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A Multilevel Analysis of the Effect of Prompting Self-Regulation
in Technology-Delivered Instruction

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Abstract

Two studies were conducted to examine the effect of prompting self-regulation, an intervention designed to improve learning from technology-delivered instruction. In Study 1, trainees who were prompted to self-regulate gradually improved their declarative and procedural knowledge over time, relative to the other conditions, whereas test scores declined over time for trainees who were not prompted to self-regulate. In Study 2, basic performance remained stable over time and strategic performance improved over time for trainees who were prompted to self-regulate, relative to the other conditions, whereas performance declined over time for trainees who were not prompted to self-regulate. Trainees' cognitive ability moderated the effect of the prompts on basic performance and task specific self-efficacy moderated the effect of the prompts on strategic performance. Prompting self-regulation resulted in stronger performance gains over time for trainees with higher ability or higher self-efficacy. These results demonstrate prompting self-regulation improved performance over time, relative to the other conditions, in both online, work-related training and laboratory settings. The results are consistent with theory suggesting self-regulation is a dynamic process that has a gradual effect on performance and highlight the importance of using a within-subjects design in self-regulation research.

Keywords:

Self-regulation

Cognitive ability

Self-efficacy

Technology-delivered instruction

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Self-regulation may be employees' most essential asset (Porath & Bateman, 2006) and is crucial for learning from technology-delivered instruction (Bell & Kozlowski, 2002a). Self-regulation is a process that enables individuals to guide their goal-directed activities over time and across changing circumstances, including the modulation of thought, affect, and behavior (Karoly, 1993). Technology-delivered instruction tends to provide trainees with more control over their learning experience than traditional classroom instruction (Sitzmann, Kraiger, Stewart, & Wisher, 2006), and failure to self-regulate may be one reason trainees frequently make poor instructional use of the control they are given (Bell & Kozlowski, 2002a; DeRouin, Fritzsche, & Salas, 2005; Kraiger & Jerden, 2007). Often trainees do not accurately assess their current knowledge levels, do not devote enough effort to training, and make poor decisions about learning, resulting in deficiencies in performance (Brown, 2001; DeRouin et al., 2005; Kanfer & Ackerman, 1989; Sitzmann, Ely, Brown, & Bauer, 2008). Thus, research is needed to identify strategies to assist trainees in effective self-regulation during technology-delivered instruction.

One strategy involves the use of prompts or questions designed to encourage self-regulatory activities, such as self-monitoring of learning behaviors and self-evaluation of learning progress (Corliss, 2005; Keith & Frese, 2005; Toney, 2000). Self-regulation prompts ask trainees questions about whether they are setting goals, using effective study strategies, and making progress towards their goals in order to encourage self-regulation during training. There is theoretical evidence to suggest that this intervention should be an effective means of enhancing knowledge and performance (Kanfer & Ackerman, 1989; Winne, 1996). However, prior studies have either failed to empirically demonstrate a positive effect for prompting self-

regulation on trainee achievement (Corliss, 2005; Keith & Frese, 2005; Toney, 2000) or reported inconsistent findings for prompting self-regulation across multiple indicators of learning (Kauffman, 2004; Kohler, 2002). Keith and Frese (2005), for example, examined whether the effect of error management training could be improved by encouraging trainees to engage in metacognitive activities (i.e., set goals, develop strategies, and self-evaluate) during training. They found encouraging metacognitive activity did not enhance the effectiveness of error management training on transfer performance. These results may be due, in part, to the fact that prior research has relied on the use of a between-subjects design. This design treats the effects of the prompts as static and does not capture performance trajectories over time. Self-regulation is a continuous process that unfolds over time as trainees set goals for increasing knowledge, evaluate and select strategies that balance progress towards their goals against unwanted costs, maintain emotion control, and monitor progress towards their goals (Butler & Winne, 1995; Kanfer & Ackerman, 1989). In addition, Kanfer and Ackerman (1996) suggest that the self-regulatory processes that are critical for learning differ in the early and later stages of skill acquisition. Accordingly, a better understanding of the utility of prompting self-regulation may be achieved by adopting a within-person perspective that models the effects of the prompts on knowledge and performance over time.

In the current paper, we present two studies that tested the effect of an intervention designed to stimulate self-regulation during technology-delivered instruction. These studies address several gaps in the literature. First, we utilize a within-subjects design to examine whether the effects of prompting self-regulation on knowledge and performance change over time. Given the unfolding and iterative nature of self-regulation, we predict that the effects of the prompts will increase throughout training. Second, we examine whether prompting self-

regulation is equally effective for enhancing multiple indicators of learning, namely basic (i.e., declarative and procedural) and strategic (i.e., tacit) performance. The focus on multiple indicators of learning allows us to examine whether the effects of the prompts generalize across tasks that require different types of knowledge and skills. Third, we test the effect of the self-regulation prompts in both field and laboratory settings and across diverse training content. This two study approach allows us to demonstrate both the internal and external validity of the intervention. In Study 1, we examine the effect of the prompts in an online course for working adults where trainees were dispersed across the United States and completed the course on their own time and in a location of their choice. In addition, the training course taught declarative and procedural knowledge across a series of modules that each covered relatively independent information. In Study 2, we examine the effect of the prompts in a laboratory setting in order to maintain tight control over the experimental manipulation and to ensure changes in performance over time can be attributed to the self-regulation prompts. This training program taught an integrated set of concepts, skills, and strategies needed to perform a complex, dynamic computer simulation. Finally, several recent studies (e.g., Donovan & Williams, 2003; Yeo & Neal, 2004) suggest that individual differences influence trainees' learning and self-regulatory processes over time. Building on this stream of research, in Study 2 we hypothesize and test two aptitude-treatment interactions to examine whether individual differences moderate the effect of prompting self-regulation. In the following section, we present an overview of self-regulation theory. We then consider the effect of prompting self-regulation on performance during technology-delivered instruction.

Self-Regulation Theory

Self-regulation is an essential mechanism for changing both the proportion of cognitive resources engaged and the proportion devoted to on-task rather than off-task activities during training (Kanfer & Ackerman, 1989). In the first phase of self-regulation, trainees clarify the task, generate goals, and develop plans for reaching their goals (Winne, 1996). They examine the breadth of information they believe is relevant to the course, assess their motivation and aptitude for the course, and identify obstacles that may prevent them from completing the course. This creates a multidimensional profile of the situation and person factors that could be used to approach training. Once committed to a task, trainees motivate and guide themselves by setting goals for increasing their knowledge levels (Bandura & Locke, 2003). Setting goals enhances learning via directing attention towards goal-related activities, increasing task effort and persistence, and leading to the discovery and use of task-relevant knowledge and strategies (Locke & Latham, 2002). Trainees then choose strategies that maximize progress towards their goals and minimize unwanted costs (Butler & Winne, 1995).

The second phase of self-regulation involves applying the chosen tactics and strategies to reach one's goals (Winne, 1996). Self-monitoring and self-evaluation are essential to this stage of self-regulation. Self-monitoring is the allocation of attention to specific aspects of one's behavior as well as the consequences of the behavior and self-evaluation is a comparison of trainees' current performance with their desired goal state (Kanfer & Ackerman, 1989). Trainees receive self-generated and external feedback as they attempt to reach their goals, and the most effective learners develop idiosyncratic routines for continuously generating internal feedback during training (Butler & Winne, 1995). Feedback aids self-evaluation as trainees judge whether their progress matches the standards they set for successful learning. Trainees then continuously monitor their progress on the task to gauge the extent to which information has been

comprehended and whether information that has been comprehended will be retained (Winne, 1995; 1996). Finally, they apply remedial strategies for addressing gaps in learning. Thus, self-regulation is a series of volitional episodes that, in aggregate, are characterized by a recursive flow of goals and strategies that ultimately determine performance (Butler & Winne, 1995).

Although self-regulation has been conceptualized as a dynamic process, prior research has generally treated the effects of self-regulation as static or stable over time (e.g., Keith & Frese, 2005; Kozlowski & Bell, 2006; Schmidt & Ford, 2003). However, a few studies have tested components of self-regulation theory using a within-subjects design, providing preliminary evidence that self-regulatory processes vary over time (e.g., Donovan & Williams, 2003; Ilies & Judge, 2005; Thomas & Mathieu, 1994, Yeo & Neal, 2004). Despite this emerging stream of research on self-regulation over time, our understanding of self-regulation at the within-person level remains limited. First, there are theoretical discrepancies regarding whether self-regulation demands attentional resources and, thus, is detrimental to performance when training is cognitive demanding. Kanfer and Ackerman (1989) argued that the engagement of self-regulatory processes (e.g., self-monitoring and self-evaluation) demands attentional resources, and learning may be compromised if working memory capacity is exceeded (Sweller, Van Merriënboer, & Paas, 1998). In contrast, DeShon, Brown, and Greenis (1996) proposed that self-regulation does not require significant attentional resources and may be an automatized process. Thus, we examined whether the self-regulation prompts should be implemented early in training, when the cognitive demands of training are generally at their peak, or whether they should be delayed until the later stages of training, when cognitive demands are generally lower. Second, previous work in this area has used relatively simple tasks that rely on previously learned information (e.g., brainstorming, Ilies & Judge, 2005) or tasks almost purely physical in

nature (e.g., athletics, Donovan & Williams, 2003). Thus, it is important to extend this stream of research to more complex knowledge and skill acquisition tasks that require ongoing learning and strategy development (Ilies & Judge, 2005). Third, it is important to identify strategies that can be used to enhance learning and performance over time. Prior research in this area has focused primarily on how individuals use goals over time in the self-regulation of performance (e.g., Donovan & Williams, 2003; Ilies & Judge, 2005; Kanfer & Ackerman, 1989). Building on this work, the self-regulation prompts encouraged trainees to set goals and evaluate goal-performance discrepancies, but also stimulated other self-monitoring and self-evaluation activities that may gradually increase knowledge as trainees progress through a course. Finally, researchers have suggested that models of self-regulation over time should be extended to include dispositions as predictors of variation in performance at the within-person level (Ilies & Judge, 2005; Yeo & Neal, 2004). Thus, in the current study we examined whether trainees' cognitive ability and self-efficacy moderated the effect of the self-regulation prompts on performance over time. In the following section, we review prior research on prompting self-regulation and use self-regulation and cognitive load theories to develop the hypotheses that were tested in the current research.

Prompting Self-Regulation

Prior research suggests trainees often fail to make effective use of the learner control inherent in technology-delivered instruction (Reeves, 1993). Trainees are often poor judges of what or how much they need to study and practice and typically withdraw from instruction before they have learned all of the material (Bell & Kozlowski, 2002a; Brown, 2001). Therefore, it is critical to identify interventions that can help trainees self-regulate and make better decisions during technology-delivered instruction. Accordingly, self-regulation prompts are designed to

encourage trainees to recognize whether information has been comprehended, gauge the extent to which information that has been comprehended will be retained, and trigger remedial procedures for filling in gaps in learning.

Two cognitive processes are essential for self-regulation and are prompted in the current study: self-monitoring and self-evaluation (Kanfer & Ackerman, 1989; Kozlowski & Bell, 2006). Self-monitoring is the allocation of attention to specific aspects of one's behavior as well as the consequences of the behavior. It occurs in response to internal or external prompts and generates feedback that can guide further action (Butler & Winne, 1995). Self-monitoring directs trainees' mental resources towards the training program and ensures they are setting goals and developing strategies to reach their goals. In the current study, self-monitoring is prompted by asking trainees to examine whether their behaviors are effective for learning the training material.

Self-evaluation is the comparison of trainees' current performance with their desired goal state (Kanfer & Ackerman, 1989). Strategies must be used to reduce discrepancies between goals and performance. When their behavior is not enabling them to reach their goals, trainees can use self-monitoring to form new goals or to develop strategies to help them reach their current goals. Self-evaluation is prompted in the current study by asking trainees to compare their current performance with their training goals.

Several studies have prompted self-regulation in an attempt to enhance learning outcomes, but these studies have produced inconsistent or equivocal findings (Corliss, 2005; Kauffman, 2004; Keith & Frese, 2005; Kohler, 2002; Toney, 2000). A common feature of these studies is the use of a between-subjects design, which treats the effect of the prompts on learning as stable over time. Because self-regulatory processes unfold over time, the effect of the intervention may be more gradual than immediate. Indeed, Keith and Frese (2005) proposed that

the practice phase in their study may have been too short to see the beneficial effects of self-regulatory processes, suggesting the effects of self-regulation are more likely to be detected if modeled over time. Thus, a within-subjects design should be used to examine the potential for gradual, intraindividual changes in performance as trainees are prompted to self-regulate. The first hypothesis is:

H1: Prompting self-regulation will have a gradual, positive effect on performance over time. Relative to the control condition, performance will improve over time when trainees are prompted to self-regulate.

The timing of administering the prompts may be an important consideration when designing and implementing the self-regulation intervention, given discrepancies in the literature regarding whether self-regulation requires cognitive resources (DeShon et al. 1996; Kanfer & Ackerman, 1989). If self-regulation is cognitively demanding, researchers must consider the cognitive resource requirements of the training situation when deciding whether it is prudent to encourage trainees to self-regulate. The cognitive demands of a situation are influenced by numerous factors, including the information processing demands of the task (Kanfer & Ackerman, 1989) and the training environment (Sweller et al., 1998).

Information processing demands are generally greatest early in skill acquisition, before knowledge is compiled (Kanfer & Ackerman, 1989). Thus, self-regulatory activity early in training may hinder performance by diverting attention away from the task (Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994). As a result, Kanfer and colleagues suggest that it may be prudent to induce self-regulation later in training, after trainees have acquired a basic understanding of the task and resource demands are reduced.

Cognitive load theory suggests trainees need to develop a schema for navigating the instructional environment as well as for the instructional content, but doing both simultaneously imposes cognitive load that can interfere with learning (Clarke, Ayres, & Sweller, 2005; Sweller et al., 1998). Clarke et al. (2005) examined the effect of the timing of learning technology skills (using a spreadsheet) and learning mathematical concepts on training performance. Trainees who were more experienced with spreadsheets had lower cognitive load and benefited from being taught spreadsheets and mathematics skills simultaneously. In contrast, trainees who were unfamiliar with spreadsheets learned more when the spreadsheet component of the course was taught before they learned mathematics skills. Related research by Eveland and Dunwoody (2001) found, on average, cognitive load is greater for Web-based than paper-based instruction. However, among trainees who were familiar with the Web, cognitive load did not differ across the delivery media. This suggests that along with the course content, learning to navigate the training environment may place cognitive demands on trainees, and trainees may need time to familiarize themselves with the training environment before they are able to master the course content. Thus, the cognitive demands of the training environment along with the training content may need to be considered when deciding when to implement the self-regulation prompts. Study 1 examined whether the prompts should be implemented at the beginning or mid-training in a Web-based tutorial where relatively independent information was taught in each module. Study 2 examined whether the prompts should be implemented before or after the knowledge compilation stage during complex skill acquisition.

However, several researchers have questioned the extent to which engaging in self-regulation requires attentional resources. DeShon et al. (1996) used a dual-task methodology to measure the attentional resource requirements of goal-oriented self-regulation. They concluded

that self-regulation does not require significant attentional resources and may be an automatized process. Further, Winters and Latham (1996) argued that Kanfer and Ackerman's (1989) findings were due to trainees' goals focusing on performance rather than learning, thereby diverting attention from the learning process (see also Locke & Latham, 2002). They demonstrated that when given a complex task that required the development of task strategies, trainees provided learning goals outperformed trainees provided do-your-best or outcome (i.e., performance) goals.

To test these competing perspectives, we included three conditions in the current studies: immediate self-regulation, delayed self-regulation, and control. In the immediate condition, trainees were prompted to self-regulate throughout the entire course. Trainees in the delayed condition were only prompted to self-regulate in the latter half of the course, when the attentional demands of the training environment (Study 1) and training task (Study 2) should be reduced. Based on prior research demonstrating the importance of self-regulation for learning in technology-delivered instruction (Bell & Kozlowski, 2002a; Kozlowski & Bell, 2006), we expect both the immediate and delayed self-regulation conditions will lead to gradual improvements in knowledge and performance over time, relative to the control condition. However, the research reviewed above is inconclusive with respect to the benefits of prompting self-regulation when the attentional demands of the course are high (i.e., early in training). Thus, we test the following research question:

Q1: Does prompting trainees to self-regulate at the beginning of training impair performance?

STUDY 1

Study 1 used an experimental design to model the effect of prompting self-regulation on declarative and procedural knowledge across 10 Web-based training modules and examined whether the effect of the prompts differed for the immediate and delayed self-regulation conditions. The training was similar to many online courses in that trainees were geographically dispersed and participated on their own time and in a location of their choice. Thus, Study 1 provided baseline evidence for the effect of the prompts on declarative and procedural knowledge and assessed the external validity of the effect among working adults. Study 2 used a tightly controlled laboratory experiment and assessed the internal validity of the intervention, extended the findings to strategic performance, and examined whether individual differences moderated the effect of the prompts.

Method

Participants

Ninety-three working adults were recruited online and received free training in exchange for research participation. The majority of participants were instructors at a university or community college (85%), and participants were highly educated (24% had a Ph.D. or M.D. and 48% had a master's degree). The average age of participants was 44 years and 66% were female.

Experimental Design and Procedure

Participants completed an online course on how to use the Blackboard Learning System™. Blackboard allows trainers to perform instructional activities online such as disseminating handouts and readings to students, creating tests, maintaining gradebooks, and organizing chat rooms.

The training consisted of 10 modules with text covering declarative knowledge and videos demonstrating the functions that can be performed in Blackboard. Within each module,

the lecture and videos covered interrelated material. For example, in the chat room module, the slides explained the purpose of the chat tool and its functions and one of the videos demonstrated how to create a chat room session. Although the modules each covered a different feature of Blackboard, there was some overlap in the steps required for using the various features. For example, the first step in many of the videos focused on locating the appropriate feature on the control panel. Thus, as trainees became familiar with the control panel, they should have begun to automate the location of each of the features and the requirements for navigation, reducing the attentional requirements of the training environment.

Trainees were given a high level of control over the pace of instruction; they could choose the amount of time spent on each training module and complete the course in a single day or spread it out over several weeks.¹ However, trainees were informed that there would be a test on all of the material at the end of training, and they were required to review all of the modules in a predetermined order before taking the test. After reviewing the 10 modules, trainees completed a test to assess their knowledge of the material.

Before beginning the course, trainees were randomly assigned to one of three self-regulation conditions (i.e., immediate, delayed, and control) based on the order in which they signed up to participate. Two components of self-regulation—self-monitoring and self-evaluation—were prompted by having trainees reflect on questions during training. Ten self-monitoring and 10 self-evaluation questions were modified based on previous research (Kauffman, 2004; Kohler, 2002; Toney, 2000; see Appendix for questions). Self-monitoring questions asked trainees whether they were allocating their attention to learning the training material and assessing the consequences of their behavior, whereas self-evaluation questions

¹ We used HLM and examined whether days required to complete the course moderated the self-regulation slope. The results indicated the effect of the prompts on declarative and procedural knowledge did not differ according to completion times.

asked trainees to compare their current knowledge and skills with their training goal. As an incentive, all trainees were told that if they correctly answered at least 16 out of 20 test questions, they would receive a Blackboard training certificate and a copy of the certificate would be sent to the human resources department at their school or organization.

Trainees in the immediate self-regulation condition received information on the desired level of performance at the beginning of training and were told, “This is a good time to tell you research has shown that asking yourself questions about whether you are concentrating on learning the training material will increase your performance on the test following training. The training program will periodically ask you questions about where you are directing your mental resources and whether you are making progress towards learning the training material. Honestly respond to these questions and use your responses to decide how to allocate your review time.” One self-monitoring and one self-evaluation question were presented on the computer screen at the end of each of the training modules, and trainees answered the questions using a 5-point scale ranging from strongly disagree (1) to strongly agree (5).

In the delayed self-regulation condition, trainees received the same message as the immediate condition indicating self-regulation increases learning. However, they received this information after reviewing five training modules in order to give them time to familiarize themselves with the instructional environment. Following modules 5 through 10, trainees were asked the same self-regulation questions as the immediate condition. Finally, trainees in the control condition were not asked questions to prompt self-regulation and were not told that self-regulation increases learning.

Trainees were asked to respond to the self-regulation prompts to ensure they were contemplating whether they were concentrating on learning the training material and considering

whether they were making progress towards their training goal. Thus, the purpose of having trainees answer the prompts questions was to ensure they were paying attention to the questions, not to gather data on whether the prompts were working. Responses to the prompts questions were not used in any of the analyses because they do not indicate the level of self-regulatory activity. For example, one of the prompts questions is “Do I understand all of the key points of the training material?” A response of strongly agree is desirable if the trainee is knowledgeable about the material, and a response of strongly disagree is desirable if the trainee realizes the need to concentrate more on learning the material. Yet, in each case the question achieves the same objective—to prompt trainees to evaluate their current level of understanding. Thus, responses to the question indicate different levels of understanding, but not different levels of self-evaluation activity. Accordingly, we compared differences in cognitive knowledge trends across training conditions in order to determine the effect of prompting self-regulation.

Knowledge Assessment

Trainees completed an exam at the end of the course to assess knowledge of the content covered in each of the 10 training modules. Declarative knowledge was assessed with 10 multiple-choice questions with four response options per question, and procedural knowledge was assessed by having trainees log in to Blackboard and perform 10 of the skills demonstrated in the training videos. Within each of the modules, there was a strong correspondence between the declarative and procedural material covered on the exam. For example, to assess knowledge of the chat room module, trainees created their own chat room session and were asked a multiple-choice question regarding the options available for managing users in a chat room. Each of the test questions was worth 1 point, and trainees received a fraction of a point for correctly performing a facet of a multipart task. For example, trainees were asked to create a Lightweight

Chat session, name the session “Review for Test,” and make the session available from August 1 until September 2. Creating the session, naming the session, and making the session available for the correct dates were each worth one-third of a point. Two test questions were used to assess knowledge of each of the training modules, and responses to questions assessing knowledge of the same module were averaged. Across the 10 modules, the average score was 14.66 ($SD = 2.43$) questions correct.

Analytic Strategy

In the current study, we were not interested in changes in knowledge over time, but rather differences in knowledge trends over time for the three self-regulation conditions. Thus, before analyzing the results, we standardized the test scores for each of the 10 modules. Standardizing the results removed true changes in knowledge over time, but allowed us to compare differences in performance trends across conditions and controls for differences in test difficulty across modules. It also resulted in a common scale across performance indicators, permitting us to compare the results across the two studies and across basic and strategic performance in Study 2.

Next, a one-way ANOVA, the analysis technique used in previous prompts research (e.g., Corliss, 2005; Toney, 2000), was used to test for differences in test scores across the three self-regulation conditions. This allowed a comparison of the current results with prior, between-subjects research on prompting self-regulation.

Hierarchical linear modeling (HLM) with full maximum likelihood estimates was used to analyze the within-subjects results using the procedure recommended by Bliese and Ployhart (2002) and Singer and Willett (2003). We ran a series of models to analyze changes in knowledge across the 10 training modules. First, we ran the unconditional means (null) model to examine the variance in test scores before accounting for any predictors. This model allowed for

the calculation of an intraclass correlation coefficient, which partitions the variance in test scores into within- and between-person components.

Our second model assessed the effect of prompting self-regulation on knowledge over time with a discontinuous growth model (Singer & Willett, 2003, pp. 189-208). A discontinuous growth model allows one to specify the functional form of the data based on theory. In the current study, we proposed that prompting self-regulation would result in a gradual increase in test scores across the 10 training modules. In order to test this assumption, we compared the fit of the data to four theoretically driven models: continuous, mean, plateau, and early decrement. These models are each entered in the equation as a level one predictor of test scores.

The first model represents a continuous effect, such that test scores improve over time as trainees are prompted to self-regulate and the improvement continues until the end of training. The continuous effect model is consistent with self-regulation theory suggesting self-regulation has a gradual, positive effect on learning over time (Winne, 1996). The continuous effect slope was coded 0, 1...8, 9 for the immediate self-regulation condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 5 for the delayed condition. The zeros for the first five modules indicate that trainees would not exhibit improvement in their test scores over time, relative to the other conditions, before they were prompted to self-regulate. However, test scores should gradually increase over time in the latter half of the course as trainees are prompted to self-regulate.

The second model represents a mean effect, such that test scores increase when the self-regulation prompts are implemented and the effect of the prompts is stable across all subsequent modules. The mean effect model is consistent with previous research using a between-subjects design that focuses on mean differences across self-regulation conditions (Kauffman, 2004; Kohler, 2002). The mean effect slope was coded 1 for all 10 modules for the immediate self-

regulation condition, suggesting the effect of the prompts is stable over time. In the delayed condition, the mean effect slope was coded 0, 0, 0, 0, 0, 1, 1, 1, 1, 1.

The plateau model is a slight variation of the continuous effect model, and suggests the effect of the prompts levels off after several modules. This is consistent with Norman and Bobrow's (1975) performance-resource function that indicates that increasing attention will result in improvements in performance, but eventually attention will be optimized and performance levels will stabilize. The plateau effect model was coded 0, 1, 2, 3, 4, 4, 4, 4, 4, 4 for the immediate condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 4 for the delayed condition.

Finally, the early decrement model tested whether prompting self-regulation impaired test scores at the beginning of training (Kanfer & Ackerman, 1989). It was coded -2, -1, 0, 1, 2, 3, 4, 5, 6, 7 for the immediate condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 5 for the delayed condition. The coding for the immediate condition suggests test scores at the beginning of training are below average, but gradually increase over time. For all four models, the control condition slope was coded 0 for all 10 modules because these trainees were not prompted to self-regulate.

The Akaike Information Criterion (AIC; Akaike, 1974) and Bayesian Information Criterion (BIC; Schwarz, 1978) were used to compare the fit of the data to the four models. These fit indices can be compared for any set of models, regardless of whether one is nested in the other, as long as all of the models are fit to identical data. For both of these indices, smaller numbers indicate the model is a better fit for the data. After identifying the best fitting model, we graphed the results by fitting the actual data points to the predicted model.

Results

The first analysis assessed whether prompting self-regulation had a significant effect on average test scores at the between-subjects level. Standardized test scores were highest for the

immediate ($M, SD = 0.05, 0.35$), followed by the delayed ($M, SD = -0.02, 0.41$) and control conditions ($M, SD = -0.06, 0.42$). However, one-way ANOVA results indicated there was not a significant difference in test scores across the three self-regulation conditions ($F(2,90) = .78, p > .05, \eta^2 = .02$). Thus, we used HLM to assess if prompting self-regulation had a gradual effect on test scores over time.

First, we ran the unconditional means model to examine the variability in learning without any predictors in the model. The intraclass correlation coefficient was .06, which indicates that 6% of the variance in test scores was between-persons whereas 94% of the variance was at the within-person level. In addition, there was significant within- and between-person variability ($\sigma_e^2 = 0.930$ and $\sigma_0^2 = 0.060, p < .05$).

Second, we compared the model fit of the continuous, mean, plateau, and early decrement models (see Table 1). The AIC and BIC were smallest for the plateau effect, indicating test scores gradually improved over time after the prompts were implemented and the effect leveled off and remained stable after several modules. In addition, the plateau was the only model where the fixed effect was statistically significant ($\gamma = .047$). In the immediate self-regulation condition, test scores slightly improved across modules one through four and then leveled off and were .08 standard deviations above average for modules 5 through 10 (see Figure 1). The delayed condition's test scores drastically increased when the self-regulation prompts were implemented. Their test scores were .09 standard deviations below average in modules one through five, but increased to .22 standard deviations above average by the end of the course. The control condition's test scores declined during training and were .18 standard deviations below average by the end of the course. Test scores in the immediate and delayed conditions exceeded those of the control by .26 and .40 standard deviations, respectively, by the end of

training. Thus, the results support Hypothesis 1 and suggest prompting self-regulation has a positive effect on learning over time, relative to the control. Moreover, there was significant variability across trainees in the effect of the self-regulation prompts on test scores, indicating there are moderators of the effect of prompting self-regulation.

Note that the early decrement effect was not statistically significant and the fit indices indicated it provided one of the worst fits to the data of the four models tested. Thus, these results do not suggest that prompting self-regulation was detrimental for learning at the beginning of training, when cognitive load is generally greatest.

Discussion

Study 1 examined the effect of prompting trainees to self-regulate on changes in declarative and procedural knowledge over time as working adults progressed through a 3-hour online training course. Overall, the results indicated prompting self-regulation had a positive effect on learning over time, relative to trainees who were not prompted to self-regulate. This is consistent with theory that suggests self-regulation is an unfolding, iterative process, and within-subjects designs are more likely to detect the effect. The results also indicated prompting self-regulation did not impair learning at the beginning of a self-paced tutorial.

STUDY 2

Study 1 provided support for the positive effect of prompting self-regulation on cognitive knowledge over time, but it is important to examine whether the results generalize across tasks that require different types of knowledge and skills. Thus, in Study 2 we examine whether the beneficial effect of prompting self-regulation differs for basic and strategic performance as trainees learn a complex, dynamic task. Basic performance refers to the extent to which a trainee has learned the fundamental principles and operations of a task and includes both declarative and

procedural knowledge (Ford & Kraiger, 1995; Tennyson & Breuer, 1997). The first study demonstrated the positive effect of the prompts on basic performance. Strategic performance refers to the extent to which a trainee has learned the underlying or deeper complexities of a task. It includes information on where, when, why, and how to apply one's knowledge and skills, and this information has been identified as critical for adaptive performance (Ford & Kraiger, 1995; Gagné & Merrill, 1992; Tennyson & Breuer, 1997). Several recent studies (e.g., Bell & Kozlowski, 2008; Kozlowski & Bell, 2006), have shown that trainees' self-evaluation activity is a significant, positive predictor of strategic performance. Thus, we expect that the positive effect of prompting self-regulation will generalize to strategic performance and test this hypothesis in Study 2 using a complex, dynamic task.

The results of Study 1 also indicated that there was significant variability in the effect of prompting self-regulation across trainees. This suggests that additional research is needed to identify aptitude-treatment interactions that may provide insight into the types of trainees that are most likely to benefit from the self-regulation prompts. In the section below, we discuss the aptitude-treatment interactions that were examined in the current study.

Moderating Effects of Individual Differences

A growing body of research has identified individual differences as predictors of trainees' self-regulatory activities (e.g., Chen, Gully, Whiteman, & Kilcullen, 2000; Payne, Youngcourt, & Beaubien, 2007) and moderators of the effect of self-regulation on performance over time (e.g., Donovan & Williams, 2003; Kanfer & Ackerman, 1989; Yeo & Neal, 2004, 2008). However, few studies have adopted an aptitude-treatment interaction approach in self-regulation research by manipulating aspects of the training environment and examining whether they interact with individual differences. One example is Schmidt and Ford (2003), who encouraged

trainees to engage in metacognitive activity during training and provided learners with 10 minutes of instruction on metacognition at the start of training. The metacognitive intervention interacted with performance-avoid goal orientation, such that the positive effect of the intervention on metacognitive activity was greater for trainees with a low performance-avoid orientation. In addition, Kanfer and Ackerman (1989) demonstrated that goal setting had a positive effect on performance when the cognitive demands of training were low, but the effect was moderated by trainees' cognitive ability. In training conditions with high cognitive demands, goal setting was detrimental for trainees with low cognitive ability. In training conditions with low cognitive demands, the effects of goal setting were more beneficial for trainees with low rather than high cognitive ability. In an effort to build on this emerging stream of research, the current study examined whether trainees' cognitive ability and task specific self-efficacy moderated the effect of prompting self-regulation on performance over time.

Cognitive ability. Cognitive ability refers to an individual's intellectual capacity and has been shown to be a strong predictor of learning (Colquitt, LePine, & Noe, 2000; Ree & Earles, 1991). In addition to being able to absorb and retain more information than lower ability trainees, higher ability trainees may be more capable of managing their own learning and using self-regulation to increase their knowledge and performance. Snow (1986) suggested higher ability trainees benefit from relatively unstructured environments that provide room for independent learning, whereas lower ability trainees require more tightly structured environments. Gully, Payne, Koles, and Whiteman (2002) provided evidence that individuals higher in cognitive ability are more capable of diagnosing and learning from errors than individuals lower in cognitive ability. Bell and Kozlowski (2002b) found higher ability trainees benefited more than lower ability trainees from the adaptive response pattern associated with a mastery orientation,

which includes a greater degree of self-regulatory activity (Payne et al., 2007). Overall, these findings suggest that higher ability trainees may be more capable than lower ability trainees of effectively using self-monitoring and self-evaluative processes to increase their performance over time when prompted to self-regulate. Accordingly, we propose the following:

H2: Trainees' cognitive ability will moderate the effect of prompting self-regulation on performance. Prompting self-regulation will have a more positive effect on performance over time for trainees with higher rather than lower levels of cognitive ability.

Task specific self-efficacy. Task specific self-efficacy is one's belief in his or her capacity to perform a given task (Bandura, 1986). Trainees with higher self-efficacy are more likely than those with lower self-efficacy to develop effective task strategies (Locke & Latham, 2002). Self-efficacy also has a positive effect on the difficulty of self-set goals, task persistence, goal revision, and goal-striving behavior (Bandura, 1997). Self-efficacy is an important affective component of self-regulation because trainees who hold stronger self-efficacy beliefs are more likely to set high standards for themselves following goal attainment and are more resilient when they receive negative feedback (Bandura, 1997; Bandura & Cervone, 1983). Trainees who do not possess adequate self-efficacy may physically or mentally disengage from training or adjust their goals downward when faced with goal-performance discrepancies.

In the current research, the self-regulation prompts were designed to enhance trainees' self-evaluation activity and, as a result, influence trainees' performance via task strategies, task persistence, and goal striving behavior. Whether trainees engage in activities to address perceived goal-performance discrepancies may depend on their self-efficacy. Trainees with higher task specific self-efficacy should be more likely to believe they are capable of successfully reaching their training goals and to use the self-regulation prompts to adjust their

training behavior. However, prompting self-evaluation activity among trainees with weaker self-efficacy beliefs may actually impair performance because the increased salience of goal-performance discrepancies may result in trainees withdrawing mentally or physically from the task to protect their competence image (Jones, 1989). Accordingly, we propose the following:

H3: Trainees' self-efficacy will moderate the effect of prompting self-regulation on performance. Prompting self-regulation will have a more positive effect on performance over time for trainees with higher rather than lower levels of task specific self-efficacy.

Method

Study 2 used an experimental design and multilevel modeling to assess the effect of prompting self-regulation on learning across nine training trials. It extended Study 1 by examining whether the effect of prompting self-regulation generalized to strategic performance and could be replicated in training that focused on complex skill acquisition. In addition, it examined whether trainees' cognitive ability and self-efficacy moderated the effect of the prompts on learning over time.

Participants

Participants were 171 undergraduate students from a large Northeastern university who received either course credit or \$30 for participating in a three-hour study.² The demographic makeup of the trainees was 55% female and 95.9% were 18 to 21 years old.

Training Simulation

The task used in this study was TANDEM (Weaver, Bowers, Salas, & Cannon-Bowers, 1995), a PC-based radar-tracking simulation. TANDEM is a dynamic and complex task, which

² Of the 171 trainees in Study 2, only 14 participants (8.2% of the sample) received the cash payment whereas 157 participants received course credit for participating in the study. Post hoc analyses revealed that the form of compensation did not have a significant main effect nor did it moderate the effects of the prompts on trainees' basic or strategic performance.

requires trainees to learn several basic and strategic skills. Basic skills involve “hooking” contacts on the radar screen, collecting information, and making decisions to classify the contact’s characteristics. Trainees needed to use this information to make an overall decision about the contact (take action/clear). Strategic skills involve preventing contacts from crossing two perimeters located on the radar screen. Trainees needed to learn how to identify the perimeters, monitor contacts approaching the perimeters, and determine their priority. Because the configuration of contacts is dynamic both within and across training trials, effective perimeter defense requires trainees to adapt their strategic skills to changes in the task environment.

Experimental Design and Procedure

Training was conducted in a single, 3-hour session. Trainees learned to operate the radar simulation described above during nine 10.5-minute training trials. Each trial consisted of a cycle of study, practice, and feedback. Participants had 3 minutes to study an online manual that contained information on all important aspects of the task followed by 5 minutes of practice. The nine trials all possessed the same general profile (i.e., same difficulty level, rules, number of contacts), but the configuration of contacts (i.e., location of pop-up contacts) was unique for each trial. After each practice trial, participants had 2.5 minutes to review veridical feedback on aspects of the task relevant to both basic and strategic performance.

Participants were randomly assigned to one of three experimental conditions: immediate self-regulation, delayed self-regulation, and control. These conditions were designed to mirror those utilized in Study 1. When the prompts were implemented, trainees in the immediate and delayed conditions received the same message used in Study 1 regarding the positive effects of self-regulation on performance and received a goal to maximize their performance by the end of

training. One self-monitoring and one self-evaluation question were then presented following the feedback sessions.³ These questions were presented on the computer screen, and participants answered each of the questions on a worksheet using a 5-point scale ranging from strongly disagree (1) to strongly agree (5). Trainees in the immediate self-regulation condition were prompted to self-regulate following all nine feedback sessions whereas trainees in the delayed condition were prompted to self-regulate following the feedback sessions for trials four through nine. The prompts were withheld following the first three trials for the delayed condition because previous research using TANDEM has shown that this is when trainees acquire basic knowledge and, therefore, the greatest resource demands are placed on trainees' cognitive resources (Bell & Kozlowski, 2002a).

Measures

Cognitive ability and demographic information was collected at the beginning of the experimental session. Task specific self-efficacy was measured early in training, following the third trial, to give trainees time to familiarize themselves with TANDEM. Basic and strategic performance were assessed using objective data collected by the simulation during each of the nine practice trials.

Cognitive ability. Cognitive ability was measured by having trainees report their highest score on the SAT or ACT. Research has shown that the SAT and ACT have large general cognitive ability components (Frey & Detterman, 2004), and the publishers of these tests report high internal consistency reliabilities for their measures (e.g., KR-20 = .96 for the ACT composite score; American College Testing Program, 1989). In addition, previous research has shown that self-reported SAT and ACT scores correlate highly with actual scores. Gully et al.

³Minor modifications were made to the prompts questions used in Study 1 to fit the training context in Study 2. We also randomly reordered the presentation of the questions across studies to ensure that the effect of the prompts was not dependent on a particular sequencing of the questions.

(2002) found self-report SAT scores correlated .95 with actual scores, and Cassady (2001) reported a correlation of .88. The majority of participants (86%) provided SAT scores. Thus, ACT scores were converted to SAT scores using a concordance chart provided by the College Board (Dorans, 1999).

Task specific self-efficacy. Self-efficacy was assessed with an 8-item self-report measure developed for use with TANDEM (Ford, Smith, Weissbein, Gully, & Salas, 1998; Kozlowski et al., 2001). A sample item is “I am certain I can manage the requirements of this task.” Trainees responded to the questions on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Internal consistency was .93.

Skill-based performance. Objective data collected by the simulation during each practice period were used to assess trainees’ basic and strategic performance across the nine training trials. The performance measures used in this study were established in previous research using the TANDEM simulation and have been shown to capture distinct dimensions of basic and strategic performance (Bell & Kozlowski, 2002a).

Basic performance involves trainees’ ability to collect information about the contacts and use this information to make appropriate engagement decisions. Thus, basic performance requires trainees to draw on their declarative and procedural knowledge. Trainees’ basic performance was calculated based on the number of correct and incorrect contact engagements during each training trial; 100 points were added to trainees’ scores for each correct contact engagement and 100 points were deducted for each incorrect contact engagement. Performance on this aspect of the task is driven by knowledge of basic task components (e.g., decision-making values and procedures).

Strategic performance focuses on trainees' ability to understand the deeper elements of the simulation and to develop two strategic skills: situational assessment and contact prioritization. Two elements of the task are relevant to the situational assessment: using the zoom function to alter the radius of the radar screen and locating and utilizing marker contacts to identify the location of an unmarked outer perimeter. Contact prioritization requires participants to gather information to determine which contacts constitute the greatest threats to the defensive perimeters and use this information to determine the order in which contacts should be pursued. To capture both situational assessment and contact prioritization, 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 the unmarked outer perimeter, and the number of high priority contacts processed during each practice trial. Each of these indicators was standardized and summed using unit weights to create a strategic performance composite.⁴

Data Analysis

The analysis strategy paralleled the analyses in Study 1. First, we standardized both basic and strategic performance for each of the nine trials in order to compare the results across the two studies and across basic and strategic performance. Next, a one-way ANOVA was used to test for differences in basic and strategic performance across the three self-regulation conditions. This allowed a comparison of the current results with prior, between-subjects research on prompting self-regulation. We then ran several level-1 HLM models for basic and strategic performance. For each outcome, the first model was an unconditional means model. Next, we

⁴To confirm that the basic and strategic performance indicators capture distinct dimensions of performance, we conducted a principal components factor analysis using varimax rotation on the indicators at trials 3, 6, and 9. In each case, a two factor solution emerged supporting the creation of separate basic and strategic performance composites. These results are available from the first author upon request.

used discontinuous growth modeling and compared the fit of the continuous, mean, plateau, and early decrement models.

After establishing the level-1 model, we added grand mean centered cognitive ability and self-efficacy as level-2 predictors to examine whether they moderated the intercept and self-regulation slope according to the procedure specified by Bliese and Ployhart (2002). These models allowed us to examine whether there are individual differences that explain variance in the effect of the self-regulation prompts on performance over time.

Results

First, we calculated the between-persons descriptive statistics and correlations for Study 2 measures (see Table 2). Basic and strategic performance were significantly correlated with both cognitive ability ($r = .20, .30$, respectively) and self-efficacy ($r = .49, .39$, respectively). Basic and strategic performance were moderately correlated ($r = .38, p < .05$).

Next, we ran a one-way ANOVA to examine if the self-regulation prompts had a significant effect on average basic and strategic performance at the between-persons level. The results indicated there was a significant difference in basic performance across the three conditions ($F(2,161) = 3.26, p < .05, \eta^2 = .04$). A comparison of means indicated that both the immediate ($M, SD = .08, .79$) and delayed self-regulation prompts conditions ($M, SD = .12, .65$) scored higher than the control ($M, SD = -.21, .69; t(113) = 2.07, t(99) = 2.47$, respectively, $p < .05$). However, the immediate and delayed self-regulation conditions did not significantly differ from one another with respect to basic performance ($t(110) = .27, p > .05$). Strategic performance scores were highest for the immediate ($M, SD = .15, .84$), followed by the delayed ($M, SD = -.01, .69$) and control ($M, SD = -.17, .66$) conditions, but one-way ANOVA results indicated there was

not a significant difference across the three self-regulation conditions ($F(2,161) = 2.54, p > .05, \eta^2 = .03$).

These results suggest that prompting self-regulation had an overall positive effect on basic but not strategic performance. This provides some support for the utility of prompting self-regulation to improve performance, but it is important to examine the effect of the self-regulation manipulation over time and to examine whether the effect of prompting self-regulation varies meaningfully based on individual differences.

Level-1 HLM Analyses

The unconditional means model examines variability in basic performance without any predictors in the model. The intraclass correlation coefficient was .47, which indicates that 47% of the variance in performance was at the between-person level whereas 53% of the variance was at the within-person level ($\sigma_e^2 = .525$ and $\sigma_0^2 = .469$).

Next, we compared the fit of the continuous, mean, plateau, and early decrement models for the basic performance data (see Table 1). The fit indices were smallest for the mean effect model, indicating prompting self-regulation resulted in basic performance increasing when the self-regulation prompts were implemented and the effect of the prompts was stable over time. In addition, the mean effect was the only model where the fixed effect was statistically significant ($\gamma = .231$). Figure 2 is a graph of the basic performance mean effect. The immediate self-regulation condition's performance was .08 standard deviations above average throughout training. The delayed condition performed at an average level before they were prompted to self-regulate. Their performance then improved to .21 standard deviations above average when the prompts were implemented. The control condition's performance declined during training and was .32 standard deviations below average by the end of the course. The immediate and delayed

conditions were outperforming the control by .40 and .53 standard deviations, respectively, by the end of training.

The ICC for strategic performance was .51, indicating that 51% of the variance in performance was at the between-persons level whereas 49% of the variance was at the within-person level. Once again, there was significant within- and between-person variability ($\sigma_e^2 = .492$ and $\sigma_0^2 = .502$).

The second model examined the effect of prompting self-regulation on the rate of change in strategic performance across trials by comparing the fit of the continuous, mean, plateau and early decrement models (see Table 1). The AIC and BIC were smallest for the plateau effect model, indicating the effect of prompting self-regulation on performance increased over time and leveled off and remained stable after several modules. In addition, the plateau was the only model where the fixed effect was statistically significant ($\gamma = .034$). In the immediate self-regulation condition, performance improved across trials one through four and then leveled off and was .16 standard deviations above average for trials five through nine (see Figure 3). The delayed condition's performance was .04 standard deviations below average in trials one through four, but increased to .11 standard deviations above average by the end of the course. The control condition's performance declined during training and was .25 standard deviations below average by the end of training. The immediate and delayed conditions were outperforming the control by .41 and .36 standard deviations, respectively, by the end of training. Thus, both the basic and strategic performance results support Hypothesis 1 and suggest prompting self-regulation has a positive effect on performance over time, relative to the control. Moreover, there was significant variability across trainees in the effect of the self-regulation prompts on basic and strategic performance, indicating there are moderators of the effect of prompting self-regulation.

The early decrement effect was not statistically significant for basic or strategic performance and the fit indices indicate the early decrement model provided the worst fit to the data of the four models tested. These results suggest that prompting self-regulation was not detrimental for performance at the beginning of training during complex skill acquisition. Thus, the results failed to support the notion that self-regulation requires significant attentional resources and impairs performance when training is cognitively demanding.

Cognitive Ability and Self-Efficacy Moderator Analyses

Next, we examined the extent to which cognitive ability and task specific self-efficacy moderate changes in basic and strategic performance across the nine trials. To test Hypotheses 2 and 3, cognitive ability and self-efficacy were added as level-2 predictors of the intercept and self-regulation slope fixed effects in both the basic and strategic performance models (see Table 3). The self-regulation slope parameter was coded as a mean effect for basic performance and a plateau effect for strategic performance. Cognitive ability had a significant main effect on the intercept for strategic performance ($\gamma = .002$) whereas self-efficacy had a significant main effect on the intercept for both basic and strategic performance ($\gamma = .429, .154$, respectively), indicating performance at trial one was elevated for trainees with higher levels of cognitive ability and self-efficacy. In addition, cognitive ability moderated the effect of prompting self-regulation on basic performance ($\gamma = .002, p < .05$) and self-efficacy moderated the effect of prompting self-regulation on strategic performance ($\gamma = .096, p < .05$).

A graph of the self-regulation prompts by ability interaction when predicting basic performance is presented in Figure 4. For higher ability trainees, performance was substantially greater over time when trainees were prompted to self-regulate, relative to the control condition. For lower ability trainees, prompting self-regulation did not have as strong of an effect on

performance. These results indicate the intervention had a stronger positive effect on basic performance over time for trainees with higher rather than lower levels of cognitive ability, supporting Hypothesis 2.

A graph of the self-regulation prompts by self-efficacy interaction when predicting strategic performance is presented in Figure 5. Prompting self-regulation had a strong positive effect on performance over time for higher self-efficacy trainees in the immediate and delayed conditions, relative to higher self-efficacy trainees in the control. Prompting self-regulation had less of a positive effect on performance over time, relative to the control, for lower self-efficacy trainees who were prompted to self-regulate. Supporting Hypothesis 3, these results suggest that prompting self-regulation had a stronger positive effect on strategic performance over time for trainees with higher self-efficacy levels.

Discussion

The results for Study 2 replicated and extended the findings of Study 1 by demonstrating that prompting self-regulation had a positive effect on both basic and strategic performance and, relative to the control, the strength of the effect increased over time. In addition, the effect of prompting self-regulation on performance was moderated by trainees' cognitive ability and self-efficacy. Trainees with higher levels of cognitive ability and stronger self-efficacy beliefs benefited more from the self-regulation prompts.

GENERAL DISCUSSION

The current results are consistent with theory suggesting self-regulation is a dynamic process that has a positive effect on learning over time (Butler & Winne, 1995; Carver & Scheier, 1990; Kanfer & Ackerman, 1996). We used a within-subjects design in two studies and demonstrated, relative to the other conditions, performance improved or remained stable over

time for trainees who were prompted to self-regulate whereas performance declined over time for trainees who were not prompted to self-regulate. Study 1 incorporated the prompts in an online, work-related training course. By the end of the course, participants in the immediate and delayed conditions were outperforming the control participants by .26 and .40 standard deviations, respectively, on a test of declarative and procedural knowledge. In Study 2, by the end of training participants in the immediate and delayed conditions were outperforming the control group by .40 and .53 standard deviations, respectively, for basic performance and .41 and .36 standard deviations, respectively, for strategic performance. Together, these results suggest that prompting self-regulation has a positive effect on performance over time and enhances the extent to which trainees learn both the fundamental principles and deeper complexities of a task.

It is noteworthy that participants in the delayed condition were outperforming participants in the immediate condition in Study 1 and for basic performance in Study 2 by the end of training. Kanfer and Ackerman (1996) propose that motivation control is essential in the latter half of training, after trainees are familiar with the material that is being taught. The early stages of knowledge acquisition are the most demanding and rewarding. However, later in training motivation control skills enable trainees to sustain on-task attention and effort. Thus, when training basic knowledge it may be prudent to implement the prompts in the later half of the course, when motivation control is likely to have the largest effect on performance (Kanfer & Ackerman). In contrast, strategic performance remains challenging throughout the entire training experience and engaging in metacognitive activity throughout the course may enable trainees to discover when, where, why, and how to perform the training task. Thus, when training strategic knowledge it may be prudent to prompt self-regulation throughout the course to encourage trainees to develop the strategies necessary to improve their strategic performance.

Our results failed to support the resource allocation perspective and suggest that encouraging self-regulation did not impair performance at the beginning of training. These results are consistent with DeShon et al.'s (1996) argument that self-regulation does not necessarily require a significant amount of attentional resources and may be carried out as an automatized process. They suggest that through training and practice, self-regulatory skills can become well-learned and relatively resource independent. Given that both of our samples were highly educated and academically accomplished, trainees may have possessed well-developed self-regulatory skills that, when prompted, operated without consuming significant attentional resources. This combined with the fact that the self-regulation prompts are relatively simple and unobtrusive may have limited the resource conflicts experienced by participants in the intervention conditions, even during the more demanding stages of learning. Future research is needed to explore the effects of the self-regulation prompts on learning for trainees with different educational backgrounds.

Our findings also support previous research (e.g., Donovan & Williams, 2003; Ilies & Judge, 2005; Vancouver & Kendall, 2006; Yeo & Neal, 2004) suggesting a within-subjects design is more appropriate for understanding intraindividual changes in self-regulation and that results may differ at the within-and between-subjects levels of analysis. We used ANOVAs, the analysis technique used in previous prompts research (e.g., Corliss, 2005; Toney, 2000), to examine whether the prompts had a significant effect on knowledge at the between-subjects level of analysis. In Study 1 and for strategic performance in Study 2, we failed to find significant between-persons effects. This is consistent with research that suggests self-regulation is an unfolding and iterative process that must be examined over time in order to understand the recursive flow of goals and strategies that ultimately determine performance (Butler & Winne,

1995; Kanfer & Ackerman, 1989; Winne, 1996). The results highlight the importance of theory in guiding our understanding of learning processes and emphasize the criticality of conducting research at the appropriate level of analysis (Kreft & de Leeuw, 1998).

It is important to consider aptitude-treatment interactions when examining the effects of prompting self-regulation. Cognitive ability moderated the basic performance results whereas task specific self-efficacy moderated the strategic performance results. For basic performance, prompting self-regulation was more beneficial for higher rather than lower ability trainees. Performance remained at a high level over time for higher ability trainees who were encouraged to self-regulate, but declined over time for higher ability trainees in the control, relative to the other conditions. Basic performance involves learning the declarative and procedural features of a task, which may be rewarding in the beginning of training when performing the task is likely to be the most challenging (Kanfer & Ackerman, 1996). Later in training, basic performance may no longer be challenging for higher ability trainees. The prompts may have enabled trainees to remain motivated to perform the task, warding off the boredom that may have resulted in the control condition's performance declining over time, relative to the other conditions. For strategic performance, prompting self-regulation was more beneficial for trainees with higher rather than lower self-efficacy. Strategic performance requires that trainees learn the underlying or deeper complexities of a task. It involves more than simple memorization as trainees must integrate important task concepts and develop and test task strategies (Bell & Kozlowski, 2002a). The development of strategic knowledge is a gradual process and trainees inevitably encounter setbacks and failures as they develop new strategies. The self-regulation prompts make these goal-performance discrepancies salient. Trainees with higher levels of task specific self-efficacy may be more likely to use the prompts to detect goal-performance discrepancies, adjust their

training behavior accordingly, and persist through challenges to master the strategic elements of the task (Chen et al., 2000).

Recommendations for Practitioners

Our results suggest it is beneficial to prompt self-regulation when teaching basic or strategic performance with technology-delivered instruction. We demonstrated that basic and strategic performance improved or remained stable over time when trainees were prompted to self-regulate, whereas performance declined over time when trainees were not prompted to self-regulate, relative to the other conditions. This suggests implementing the prompts will enhance trainees' ability to remember the key principles presented in training and their understanding of when, where, why, and how to apply their knowledge and skills (Ford & Kraiger, 1995; Gagné & Merrill, 1992; Tennyson & Breuer, 1997). In addition, prompting self-regulation is a low cost intervention that is easy to implement. To incorporate the prompts in training, organizations need to add a series of reminders to their courses to encourage trainees to monitor their learning behaviors, develop goals and strategies, and assess their learning progress.

Organizations should be aware that highly intelligent trainees and trainees with higher self-efficacy benefit more from the prompts. Although the prompts should have little or no effect on learning for lower ability or lower self-efficacy trainees, we did not find evidence that the prompts were detrimental to the performance of these trainees. These findings suggest that organizations can use the prompts without much risk of hurting trainees' learning and performance, but certain individuals may not benefit without additional structure and guidance.

Limitations and Directions for Future Research

Each of the individual studies has several limitations, but they also provide unique contributions. Study 1 assessed knowledge of each of the training modules at the end of the

course. The relative independence of the content covered in each of the modules, the objective assessment of trainees' knowledge, and replication of the positive effects of the prompts in the laboratory enhances confidence in the knowledge trajectories observed in Study 1. Ideally, however, assessment of changes in knowledge should measure learning temporally as trainees progress through the course, as was done in the second study. Study 2 utilized undergraduates participating in a laboratory study, which may limit the extent to which the results generalize to organizational training courses. In addition, the cognitive ability measure was self-reported, which may have increased the measurement error and attenuated the moderator results.

The current results suggest adults are capable of managing their own learning when they receive reminders to monitor their learning behaviors and evaluate their progress during training. However, the current research did not investigate the mediating psychological processes (e.g., effort, self-assessment, on-task cognition) that may explain differences in performance across the self-regulation conditions. Thus, future research is needed that builds on the current findings and directly examines these mediating mechanisms. As many of these proposed processes are considered “executive functions” of the mind, direct measurement of them (via self-report) may not yield accurate data, or the act of measurement may disrupt the processes one is hoping to assess. Accordingly, future research may explore potential mediating processes through non-self-report measures such as reaction times or secondary task performance. In addition, future research should compare the effects of prompting self-regulation to the effects of providing trainees with diversions or breaks from the training material. Although research suggests that interruptions generally impede information-processing and performance (Cellier & Eyrolle, 1992; Gillie & Broadbent, 1989; Monk, Boehm-Davis, & Trafton, 2004; Zijlstra, Roe, Leonora, & Krediet, 1999), research on alternating task protocols (e.g. Goettl, Yadrick, Connolly-Gomez,

Regian & Shebilske, 1996) suggests moving between different tasks can aid learning and retention. Thus, future research is needed that examines the mechanisms through which prompting self-regulation enhances learning processes and outcomes.

Research is also needed to replicate the current findings and examine boundary conditions for the effect of the prompts on learning over time. For example, the results indicate that in Study 1 the effect of the prompts on basic performance (i.e., declarative and procedural knowledge test scores) followed the plateau model, but in Study 2 the effect of the prompts on basic performance followed the mean effect model. The different functions observed for basic performance across the two studies may be explained by the training methods employed in each study. Study 1 used a progressive part-task training method (Naylor & Briggs, 1963), in which the modules each covered a different feature of Blackboard. Trainees who received the self-regulation prompts exhibited gradual increases in performance as they learned these different features. Eventually, they were able to automatize some of the steps that are similar across the various features and performance leveled off. Study 2, however, used a whole-task training method, in which trainees practiced all of the basic skills (e.g. “hooking” contacts, collecting information, making decisions) together. Whole-task training is an efficient method for training complex tasks that possess a high degree of organization (e.g., interdependence among task dimensions; Briggs & Naylor, 1962; Naylor & Briggs, 1963). The use of a whole-task approach in Study 2, as opposed to a more gradual part-task approach, may explain why the self-regulation prompts caused an abrupt increase in basic performance followed by a period of stabilization.

Future research should also explore strategies that can be used to stimulate and support the self-regulatory activities and learning of trainees with lower levels of cognitive ability and self-efficacy, as these may be the trainees that need the greatest assistance. One fruitful avenue

may be focusing trainees' attention on the affective element of self-regulation, which has traditionally been understudied in previous research (Ilies & Judge, 2005). In particular, emotion control is a critical component of self-regulation and involves limiting the intrusion of performance anxiety and other negative emotions during training (Kanfer, 1996; Kanfer & Ackerman, 1996). Negative emotions may be more likely to interfere with the performance of low self-efficacy trainees (Bandura, 1997; Bandura & Cervone, 1983). Thus, future research should examine whether prompting both cognitive and affective self-regulation increases the extent to which lower self-efficacy trainees benefit from the prompts.

Finally, research should examine the extent to which trainees continue to self-regulate in future courses that do not include prompts and the extent to which trainees become desensitized to the prompts over time. It is possible that incorporating the prompts in one course is sufficient for improving trainees' self-regulatory skills and trainees will be able to apply these skills in future courses. However, there is also research evidence indicating that self-regulation ability varies greatly across tasks and situations (Weaver & Kelemen, 2002). This suggests that the prompts may need to be incorporated in all courses to continuously remind trainees to self-regulate or the prompts may not be effective in all courses. Research should also be conducted to examine the optimal timing of implementing the self-regulation prompts. Specifically, when should the prompts be presented during training (i.e., beginning, middle, or end of a module) and how often should trainees be prompted to self-regulate?

Conclusion

Prompting self-regulation is an effective intervention for enhancing learning from technology-delivered instruction. Results from two studies demonstrated that, relative to the other conditions, performance improved or remained stable over time for trainees who were

prompted to self-regulate whereas performance declined over time for trainees who were not prompted to self-regulate. In addition, cognitive ability moderated the effect of the prompts on basic performance and task specific self-efficacy moderated the effect of the prompts on strategic performance. Prompts resulted in stronger learning gains over time for trainees with higher ability and higher self-efficacy. These results highlight the value of multilevel modeling for understanding learning processes and provide a baseline for future research examining the effect of prompting self-regulation in technology-delivered instruction.

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Table 1

Comparison of Models for Studies 1 and 2

	Study 1		Study 2: Basic Performance		Study 2: Strategic Performance	
	Fixed Effect	Fit Indices AIC/BIC	Fixed Effect	Fit Indices AIC/BIC	Fixed Effect	Fit Indices AIC/BIC
Continuous effect	0.021 (0.012)	2588.8 2598.9	0.012 (0.010)	3606.1 3618.7	0.018 (0.009)	3526.1 3538.7
Mean effect	0.122 (0.076)	2589.3 2599.4	0.231* (0.062)	3593.7 3606.2	0.112 (0.060)	3526.4 3538.9
Plateau effect	0.047* (0.020)	2586.2 2596.3	0.021 (0.014)	3605.4 3618.0	0.034* (0.014)	3523.8 3536.3
Early decrement effect	0.023 (0.104)	2589.2 2599.4	0.011 (0.010)	3606.4 3619.0	0.016 (0.010)	3527.1 3539.7

Note. AIC stands for Akaike Information Criterion (Akaike, 1974). BIC stands for Bayesian Information Criterion (Schwarz, 1978). For Study 1, the continuous effect model was coded 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 for the immediate condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 5 for the delayed condition. Mean effect was coded 1 for all 10 modules for the immediate condition and 0, 0, 0, 0, 0, 1, 1, 1, 1, 1 for the delayed condition. Plateau effect was coded 0, 1, 2, 3, 4, 4, 4, 4, 4, 4 for the immediate condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 4 for the delayed condition. The early decrement effect was coded -2, -1, 0, 1, 2, 3, 4, 5, 6, 7 for the immediate condition and 0, 0, 0, 0, 0, 1, 2, 3, 4, 5 for the delayed condition. A similar coding scheme was used in Study 2, but it was adjusted to account for the 9 rather than 10 performance trials. In the fixed effect columns, the top number is the fixed effect coefficient and the number in parentheses is the standard error.

* $p < .05$

Table 2

Correlations among Study 2 Measures at the Between-Persons Level of Analysis

	<i>Mean</i>	<i>SD</i>	1	2	3	4	5
1 Immediate (1) vs. delayed self-regulation & control (0)	0.37	0.49					
2 Delayed (1) vs. immediate self-regulation & control (0)	0.30	0.46	-.50*				
3 Cognitive ability	1341.04	112.98	.02	.09			
4 Self-efficacy	3.31	0.78	.05	.14	.18*		
5 Basic performance	0.00	0.73	.09	.11	.20*	.49*	
6 Strategic performance	0.00	0.75	.15*	-.01	.30*	.39*	.38*

* $p < .05$

Table 3

Level-2 HLM Results Predicting Basic and Strategic Performance in Study 2

	Basic Performance	Strategic Performance
Intercept	-0.087 (0.072)	-0.070 (0.060)
Ability	0.000 (0.001)	0.002* (0.001)
Self-efficacy	0.429* (0.098)	0.154* (0.078)
Self-regulation slope	0.162* (0.076)	0.029* (0.015)
Ability	0.002* (0.001)	0.000 (0.000)
Self-efficacy	0.017 (0.104)	0.096* (0.019)

Note. The self-regulation slope parameter is coded as a mean effect for basic performance and a plateau effect for strategic performance. The top number is the fixed effect coefficient and the number in parentheses is the standard error.

* $p < .05$

Figure 1. Graph of the effect of prompting self-regulation on learning across the 10 training modules for Study 1.

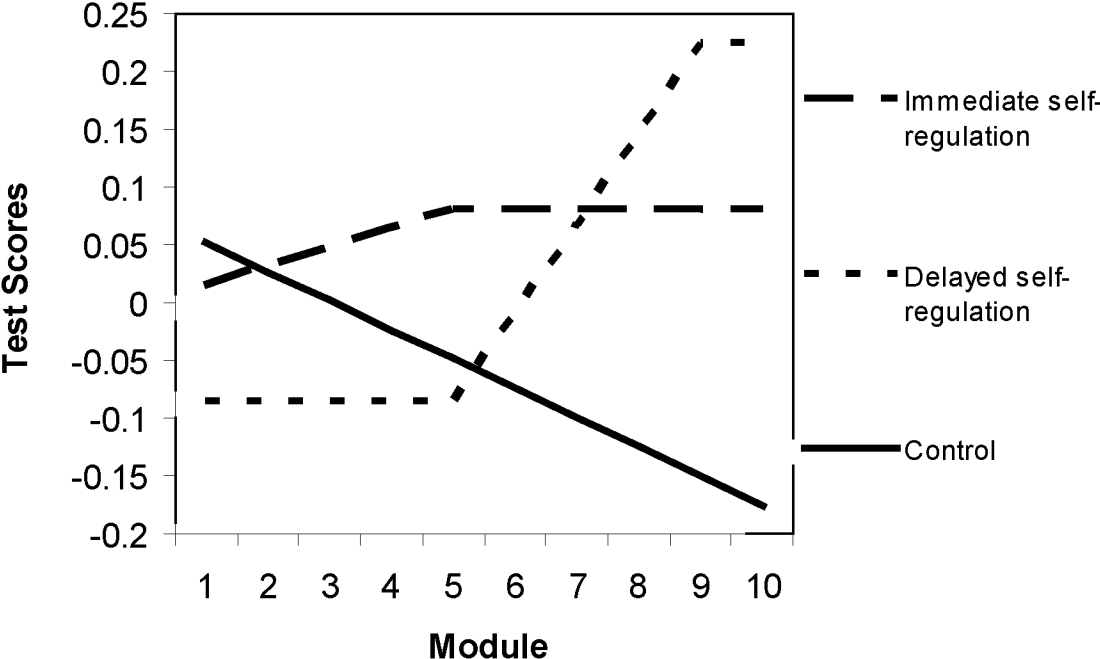


Figure 2. Graph of the effect of prompting self-regulation on basic performance across the nine training trials for Study 2.

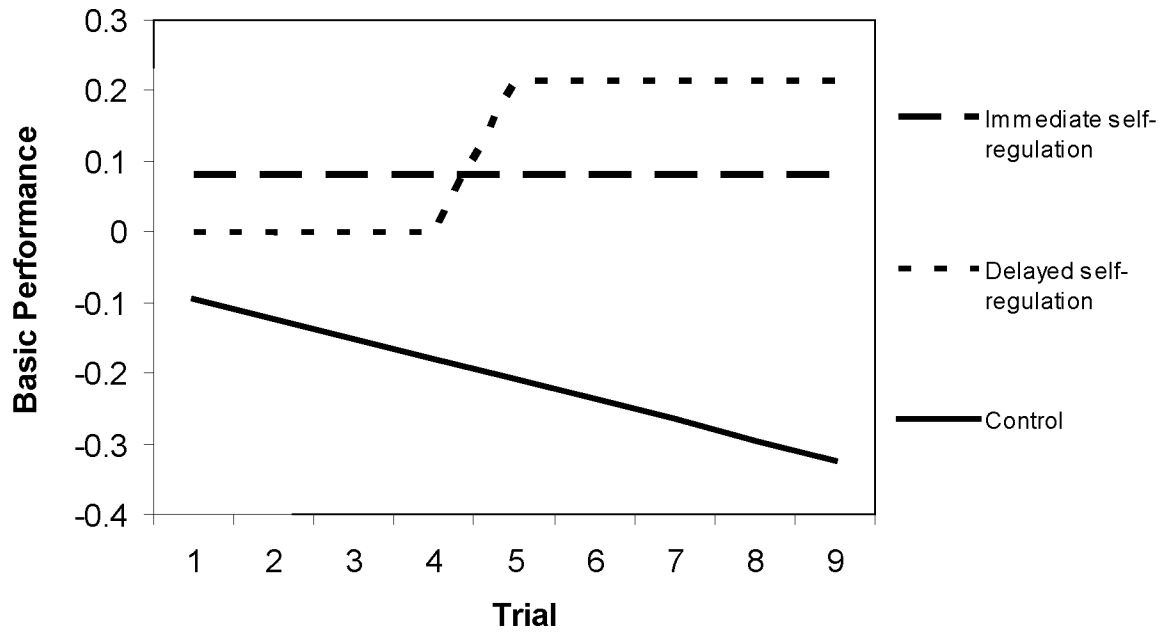


Figure 3. Graph of the effect of prompting self-regulation on strategic performance across the nine training trials for Study 2.

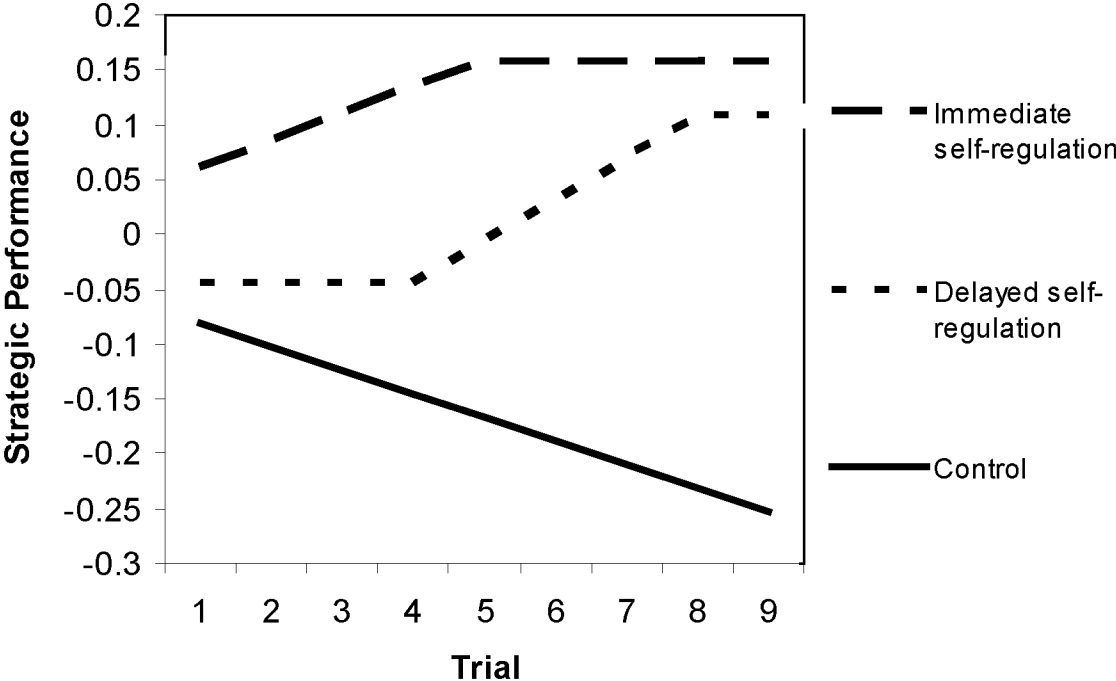


Figure 4. Graph of the self-regulation prompts by ability interaction when predicting basic performance across the nine training trials for Study 2.

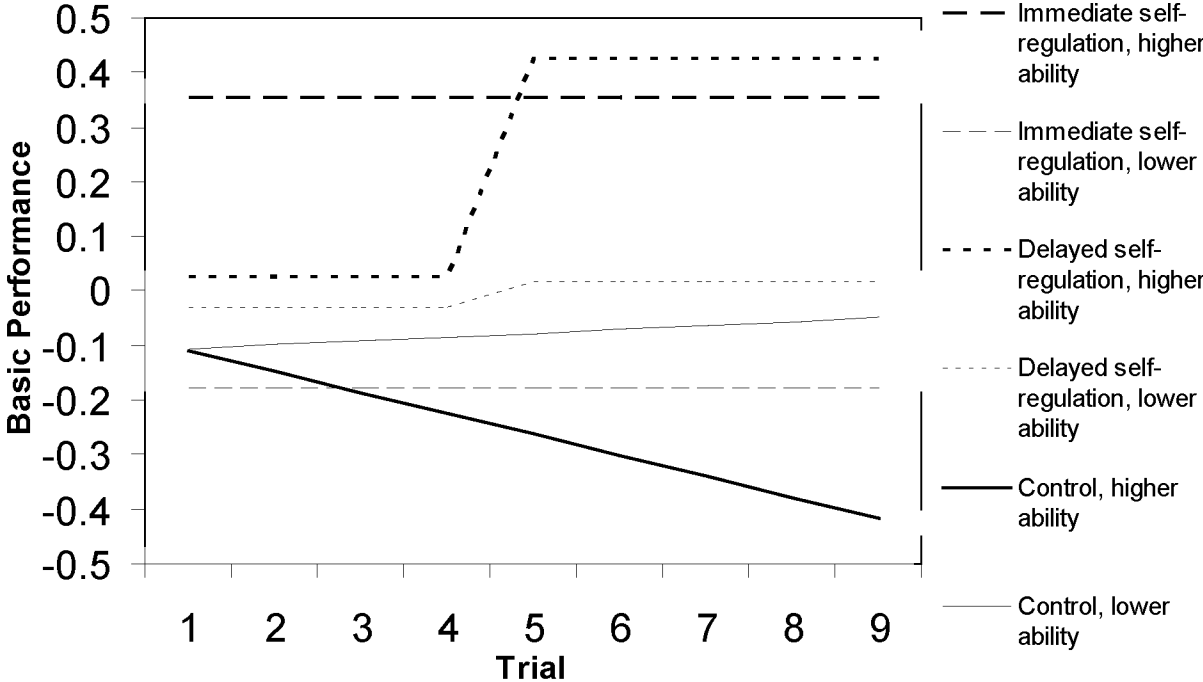
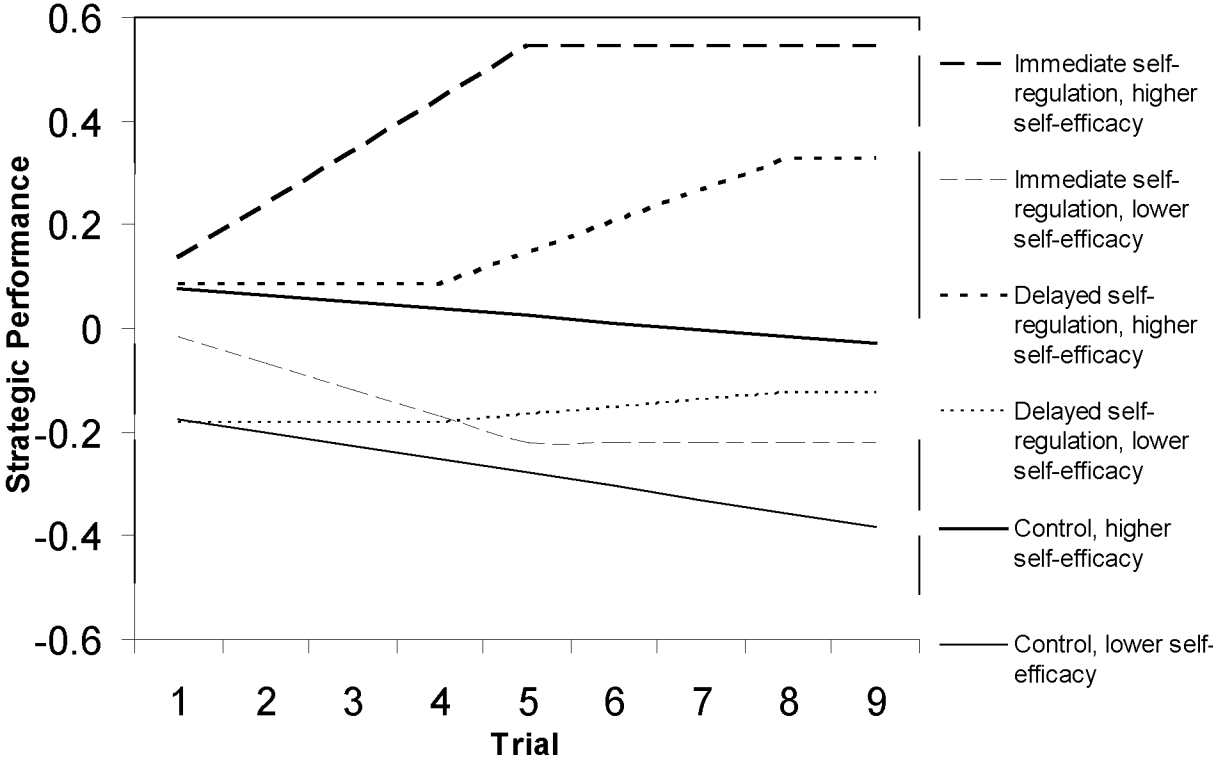


Figure 5. Graph of the self-regulation prompts by self-efficacy interaction when predicting strategic performance across the nine training trials for Study 2.



Appendix

Questions Used to Prompt Self-Monitoring and Self-Evaluation

Self-Monitoring

1. Am I concentrating on learning the training material?
2. Do I have thoughts unrelated to training that interfere with my ability to focus on training?
3. Are the study tactics I have been using effective for learning the training material?
4. Am I setting learning goals to help me perform better on the final exam?
5. Am I setting learning goals to ensure that I will be ready to take the posttest?
6. Have I developed a strategy for increasing my knowledge of the training material?
7. Am I setting learning goals to ensure I have a thorough understanding of the training material?
8. Are the study strategies I'm using helping me learn the training material?
9. Am I distracted during training?
10. Am I focusing my mental effort on the training material?

Self-Evaluation

1. Do I know more about the training material than when training began?
2. Would I do better on the final exam if I studied more?
3. Do I know enough about the training material to answer at least 80% of the questions correct on the posttest?
4. Have I forgotten some of the terms introduced in previous training material?
5. Are there areas of training I am going to have a difficult time remembering for the final exam?
6. Do I understand all of the key points of the training material?
7. Have I spent enough time reviewing to remember the information for the final exam?
8. Have I reviewed the training material as much as necessary to perform the skills on the final exam?
9. Do I need to continue to review before taking the final exam?
10. Am I making progress towards answering at least 80% of the questions correct on the posttest?