pool of cognitive attentional resources a trainee has to draw on can be influenced by numerous factors, including trainees' general cognitive ability and the information-processing demands of a task. When these resources are limited, self-regulatory activities can hinder performance by diverting attention away from the task (Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994).

As noted above, adaptive guidance stimulates trainees' self-regulatory activity in an effort to enhance decision-making during learning. However, the resource allocation perspective suggests that adaptive guidance may only aid trainees' learning and performance when there are sufficient resources available for both self-regulation and task performance. When resources are limited, adaptive guidance may actually be detrimental to learning and performance. Based on this rationale, we predict that adaptive guidance will have a positive effect on the learning and performance of high ability trainees, but no effect or a negative effect on the learning and performance of low ability trainees. Further, we expect that this aptitude-treatment interaction will be most prevalent on trainees' basic knowledge and performance, because these competencies are developed early in training when information-processing demands are greatest and the cognitive resources of low ability trainees are further constrained (Kanfer & Ackerman, 1989).

> ***Hypothesis 3: Adaptive guidance will have a positive effect on the learning and performance of high ability trainees, but no effect or a negative effect on the learning and performance of low ability trainees.***

Guidance and Motivation to Learn

Motivation to learn, or training motivation, can be defined as, "… the direction, intensity, and persistence of learning-directed behavior in training contexts" (Colquitt, LePine, & Noe, 2000, p. 678). Noe (1986) hypothesized that, "… trainees who are enthusiastic about attending the program and desire to learn the content of the training program are likely to acquire more knowledge and skills and demonstrate greater behavior change and performance improvement than trainees not motivated to learn." A recent meta-analysis Colquitt et al. (2000) provides strong support for this hypothesis. Based on an integration of 20 years of research on training motivation, the authors not only identified a number of individual (e.g., anxiety) and situational (e.g., climate) characteristics that influence motivation to learn, but also showed that motivation to learn positively predicts multiple training outcomes, including declarative knowledge and skill acquisition.

Colquitt et al. (2000) note that one issue that warrants additional attention in the training motivation literature is aptitude-treatment interactions. More specifically, the authors suggest that training design variables may moderate the effects of motivation to learn. In the current study, we predict that adaptive guidance may moderate the effects of trainees' motivation to learn. As noted earlier, research on learner control has typically failed to reveal a positive relationship between trainees' motivation and learning and performance (e.g., Steinberg, 1977). This is because learners typically do not make good use of the control they are given, particularly in more cognitively complex and dynamic training environments (Bell & Kozlowski, 2002; Reeves, 1993). For example, learners will often skip over important learning opportunities and practice other skills well beyond the point at which they have been acquired (Tennyson 1980, 1981). Adaptive guidance, however, not only focuses trainees' effort on learning activities that address current knowledge and performance deficiencies but also assists trainees in calibrating their current progress toward task mastery, which can help sustain effort during training. Thus, we predict that adaptive guidance will serve to strengthen the positive effects of motivation to learn on trainees' knowledge and performance. Based on this rationale, we offer the following hypothesis:

> ***Hypothesis 4: Motivation to learn will be positively related to knowledge and performance in the adaptive guidance conditions, but unrelated to knowledge and performance in the learner control condition.***

Method

Participants

Participants were 130 undergraduate students enrolled in an introductory human resource management course at a large northeastern university. In exchange for their participation, individuals earned course credit and were eligible for cash prizes (up to $100) based on their knowledge and performance during training. Fifty-nine percent of the participants were male and most (93.1 percent) were between 18 and 21 years old.

Task

The task used in this study was a version of TANDEM (Dwyer, Hall, Volpe, Cannon-Bowers, & Salas, 1992), a computer-based radar-tracking simulation that presents participants with multiple targets on the computer screen. Trainees were required to learn how to perform a number of both basic and strategic skills. With respect to basic skills, they had to learn to "hook" targets on the radar screen, collect cue information, make 3 subdecisions to classify the targets' characteristics, and then make an overall decision (take action/clear). Trainees received points for correct decisions and lost points for incorrect decisions. They also needed to learn strategic skills that involved preventing targets from crossing two perimeters located on their display. Individuals need to learn how to identify the perimeters, determine which targets were higher priority than others, and make trade-offs between targets that were higher or lower priority. Targets that crossed perimeters cost points.

Procedure

Training on the radar simulation was conducted in a single three-hour session with groups of one to four participants. Trainees within sessions were randomly assigned to one of the three experimental conditions: controlling guidance, autonomy-supportive guidance, or a learner control condition. Trainees were first presented with a brief demonstration of the simulation that outlined its features and decisions rules. They were then shown how to use an on-line instruction manual that contained complete information about the simulation. After this brief demonstration, trainees had an opportunity to familiarize themselves with the instruction manual for three minutes and familiarize themselves with the task in a five-minute trial. They were then told that they would progress through nine study, practice, and feedback cycles, followed by an opportunity to demonstrate how much they had learned on a more difficult and complex version of the task.

Participants were given nine 10.5-minute training trials to acquire the knowledge and skills needed to perform the simulation. Each training trial consisted of a cycle of study, practice, and feedback. They had three minutes to study the online instruction manual, five minutes of hands-on practice, and 2.5 minutes following practice to review their feedback. Veridical descriptive feedback on all aspects of the task relevant to both basic and strategic performance was provided immediately following the completion of each practice trial. Trainees in all three experimental conditions received feedback regarding their performance on the same task dimensions. Following the third and ninth trials, participants were given basic and strategic knowledge tests. They were also given a 5-minute break following the third and ninth trials. After the second break, participants were presented with a 10-minute generalization task that was more difficult and complex than the scenarios they had practiced.

Training Manipulations

Learner control condition. Learner control served as the control condition in this experiment. Trainees in all three conditions received descriptive feedback on the same elements of performance, had access to the same training materials (e.g., instruction manual), and were given the same degree of control over the content, sequence, and pace of the training. Specifically, all trainees could exercise control over what they study and practice (content), the order in which they study and practice the material (sequence), and the pace of their learning, such as how much time to spend studying the computerized manual or reviewing feedback. For design reasons, however, it was necessary to impose maximum time limits on the study and practice sessions. However, only the control condition was a “pure” learner control situation because the other two conditions provided trainees with guidance. Before the first training session, individuals in the learner control condition were given a randomized list of learning topics and were told that the list outlined all important task concepts and skills, but what they chose to study and practice was at their discretion. Following each practice trial learner control trainees received feedback on the same dimensions as other trainees, but did not receive any guidance information.

Adaptive guidance conditions. The guidance manipulations created for the current study were modeled after the adaptive guidance strategy described by Bell and Kozlowski (2002). The guidance was adaptive based on trainee’s performance during the preceding practice trial and was presented immediately following feedback. The guidance was adaptive based on three levels of performance. Cutoff scores based on pilot data were set at the 50^{th} and 85^{th} percentiles to allow discrimination among scores representing low, medium, and high performance. These standards were used to determine the guidance a trainee received, but trainees were not aware of the cutoff scores or percentiles. Based on the standards, adaptive guidance provided evaluative information to help the trainee calibrate current progress and then provided guidance on how to improve deficiencies.

Drawing on manipulations used in previous studies on autonomy-supportive and controlling contexts (e.g., Vansteenkiste et al., 2004), the two types of guidance were created based on differences in the wording of five phrases. Specifically, in the *autonomy-supportive* *guidance* condition, the guidance used phrases such as, “you can,” “you might,” “you may,” and “if you choose,” whereas in the *controlling guidance* condition the wording involved phrases such as “you have to,” “you must,” “you should,” and “you had better.” For example, it was stated in the autonomy-supportive guidance condition, “You may want to study the material in your manual on prioritization strategies,” whereas in the controlling guidance condition trainees were told, “You must study the material in your manual on prioritization strategies.” Other than the differences in the use of autonomy-supportive or controlling phrases, the two types of adaptive guidance were identical.

If trainees fell below the 50th percentile, the guidance informed the person they had not yet learned the skill or strategy and highlighted what the trainee could/must be studying and practicing to improve. Guidance for individuals between the 50th and 85th percentile informed the trainee they had reached a basic level of proficiency and indicated what they might/had better be practicing to improve. For individuals above the 85th percentile, guidance informed the person that they had mastered the skill or strategy and indicated that they could/should concentrate on improving in other areas in which they were still deficient. Thus, each instance of adaptive guidance provided participants with evaluative information to help them judge their progress and personalized information on what they can/must study and practice to improve.

In both guidance conditions, adaptive guidance was designed to sequence trainee learning and practice. More precisely, the guidance focused on helping trainees build fundamental or basic skills early in training, before proceeding later in training to developing more strategic competencies which build on the fundamental skills. At the beginning of training, individuals in the guidance conditions were given a topic sheet similar to that given to participants in the learner control condition. However, for participants in the guidance conditions the list was ordered in a ramped sequence. In addition, before each training session the guidance highlighted the topics that trainees may/must cover during the next three practice and study sessions. The guidance following each practice trial then presented with either controlling or autonomy-supportive information about the study and practice activities that would improve their performance in these areas.

Measures

The individual differences, cognitive ability and motivation to learn, were measured at the beginning of the experimental session. Consistent with the learning sequence described earlier, basic knowledge and performance were measured early in training during the first training session, whereas strategic knowledge and performance were assessed later in training during the final training session. Trainees' basic and strategic performance was also measured during the generalization trial that that took place at the end of the experimental session.

Cognitive ability. Participants provided their SAT or ACT scores at the beginning of the experimental session. The scores were standardized using national means and standard deviations published by the CollegeBoard and ACT. The standardized scores served as a measure of individuals' general cognitive ability (Frey & Detterman, 2004).

Motivation to learn. Trainees' motivation to learn was measured using 7-items developed by Noe and Schmitt (1986). Items were modified to be consistent with our training setting and were rated on a five-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). A sample item is "I will put a lot of effort into doing well in the training program." Internal consistency reliability of the scale was .86.

Declarative knowledge. Declarative knowledge was measured using the basic and strategic knowledge tests developed by Bell and Kozlowski (2002) for this task (see also, Kozlowski & Bell, 2006). Basic knowledge was measured following the completion of the third practice trial. The basic knowledge test consisted of thirteen multiple-choice items focusing on the extent to which declarative knowledge (e.g., target characteristics; basic operating features of the task) about the task had been acquired. Following the ninth practice trial, participants completed the strategic knowledge test. This test consisted of twelve multiple-choice items focusing on the extent to which strategic knowledge (e.g., locating the perimeters, identifying high priority targets) about the task had been acquired. A confirmatory factor analysis (CFA) confirmed that these two scales were indeed measuring different aspects of knowledge (χ^2(53, N = 130) = 66.14, $p > .10$; χ^2/df = 1.25; CFI = .93; IFI = .94; and RMSEA = .044 (.000, .075)). Using the equation specified in Fornell and Larcker (1981, p. 45), we calculated the composite reliability, which is analogous to coefficient alpha, of each of the knowledge measures. The composite reliabilities for the basic and strategic knowledge scales were .85 and .82, respectively.

Training performance. Data were collected that allowed assessments to be made of participants' performance during training on both the basic and strategic aspects of the task. Participant's basic performance was calculated based on the number of correct and incorrect decisions during the third practice trial. Strategic performance was composed of the number of times participants zoomed out, the number of markers hooked in an effort to identify the location of an invisible outer perimeter, and the number of high priority targets processed during the ninth practice trial. These measures have been established in previous research using the TANDEM simulation (e.g., Bell & Kozlowski, 2002), and an exploratory principal components factor analysis using varimax rotation yielded a two-factor solution with the basic and strategic performance indicators loading cleanly on their respective dimensions (Component 1: strategic performance, eigenvalue = 2.23, variance = 44.50%; Component 2: basic performance, eigenvalue 1.08, variance = 21.57%). The indicators were standardized and summed using unit weights to create separate basic and strategic performance composites.

Generalization performance. Participants performed a final 10-minute trial at the end of the three-hour session. This trial was more difficult, complex, and dynamic than the practice trials. The generalization trial was longer in duration (10 vs. 5 minutes), it included more targets on the screen (60 vs. 22), a greater number of targets popped up suddenly on the screen, and more targets threatened the outer perimeter. In addition, rules were modified so that a greater number of points were deducted when targets crossed the visible inner perimeter (175 points) and the invisible outer perimeter (125). To achieve high levels of basic and strategic performance on this final trial, participants needed to adapt their strategies and generalize their skills. The same basic and strategic performance composites were used to assess participant's performance on the generalization trial (Bell & Kozlowski, 2002). A principal components factor analysis with varimax rotation again yielded a two-factor model with the indicators loading cleanly onto their respective performance dimensions (Component 1: strategic performance, eigenvalue = 2.49, variance = 49.72%; Component 2: basic performance, eigenvalue 1.36, variance = 27.09%).

Data Analytic Strategy

In the current study, the hypotheses were tested using hierarchical regression analyses. Cognitive ability and motivation to learn were entered in the first step to test for their linear relations. The guidance manipulations were entered in the second step to examine their effects over and above the individual differences. Separate dummy coded variables were created to represent the controlling guidance and autonomy-supportive guidance conditions. In each case the guidance condition was coded 1 and the learner control condition represented the comparison condition. All main effects were interpreted at the step they were entered in the regression equation. Follow-up t-tests were performed to test for hypothesized differences between the controlling and autonomy-supportive guidance conditions. The terms representing the interactions of the guidance manipulations with cognitive ability and motivation to learn were entered in the third and final step. All variables were centered before creating the interaction terms (Aiken & West, 1991). Since each of the hypotheses was directional, one-tailed tests of significance were used.

Results

The means, standard deviations, and intercorrelations among all variables examined in the present study are shown in Table 1. Table 2 presents the regression results predicting basic knowledge and performance and Table 3 presents the regression results predicting the strategic outcomes. In the following sections, we present the results for the hypotheses, beginning with the direct effects of the guidance manipulations and then focusing on the hypothesized interactions.

Guidance Effects

Hypothesis 1 predicted that trainees who receive adaptive guidance would have higher levels of knowledge and performance than trainees in the learner control condition. Tables 2 and 3 reveal that this hypothesis was generally supported for controlling guidance. Specifically, trainees who received controlling guidance had higher levels o f basic knowledge ($\beta = .17$, $p < .05$), basic performance during training ($\beta = .19$, $p < .05$), strategic performance during training ($\beta = .50$, $p < .01$), and strategic performance during generalization ($\beta = .40$, $p < .01$) than trainees in the learner control condition. The results for the autonomy-supportive guidance revealed that the manipulation did not have a significant effect on the basic outcomes, but did impact the strategic performance outcomes. In particular, trainees who received autonomy-supportive guidance exhibited higher levels of strategic performance during both training ($\beta = .19$, $p < .05$) and generalization ($\beta = .17$, $p < .05$) relative to trainees in the learner control condition.

Hypothesis 2 predicted that trainees who receive controlling guidance would exhibit higher levels of knowledge and performance than trainees who receive autonomy-supportive guidance. The results revealed that trainees in the two guidance conditions did not significantly differ on the basic outcomes or on strategic knowledge. However, trainees who received the controlling guidance demonstrated higher levels of strategic performance during both training ($t = 3.55$, $p < .01$) and generalization ($t = 2.33$, $p < .05$) than trainees who received autonomy-supportive guidance. Thus, Hypothesis 2 was partially supported. When combined with the findings for Hypothesis 1, we can conclude that there were significant differences in trainees' strategic performance across the three training conditions, with controlling guidance yielding the highest levels of strategic performance followed by autonomy-supportive guidance and finally the learner control condition. Mean differences in the strategic outcomes across the three training condition are shown in Figure 1.

Guidance x Cognitive Ability Interactions

Hypothesis 3 predicted that guidance would have a positive effect on high ability trainees' knowledge and performance, but no effect or a negative effect on the knowledge and performance of low ability trainees. In addition, we predicted that the interaction of guidance and cognitive ability would be most prevalent when examining trainees' basic knowledge and performance because these competencies are developed early in training when cognitive resource demands are greatest. The results revealed that adaptive guidance and trainees' cognitive ability did not significantly interact to affect the strategic outcomes, which are developed later in training. However, controlling guidance and cognitive ability interacted to significantly influence trainees' basic knowledge ($\beta = .27$, $p < .05$) and basic performance during the generalization trial ($\beta = .26$, $p < .05$). As predicted, the nature of both these interactions was such that controlling guidance had a positive effect on high ability trainees' basic knowledge and performance, but had no effect on low ability trainees' basic knowledge and performance. Thus, Hypothesis 3 received partial support. To illustrate the nature of this effect, the significant interaction of cognitive ability and controlling guidance on trainees' basic knowledge is shown in Figure 2.

Guidance x Motivation to Learn Interactions

In Hypothesis 4 we predicted that motivation to learn would be positively related to knowledge and performance in the adaptive guidance conditions, but unrelated to knowledge and performance in the learner control condition. The results revealed that autonomy-supportive guidance and motivation to learn significantly interacted to effect trainees' strategic performance during training (β = .25, $p < .05$) and basic performance during generalization (β = .26, $p < .05$). The nature of these interactions are displayed in Figure 3 and Figure 4. As expected, these figures reveal a positive relationship between motivation to learn and performance in the guidance condition. In the learner control condition, however, a negative relationship between motivation to learn and performance is observed. While this negative relationship is somewhat surprising, it does provide further evidence that in pure learner control environments higher levels of motivation are unlikely to translate into higher levels of performance. Overall, these results provide some support for Hypothesis 4.

The results also revealed that the controlling guidance and motivation significantly interacted to effect trainees' basic performance during training (β = -.29, $p < .05$). This nature of this interaction is shown in Figure 5. Consistent with expectations, we see that in the learner control condition there is essentially no relationship between motivation to learn and performance. However, contrary to our predictions, Figure 5 reveals a negative relationship between motivation to learn and performance in the controlling guidance condition. These results suggest that controlling guidance was beneficial for trainees with low motivation, but not trainees with high levels of motivation. One potential explanation for this finding is that controlling guidance conflicts with the intrinsic motivation of individuals high in motivation to learn. Combined with the findings above, we can conclude that for individual high in motivation to learn autonomy-supportive guidance is likely to be more effective than controlling guidance.

Discussion

Although organizations are increasingly relying on online training to train their workforces, research suggests that learners do not always make good use of the learner control inherent in technology-based training environments (Bell & Kozlowski, 2002; Reeves, 1993). Adaptive guidance has been shown to have aid trainees' decisions during e-learning, yet it is still unclear how trainers can best present guidance information to trainees to obtain maximum impact on trainees' self-regulation and learning. Given that autonomy in a learner-controlled environment has several potential benefits (e.g., trainees have greater motivation and the training is less expensive to develop) and costs (e.g., autonomy can have a negative impact on learning outcomes), we examined the effects of framing guidance as more autonomy supportive or controlling on trainees' learning and performance. We also examined the role of cognitive ability and motivation to learn as two potentially critical individual difference variables that may interact with adaptive guidance to influence learning and performance.

Our results revealed that adaptive guidance had a significant impact on trainees' knowledge and performance. Trainees who received guidance generally had higher levels of knowledge and performance than trainees in a learner control condition. These results not only replicate the findings of Bell and Kozlowski (2002) but also provide additional support for the argument that trainees in learner controlled environments need guidance in order to benefit from instruction.

Perhaps more importantly, our results also revealed that the type of guidance trainees received made a difference. First, more consistent, positive effects were observed for controlling than autonomy supportive guidance. Controlling guidance impacted both basic and strategic outcomes, whereas autonomy-supportive guidance had a significant, positive effect on only the strategic performance outcomes. In addition, on these strategic outcomes, the effect of controlling guidance was significantly larger than that of autonomy-supportive guidance. Thus, we can conclude that while autonomy-supportive guidance aids in the development of more complex, strategic skills, controlling guidance is a more effective guidance strategy. It is important to remember that we focused on trainees learning and performance in a complex, dynamic training environment. In more simple, straightforward tasks, these findings may actually reverse as the motivational benefits of autonomy-supportive guidance become more critical to performance than the effects of controlling guidance on the nature of trainees study and practice.

Importantly, we found also that individual differences in trainees' cognitive ability and motivation to learn interacted with the guidance to influence training outcomes. We found that controlling guidance interacted with cognitive ability such that it had an impact on high but not low ability trainees' basic knowledge and basic performance (see Figure 2). These findings are consistent with the resource allocation perspective that strategies designed to stimulate self-regulation are only effective if trainees have the resources available to devote to both self-regulatory and on-task activities. It is also noteworthy that these effects were only observed on the basic competencies, which are developed early in training when information-processing demands were highest. The absence of significant cognitive ability-guidance interactions on the strategic outcomes suggests that by later in training when resource demands are less, low ability trainees were able to benefit from the guidance as much as high ability trainees. Additional support for this conclusion is provided by the fact that cognitive ability did not have a significant main effect on the strategic performance outcomes. This suggests that the guidance manipulations may have been capable of neutralizing the effect of cognitive ability on more complex skill development. However, when guidance was ineffective for the development of strategic knowledge, cognitive ability emerged again as a powerful predictor ($\beta = .35$, $p < .01$). Overall, these findings suggest that guidance should not be used with low ability individuals in the early stages of training, but may be used later in training after they have developed declarative representations of the task.

We also found some support that motivation to learn and guidance interact in their effect on trainees learning and performance. Across these interactions, we found that motivation to learn was either unrelated to or negatively related to performance in the pure learner control condition. This finding is consistent with research in the learner control literature that has failed to show that the higher levels of motivation created by learner control enhance performance.

However, our results also suggest that the two forms of guidance had different effects on how motivation to learn impacted trainees performance. In the autonomy-supportive condition, there was the anticipated positive relationship between motivation to learn and performance. However, in the controlling guidance condition, motivation to learn was negatively related to performance. If we examine Figure 5, we see that controlling guidance benefited individuals low in motivation but had no effect on the basic performance of trainees high in motivation. As suggested earlier, this may be because the controlling guidance conflicted with the intrinsic motivation of individuals high in motivation to learn. Overall, we can draw two practical implications from these findings. First, autonomy-supportive guidance should be given to trainees with high levels of motivation to learn, as it helps to translate this motivation into bigger gains in performance. Second, for trainees with low levels of motivation to learn, autonomy supportive guidance was ineffective. Controlling guidance, however, showed some evidence of being able to improve the performance of these individuals and appears likely to be a better strategy.

Conclusion

In summary, this study provides additional evidence that adaptive guidance represents and effective strategy for assisting trainees in making the most of the learner control offered by technology-based training environments. However, we also showed that the benefits of guidance are dependent on not only the type of guidance provided but also the characteristics of the trainees receiving it. We are hopeful that future research will be able to build off of our findings to further identify the situational and individual factors that affect the efficacy of adaptive guidance.

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Table 1
Means, Standard Deviations, and Intercorrelations

Variable	M	SD	1	2	3	4	5	6	7	8	9	10
1. Autonomy-supportive Guidance	0.41	0.49	--									
2. Controlling Guidance	0.32	0.47	-.57**	--								
3. Cognitive Ability	2.81	0.85	.12	-.06	--							
4. Motivation to Learn	3.30	0.62	-.08	.06	-.04	--						
5. Basic Knowledge	11.30	1.94	-.05	.15	.24**	.12	--					
6. Strategic Knowledge	9.20	2.10	.08	.04	.35**	.11	.49**	--				
7. Basic Performance: Training	0.00	1.00	-.03	.15	.21**	-.10	.50**	.39**	--			
8. Strategic Performance: Training	0.00	1.00	-.09	.39**	.06	.08	.35**	.34**	.37**	--		
9. Basic Performance: Generalization	0.00	1.00	-.03	.09	.29**	-.10	.58**	.41**	.61**	.22*	--	
10. Strategic Performance: Generalization	0.00	1.00	-.05	.29**	.10	.07	.27**	.27**	.27**	.59**	.23**	--

Note: * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at 0.01 level (2-tailed). Autonomy-supportive guidance and controlling guidance are dummy-coded variables with the learner control condition as the comparison condition. Basic knowledge and training performance were measured early in training, strategic knowledge and performance were measured at the end of training. The performance measures have been standardized to facilitate comparisons across dimensions.

Table 2

Hierarchical Regression Results: Predicting Basic Knowledge, Training Performance, and Generalization Performance

Predictor/Step	β At Step	β Final	R^2	ΔR^2
DV: Basic Knowledge				
1. Cognitive Ability	.24**	.07		
Motivation to Learn	.13	.08	.07**	.07**
2. Autonomy-supportive Guidance	.03	.06		
Controlling Guidance	.17*	.20*	.10*	.03
3. Autonomy x Ability	.02	.02		
Controlling x Ability	.27*	.27*		
Autonomy x Motivation	.09	.09		
Controlling x Motivation	-.06	-.06	.15*	.05
DV: Basic Performance - Training				
1. Cognitive Ability	.20*	.09		
Motivation to Learn	-.09	.07	.05*	.05*
2. Autonomy-supportive Guidance	.04	.05		
Controlling Guidance	.19*	.22*	.08*	.03
3. Autonomy x Ability	.09	.09		
Controlling x Ability	.15	.15		
Autonomy x Motivation	-.01	-.01		
Controlling x Motivation	-.29*	-.29*	.14*	.06†
DV: Basic Performance - Generalization				
1. Cognitive Ability	.29**	.08		
Motivation to Learn	-.09	-.20	.09**	.09**
2. Autonomy-supportive Guidance	-.02	.01		
Controlling Guidance	.10	.14	.11**[a]	.01
3. Autonomy x Ability	.09	.09		
Controlling x Ability	.26*	.26*		
Autonomy x Motivation	.26*	.26*		
Controlling x Motivation	-.15	-.15	.21*[a]	.11**

Note: DV = dependent variable. β is the standardized regression coefficient and significance levels are based on directional, one-tailed t-tests. Increments for variables entered at the ΔR^2 significance levels are based on F tests for that step. † $p < .10$. * $p < .05$. ** $p < .01$. [a]R^2 values do not add up due to the rounding of numbers.

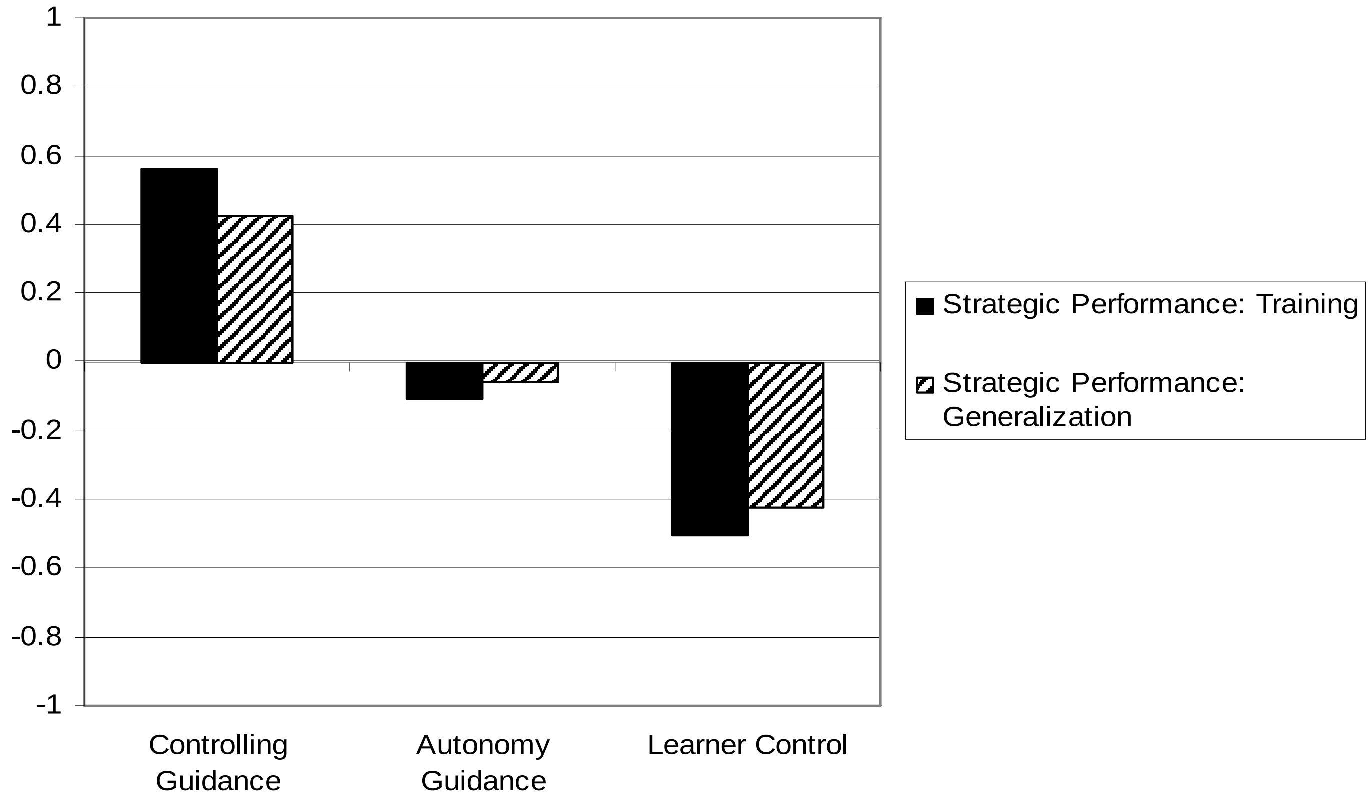
Table 3

Hierarchical Regression Results: Predicting Strategic Knowledge, Training Performance, and Generalization Performance

Predictor/Step	β At Step	β Final	R^2	ΔR^2
DV: Strategic Knowledge				
1. Cognitive Ability	.35**	.35*		
Motivation to Learn	.12	.05	.14**	.14**
2. Autonomy-supportive Guidance	.11	.13		
Controlling Guidance	.11	.12	.15**	.01
3. Autonomy x Ability	-.09	-.09		
Controlling x Ability	.07	.07		
Autonomy x Motivation	.10	.10		
Controlling x Motivation	.01	.01	.16**[a]	.02
DV: Strategic Performance – Training				
1. Cognitive Ability	.06	.06		
Motivation to Learn	.08	-.13	.01	.01
2. Autonomy-supportive Guidance	.19*	.21*		
Controlling Guidance	.50**	.51**	.19**	.19**
3. Autonomy x Ability	-.10	-.10		
Controlling x Ability	.09	.09		
Autonomy x Motivation	.25*	.25*		
Controlling x Motivation	.06	.06	.23**	.04
DV: Strategic Performance – Generalization				
1. Cognitive Ability	.10	.17		
Motivation to Learn	.07	.05	.01	.01
2. Autonomy-supportive Guidance	.17*	.17*		
Controlling Guidance	.40**	.40**	.12**	.11**
3. Autonomy x Ability	-.18	-.18		
Controlling x Ability	.06	.06		
Autonomy x Motivation	.09	.09		
Controlling x Motivation	-.08	-.08	.16**	.04

Note: DV = dependent variable. β is the standardized regression coefficient and significance levels are based on directional, one-tailed t-tests. Increments for variables entered at the ΔR^2 significance levels are based on F tests for that step. † $p < .10$. * $p < .05$. ** $p < .01$. [a]R^2 values do not add up due to the rounding of numbers.

Figure 1
Main Effect of Training Condition on Trainees' Strategic Performance During Training and Generalization



Note: Mean levels of strategic performance are significantly different across all three training conditions.

Figure 2
Interactive Effect of Controlling Guidance and Cognitive Ability on Trainees' Basic Knowledge

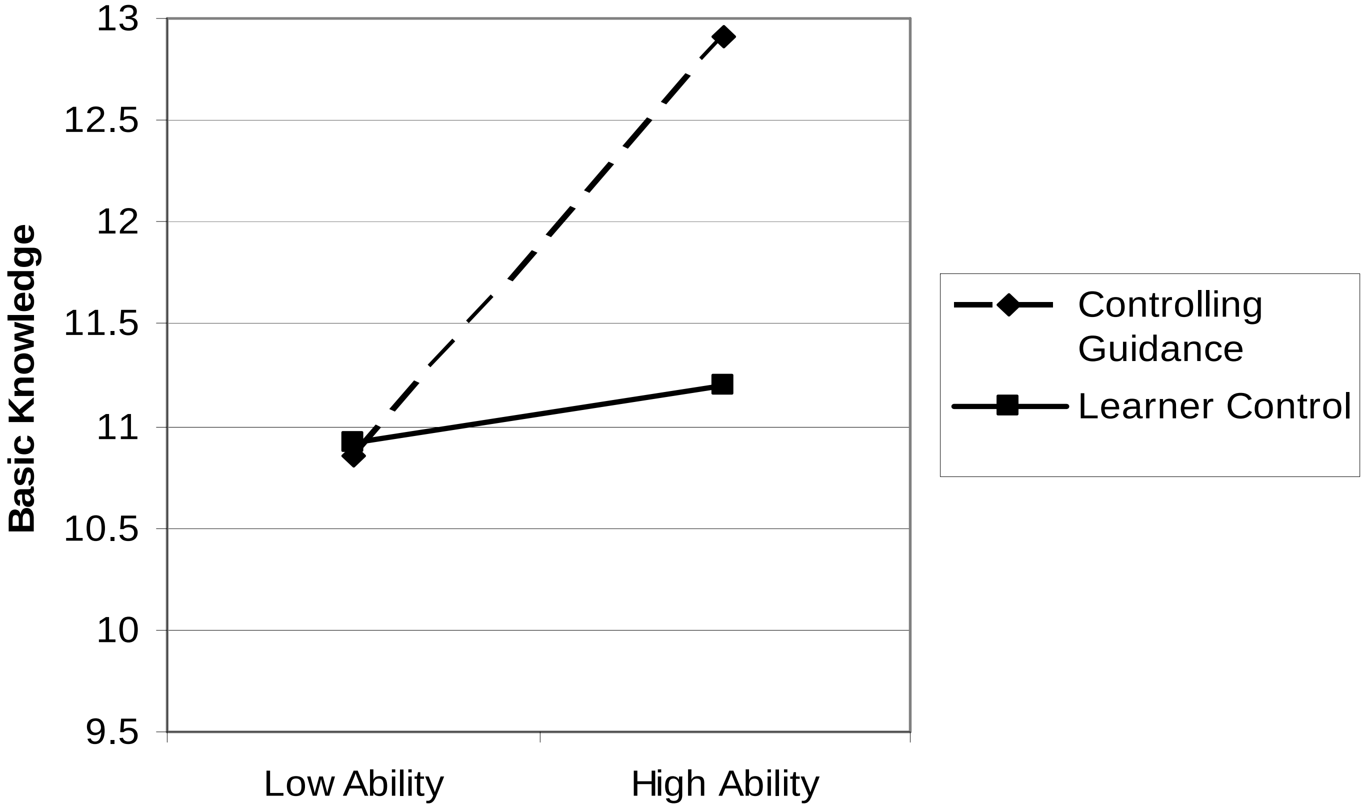


Figure 3
Interactive Effect of Autonomy-Supporting Guidance and Motivation to Learn on Trainees' Strategic Performance During Training

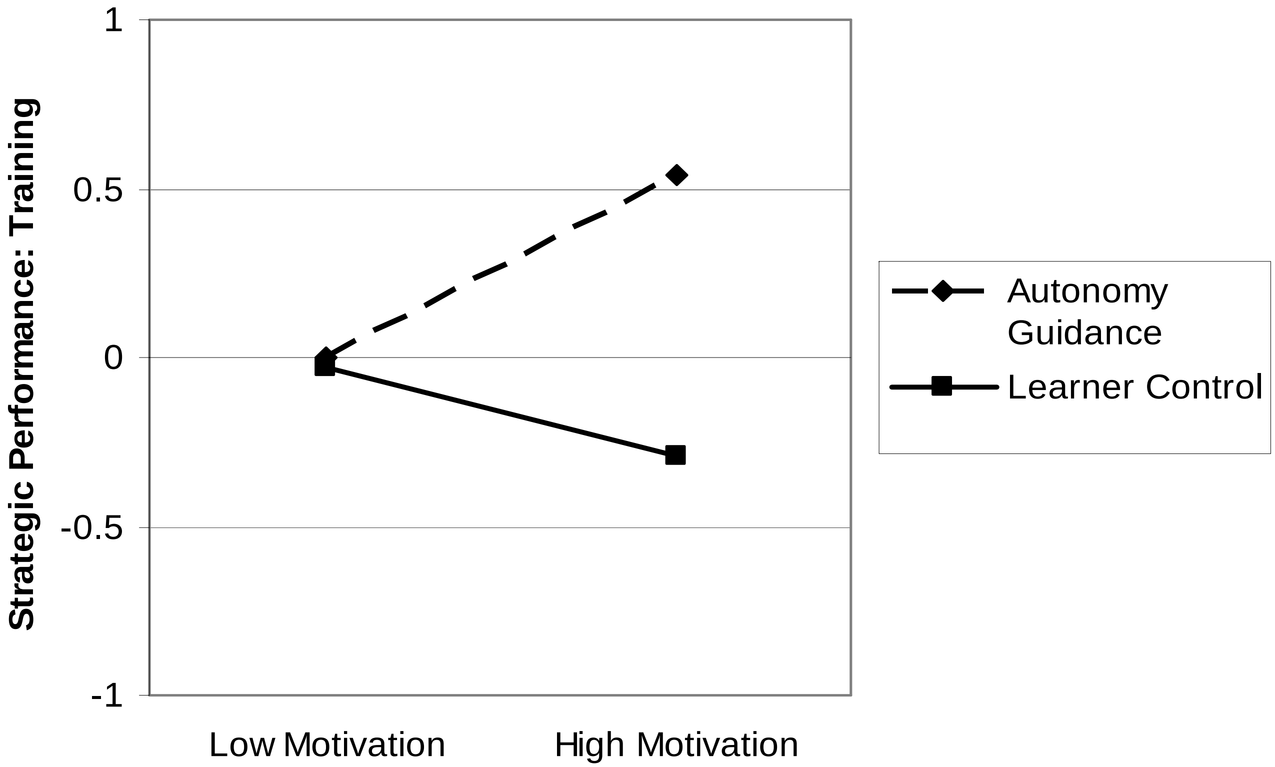


Figure 4
Interactive Effect of Autonomy-Supporting Guidance and Motivation to Learn on Trainees' Basic Performance During Generalization

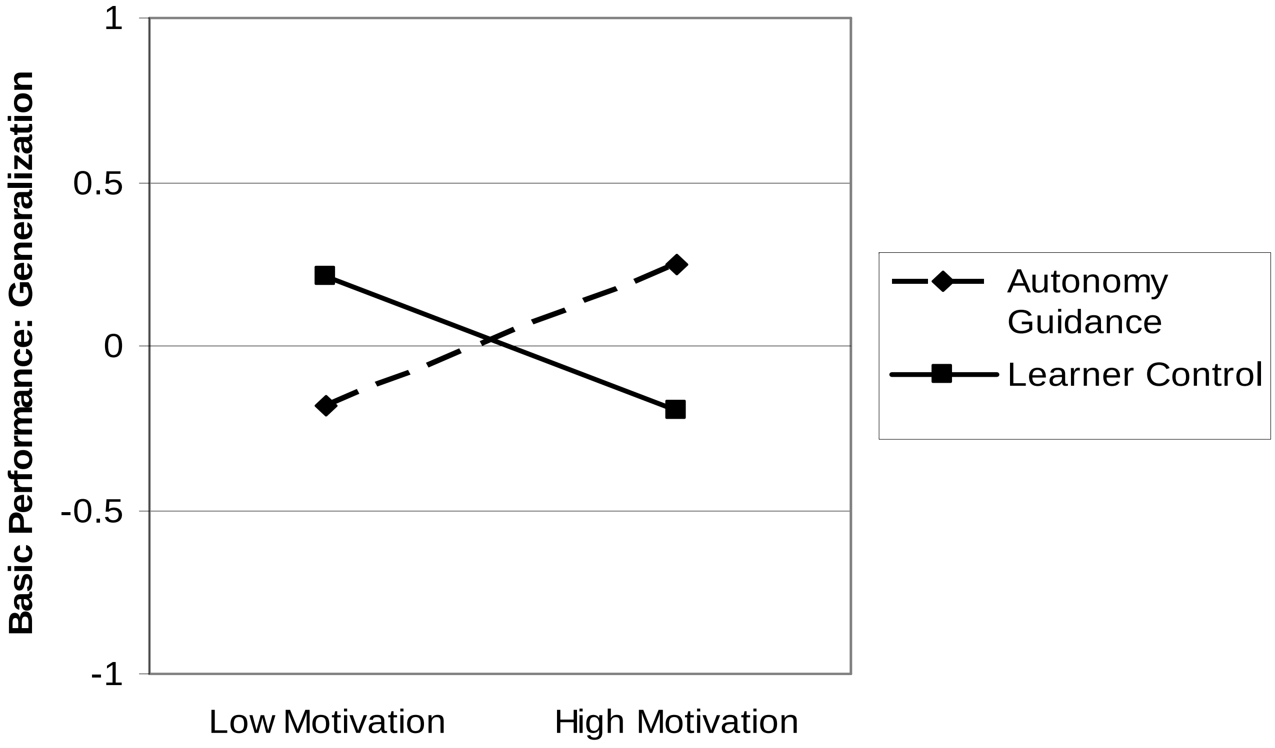


Figure 5
Interactive Effect of Controlling Guidance and Motivation to Learn on Trainees' Basic Performance During Training