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THE EFFECTS OF PRACTICE VARIABILITY AND VELOCITY FEEDBACK ON THE DEVELOPMENT OF BASIC AND STRATEGIC TRAINING SKILLS

By

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ABSTRACT

THE EFFECTS OF PRACTICE VARIABILITY AND VELOCITY FEEDBACK ON THE DEVELOPMENT OF BASIC AND STRATEGIC TRAINING SKILLS

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A study is presented in which two training manipulations (practice variability and the provision of velocity feedback) were hypothesized to bring about increased self-regulation on the part of trainees. This increased self-regulation was then hypothesized to lead to the enhancement of both basic and strategic performance during training, which along with declarative and adaptive knowledge about the task should influence performance on a more difficult generalization version of the training task. It was suggested that situational judgment testing provided an ideal assessment methodology for adaptive performance, and a situational judgment test was developed for this study. Contributions of the study are discussed.

For Cindy… Without you, I wouldn't be here

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INTRODUCTION

It has become increasingly clear in the last two decades that training design should concentrate on moving beyond "fads" and instead look for those options, available to trainers, which are most likely to result in the greatest learning, skill generation, and ultimately, skill transfer and retention. The advancement of training as a field of study within scientific psychology requires that questions be asked not only about how we can best generate the kinds of results organizations value, but also why the manipulations we employ can and should be effective. The literature on training design offers many potential avenues to be explored. Design elements that have received attention in the literature include: sequencing of materials (Dansereau, Brooks, Holley, & Collins, 1983); provision of feedback (Earley, Northcraft, Lee, & Lituchy, 1990; Waldersee & Luthans, 1994); amount of control given to learners over their learning experiences (Tennyson, 1980, 1981; Gay, 1986; Nelson, Dunlosky, Graf, & Narens, 1994); variability of training experiences (Schmidt & Bjork, 1992; Schmidt, 1975); and provision of goals (Locke & Latham, 1990; Latham & Locke, 1991). While these do not constitute a closed set of training manipulations, they should serve to illustrate the kinds of things that can be done within training programs to assist trainees.

In this study, I have examined the effects of two specific training manipulations, based around the nature of the practice in which trainees engage and the feedback they receive about their practice. These general areas are two that should receive increased attention as training design efforts become more complex and begin to fully utilize the technologies available. Kozlowski, Toney, Mullins, Weissbein, Brown, and Bell (in press) argue that the capabilities to (1) generate various types of skill-developing practice scenarios and (2) provide detailed feedback information regarding those scenarios, are likely to be central components of many future training systems, particularly those used to train individuals to perform complex tasks. As such, the manipulations utilized for this study represent the cutting edge of training theory and practice, making the further understanding of their effects offered by this study all the more crucial to progress in training design.

"Practice" and "feedback," however, are exceedingly broad in their scope. Questions of appropriate practice during training may range from how much practice, to the extent to which the practice experiences of trainees vary substantially over the course of training. Feedback is perhaps an even broader term, and can range from the purely descriptive (how accurate was the trainee, how frequently were certain actions performed, how consistent was the trainee's performance with regard to the goals of training) to the highly evaluative (being referenced to others who are going through the training or have done so in the past, to the trainee him- or herself, or to a general positive/negative label) (Kozlowski et al., in press). Moreover, feedback can be provided that combines both descriptive and evaluative components.

This study begins the task of understanding how feedback and practice work together by isolating elements of each and looking at their effects as well as their interactions with one another. It makes sense, as we will see, to argue that the manipulations employed should have an effect on valued training outcomes. However, little empirical support exists for such contentions in the training literature itself, and this study seeks to fill that void.

In the opening section of this paper, I will accomplish several goals. First, to frame the study, I will review the literature on training, focusing on the kinds of outcomes that are valued in training settings. With an understanding of our desired end-states established, I will then turn my attention to the question of what kind of cognitive processes we should be attempting to stimulate in trainees to reach our goals. I will argue that a critical element of any successful training program may be the successful stimulation of trainee self-regulatory activity. Trainees should be active in the learning process, should be considering how to use the information and skills they are gaining, and should be attempting to make the information presented in training make sense in light of the overarching goals not only of the training program, but of the job to which they must transfer the knowledge and skills from training.

Once my review of the literature on self-regulation is completed, I will discuss the literature surrounding my two focal manipulations. Both the practice and feedback literatures are extensive, so I will discuss them first at a broad macro level, and then move to a more specific consideration of the potential ways to operationalize them. I will discuss the options available to trainers with respect to the types of feedback and how practice may be utilized before discussing my specific manipulations, along with a rationale based on training and other literatures for why they should produce the desired outcomes, with arguments here centering on the stimulation of self-regulatory activity. Here, as with the section on self-regulation, I will focus not only on the training literature, but also on what can be gained from examinations of literatures outside the traditional purview of Industrial/Organizational Psychology -- specifically, the cognitive and educational fields.

Each section of the literature review, then, will build on the previous. In considering the manipulations, I will argue that the two manipulations I have selected will enhance self-regulation on the part of trainees, which I will have already argued as the appropriate method for reaching the kinds of outcomes valued by organizations in today's marketplace. The next section, then, will discuss those training outcomes, and the research and theory available to guide our understanding of them.

Training Outcomes

The literature on training is expanding with every new journal issue, and a comprehensive review of the literature on training is becoming prohibitive for anything less than a series of books. Such a review is not necessary for the purposes of this study, however, because a great deal of the most critical information is contained in the literature on training outcomes.

Depending on the goals of the specific training program, the knowledge and skills to be gained will vary. It may be that the training was commissioned solely to teach trainees appropriate behaviors in the workplace (e.g., sensitivity training), in which case the goals would involve the capability of trainees, following the program, to be able to identify those behaviors which are appropriate or inappropriate in the workplace. Or the training may have been commissioned to teach a new skill, like the use of a new piece of software, in which case the goal would involve trainee capacity to use the program following completion of the training. In either case, however, it will be hoped that trainees will retain what they have learned beyond the final training session and will actually apply what they have learned on the job. This is most commonly referred to as "transfer," and issues of transfer have become increasingly salient to training researchers in recent years (e.g., Baldwin & Ford, 1988; Ford, 1997). Transfer can occur in terms of either simple retention (do trainees do the same things they were taught in training on the job?) or more complex adaptation (do trainees take what they have learned and attempt to apply it to their job context, which will be non-identical to the context of training and may complicate the usage of their knowledge/skills?). The more interesting theoretical and practical question is the one involving the adaptation of knowledge or skills, since in most cases, the job context and the training context are markedly different. This presents problems of a practical nature, as trainees must be able to adapt their skills to the different environment if the training is to have any value. The theoretical problems are interesting as well, as we find ourselves faced repeatedly with the question of how training can be designed in order to ensure that the skills gained should be adaptable, from a theoretical standpoint.

Retention-based transfer is the simpler of the two general types. Here, our goal is simply that trainees retain as much of the information or skills from training as possible, in a form identical (or nearly so) to what they were taught during the training program. It is easiest to think about retention-based transfer from both knowledge and skill perspectives.

The knowledge gained in training is the element most likely to be retained with minor modifications. Consider training on a new computer program. An example of the kind of knowledge that would simply need to be retained from such a training program might be the meaning assigned to the function keys (F1-F12) on the keyboard. If the program's "Help" function is activated by pressing F3, this is something trainees will need to learn in training, and will need to remember when they begin using the program on the job.

The specific skills gained in training on such a program should also be retained. For example, assume the program in question is an upgrade of a spreadsheet program. The process for entering data and doing computations is one which should not change from the training environment to the job, because the program itself is going to remain constant. Hence, once the skill is gained, it should not be lost. Note that the distinction between this example and the previous example is intended to be one of declarative versus procedural knowledge; in the former example, we simply want the trainee to know that if the F3 key is the "Help" key, while in this example we want to trainee to know how to do more complicated things with the program, such as data entry. There are certainly declarative components to data entry tasks, but there are also procedures to be followed with respect to frequency of saves, backup procedures, and the like which are a concern while data are being entered as well.

The real difficulties come not in getting trainees to retain what they have learned in training (though statistics do show that only a small percentage of what is learned may be retained), but in getting trainees to adapt what they have learned in training. Learning by rote is one thing; developing adaptive skills is another altogether. This problem has been discussed for over a decade now in I/O journals, with one of the articles that shaped the field being a paper by Baldwin and Ford (1988) in which the authors pointed out that both the maintenance of skills and the generalization of those skills to the job were critical elements of transfer.

Recently, the broader psychological literature has begun to pay attention to issues of adaptation and adaptability. The act of learning, and more broadly, the use of knowledge and skills gained through the learning process, is not static. Rather, the bulk of what we learn may be specific to the context in which it was originally learned, meaning that in order to use it in other contexts, we must adapt or change it in some way. The adaptation required may be subtle (the keyboard layout on the computers used in training may be different from the keyboard layout of the computers used on the job, requiring an adaptation to the new layout) or much more complex (different tasks may need to be performed with the new program once it is implemented on the job, for which trainees were not specifically trained). Training researchers (e.g., Hesketh, 1997) have begun discussing such topics as "adaptive expertise," but the notion of adaptability has long been inherent in training research. This is evidenced by Kelly's (1982) discussion of generalization across time, settings, and situations.

We are therefore concerned about the retention/maintenance of knowledge and skills gained in training, as well as their potential adaptation to different contexts. A reasonable next question is what factors we might expect to have an impact on the likelihood that transfer, in its various forms, may occur. In general, the literature discusses three sets of factors that will affect whether or not transfer occurs. These are individual factors, situational factors, and design factors. Individual factors are those things trainees bring with them into the training situation. Warr and Bunce (1995) listed several potentially important individual factors, including demographics such as age, educational qualifications, job tenure, and specific experiences on the job, as well as more internal factors like attitude, motivation, anxiety, self-efficacy, and the use of strategies. While not all of the individual factors were ultimately shown to be critical to obtaining desired outcomes from training, the study nonetheless showed that individual factors are something we must be cognizant of, and at the very least be able to control for or predict in our training programs. Tesluk, Farr, Mathieu, and Vance (1995) also considered individual factors, including organizational commitment and cynicism, but went beyond the individual and considered situational factors. Tesluk et al. considered two levels of situational factors, the suborganization, and the organization, and at both levels considered such situational variables as managers' attitudes towards the material to be trained and the presence of an appropriate climate. Multiple climates exist within an organization, reflecting the organization's norms and values in many different areas (e.g., the climate for cooperation defining the norms for employees cooperating with one another, or the more general interpersonal climate defining the norms for how employees interact with one another around the office; Mullins, Kozlowski, Schmitt, & Howell, in preparation). The norms for how work gets done and how knowledge and skills from training may be implemented into day-to-day activities will clearly influence the extent to which retention and adaptation of skills occurs. Hence, climate may be a primary situational constraint.

Studies involving training transfer are therefore made complicated by both the characteristics trainees bring with them into the training program, and by the environment to which they must ultimately return in order to utilize their new knowledge and skills. Both of these factors make it difficult for us to determine the unique effects our training interventions – that is, how we design our training – may have had on the likelihood of transfer. A solution to this problem, at least in the early stages of attempting to understand transfer, is the use of lab studies in which individual differences and transfer environments can be controlled. This study attempts to do precisely that. Information on individual characteristics is collected before, during, and at the conclusion of the experiment. Moreover, the transfer task is identical for all participants, lending us the opportunity to observe the capability of individuals to generalize their skills based primarily on the training manipulations to which they have been exposed. Ideally, this means that we will be able to make statements about the efficacy of the specific training design elements utilized.

As was noted at the beginning of this paper, the literature on training design offers many potential avenues by which transfer (in terms of maintenance and adaptation/generalization) might be encouraged. Rather than begin a detailed discussion of the manipulation at this point, though, it is reasonable to ask what cognitive processes might allow our manipulations to actually have an effect on the outcomes of interest, as discussed in the previous pages. One domain which has begun to be more heavily researched in this regard is self-regulation.

Self-Regulation

Self-regulation came to prominence with Flavell's (1979) discussion of metacognition as an individual's awareness of and control over his or her own thought processes. A more specific form of metacognitive activity, self-regulation, has received increased attention in both educational (e.g., Ames & Archer, 1988; Bouffard, Boisvert, Vezeau, & Larouche, 1995) and I/O (e.g., Kanfer & Ackerman, 1989) psychology. Self-regulation is the act of monitoring the differences between goals and current states (Kozlowski, Toney, Weissbein, Mullins, Brown, & Bell, 1998), and involves cognitive, behavioral, and affective components (Kozlowski, Toney, Weissbein, Brown, & Mullins, 1997). The centrality of self-regulation to cognitive processes has been forcefully argued by Bandura (1991; Bandura & Wood, 1989), who posited a system in which individuals engage in self-monitoring, judgment, and self-reaction while attempting to regulate their own behavior. While the labels applied to the subcomponents of self-regulation may differ across theoretical approaches, several aspects of self-regulation are relatively constant. First, individuals engaging in self-regulatory activities should, based on their monitoring of their behavior, note discrepancies between their desired performance and actual performance and act to minimize those discrepancies. Moreover, by actively thinking about how they are approaching the task and how they can best reach their goals, individuals should be forced to not only develop a full representation of the problem space, but also to develop a flexible representation, which can be adapted as new information is discovered. Constant self-regulation allows them to better adapt what they have learned without sacrificing anything they have gained from prior experiences. From an affective or self-reactive standpoint, it is also clear that how people feel about their own behavior (often operationalized in terms of self-efficacy, or beliefs regarding their capabilities to perform the task) will influence future behavior as well. Hence, while slightly different perspectives may be taken to understanding what self-regulation is, the correspondence across these perspectives is high with respect to both the basic functioning and the theoretical importance of self-regulatory mechanisms.

In this section, I will review recent research on self-regulation that is relevant to topics within training. First, I will discuss the linkage between self-regulation and goals, with particular attention paid to a type of goals (mastery/learning; Ames & Archer, 1988) that is likely to enhance the quality of self-regulation during training. I will then consider the role of feedback relative to goals, with respect to self-regulatory activities. While conventional wisdom seems to indicate that feedback in general should be optimized by simple concurrence with goals (Latham & Locke, 1991), the fact that different mechanisms may be operating in determining the amount, quality, or type of self-regulatory activity arising from goals as opposed to feedback may cast doubt on this assumption. The distinction between goals and feedback is made at this time simply to demonstrate the explanatory capacity of self-regulation as a guiding frame, but will be returned to in later discussions of substantive issues as well. Once the discussion of feedback is concluded, I will briefly discuss other manifestations of self-regulation, to provide the reader with an overview of other domains in which the concept has been applied, and then I will conclude this section by presenting a model of the self-regulatory system developed by Kozlowski, Weissbein, Brown, Toney, and Mullins (1997).

Self-Regulation and Goals

One understanding of self-regulation, advanced by Ridley, Schutz, Glanz, and Weinstein (1992) puts central importance on the role of goals. The authors treat goals as potentially motivating via their actions on the self-regulatory process, specifically through their impact on self-evaluation and self-efficacy judgments. Such judgments are based on the perceived fit between the goals adopted by the individual and the feedback individuals receive about how well they are meeting their goals. Mitchell, Hopper, Daniels, George-Falvy, and James (1994) echoed Ridley et al.'s (1992) findings, arguing that when resources were available, goals should bring about increased, beneficial self-regulatory activity. These papers, however, discussed goals and goal setting in very general ways and do not provide a great deal of guidance with respect to what type(s) of goals might best enhance self-regulatory processes in trainees. That some goals should do so is not in doubt, but it is not unreasonable to ask what specific type of goals might be applied if we wish to maximize the extent to which our trainees engage in self-regulatory activities.

One recommendation arises from a distinction originally drawn in the educational literature based on goal orientation. Goal orientation (Elliot & Dweck, 1988; Dweck & Leggett, 1988) refers to the extent that individuals tend to adopt or prefer either mastery or performance goals. Mastery-oriented persons tend to adopt goals that focus on improving skills and increasing competence (Duda & Nicholls, 1992), whereas performance-oriented persons adopt goals designed to help them perform well and to look good in comparison to others (Meece, 1994). The cognitive processes surrounding the adoption of these two types of goals are likely very distinct. Because of the focus mastery orientation applies on skills and competencies, individuals with such an orientation might reasonably be expected to engage in high levels of self-regulatory activity in pursuit of their goals. Performance orientations, on the other hand, might be expected to require somewhat less self-regulatory activity, as the capacity to perform on a task may be something which is optimized when automatization of the skill set has been achieved. This distinction is borne out in the literature, where research has consistently shown that mastery-oriented individuals do engage in more active self-monitoring and other self-regulatory activities than do performance-oriented individuals (Bouffard et al., 1995; Ames & Archer, 1988; Meece, Blumenfeld, & Hoyle, 1988; Miller, Behrens, Greene, & Newman, 1993).

Goals obviously provide critical information to trainees, which can then be used to help the trainees make judgments about their progress throughout the training program. Such judgments are central elements of the self-regulation that trainees engage in during training. While they may be stimulated by any type of goal, research seems to indicate that providing mastery goals, which focus trainees on gaining skills and competencies rather than on simply performing a new set of skills (Kozlowski et al., 1998), may offer one of the best goal-based manipulations of self-regulation. Hence, if one of our training goals is high levels of self-regulation among our trainees, we might be well-advised to utilize mastery goals as a training manipulation.

While substantial evidence exists to demonstrate that mastery (vs. performance) goals are superior in enhancing self-regulatory activity, I am interested in moving beyond simple considerations of such goals to determine how we can further amplify their effects on self-regulation in training. It is possible that other manipulations may possess additive effects in combination with the presentation of mastery goals. Some of these were mentioned in the introduction to this paper. For instance, the extent to which trainees who are learning a task are given variable versions of the task on which they may practice, as opposed to practicing an identical task every time, might impact self-regulatory activity by providing trainees with a broader experiential base from which to draw (Schmidt & Bjork, 1992; Schmidt, 1975). Similarly, it has recently been suggested that errors be used as training tools; sometimes they are built in to training scenarios to encourage alterations in the way trainees practice and think about the task, while in other situations trainees are encouraged to make errors while practicing and observe the consequences (Lord & Levy, 1994; Frese & Altmann, 1989; Ivancic & Hesketh, 1995).

Using errors as practice manipulations can be particularly beneficial, Ivancic and Hesketh (1995) point out, when problem solving and hypothesis testing skills are desired. In either case, however, errors provide information which is likely to stimulate self-regulatory activity on the part of trainees. As a final example, consider the sequencing of materials presented in training (Dansereau et al., 1983). The order in which trainees are exposed to elements of the material to be learned can be used to guide their relevant cognitions. This capacity, in turn, can also be used to shape the self-regulatory activities in which trainees engage by forcing them to develop their understanding of the training domain in a specific manner. Any or all of these manipulations have the potential to augment the self-regulatory effects of mastery goals.

In the beginning of this section, I mentioned that the self-regulatory effects of goals may arise from a comparator process between the goals provided and the feedback received. While this may be the case, more theoretical work has been done understanding the effects of feedback on self-regulation than has been done understanding the general linkage between goals and self-regulation. The comparator argument, however, may be insufficient. Assuming that nothing more occurs in determining self-regulation than a comparison of training goals with feedback is overly simplistic; both empirical and theoretical work on the role of feedback, particularly relevant to self-regulation, push us to a broader consideration of feedback within training.

Self-Regulation and Feedback

In considering feedback, we must first think about relevant theoretical frameworks from which the effects of feedback on self-regulation can be considered. One obvious theoretical framework we can use for this purpose is control theory (Carver

& Scheier, 1982, 1990). Control theory posits a negative feedback loop in which individuals notice a discrepancy between how they believe they should be performing and how they actually are performing, leading them to engage self-regulatory mechanisms to assist in reducing that discrepancy. The negative feedback loop reduces deviations from a compared value beginning with an input function involving a perception of the present state. This perception is then compared to a reference value by a comparator mechanism. If the individual perceives a discrepancy between the present state and the reference value, an output function is engaged (a behavior is performed) to reduce the discrepancy. This causes a change in the perception of the present state. Other external forces (disturbances) may also impact the environment and cause a present state change. While most often disturbances increase the discrepancy between the present state and reference value, they may also act to reduce the discrepancy. Under control theory, then, the process briefly described in the previous section occurs. Individuals (trainees) receive information about their performance during training, compare that information with their initial goal state, and alter their behavior in such a way as to maximize the likelihood that they will meet their goals. The view of control as a central element of self-regulation is echoed in the work of other authors (e.g., Nelson, 1996).

Control theory also aligns itself well with what Karoly (1993) referred to as the "directive function" of self-regulation. That is, self-regulation helps to direct future behavior, in this instance by comparing current behavioral states with desired goal states. However, recent work has called into question the assumption that a simple matching of goals to feedback may allow control theory to operate. Mullins, Kozlowski, Toney, Bell, Brown, and Weissbein (1999) tested the effects of matching or mismatching feedback to goals which were designed around either mastery or performance goal orientations. In this study, the authors provided trainees with either mastery ("Learn and master these critical skills") or performance ("Obtain a score of [x] on the task") goals, then provided either feedback that matched the goal (mastery feedback for mastery goals, etc.), feedback that did not match the goal (performance feedback for mastery goals), or a combination of mastery and performance feedback, along with extra information used in calculating the overall performance feedback information. Because the task was heavily cognitively-loaded and required substantial self-regulation and strategy use in order to generalize the skills gained in training to a more difficult environment, the authors hypothesized that providing mastery goals (consistent with the literature, e.g., Ames & Archer, 1988) and mastery feedback (was mastery demonstrated?) would optimize generalization of the material from training. However, the authors found that simply matching feedback to goals did not maximize generalization/transfer performance. Instead, they found that the best generalization occurred when individuals were given mastery goals and both performance and mastery feedback. A further examination of the feedback literature provides one potential explanation for this finding.

Karoly's call for self-regulation to serve a directive function is critical to our explanation of Mullins et al.'s (1999) findings. Some forms of feedback may be better suited to direct or guide trainee attentions than are others. Mastery feedback, while it offers descriptive information about the behaviors in which trainees engaged, may not ultimately be directive in the sense that it can motivate trainees and encourage them to continue moving forward. The kind of feedback which is more apt to do so has been referred to in the literature as "velocity" feedback, which is information that allows trainees to make judgments about their progress on a task (Carver & Scheier, 1990; Hsee & Abelson, 1991; Kluger & DeNisi, 1996). The capacity to observe improvement over the course of a training program is likely central to individuals' beliefs regarding their potential to deal with the material from training and any changes which might arise in its generalization, and is also likely to provide more of a directive influence. Thus, it may be that because it provided a way for trainees to observe their improvement during training, the performance feedback served as velocity information and actually increased the amount of self-regulation in which trainees engaged during the Mullins et al. (1999) experiment.

In total, then, theoretical explanations exist for why feedback should impact self-regulation. Adopting a control theory perspective (Carver & Scheier, 1990) allows us to consider discrepancies between goals and feedback as one potential avenue through which self-regulation may be accomplished. However, recent research has pointed out a potential flaw in this logic, as in some cases additional feedback will need to be offered to provide velocity information, which can provide a directive force to trainee cognitions.

Manifestations of Self-Regulation

An impressive array of issues have been considered by researchers concerned with self-regulation. In this section I will highlight several such issues which are relevant to the discussions in the previous portions of this review, and which serve to better define what is meant by self-regulation before moving on to a theoretical model of the self-regulatory system that can serve as a guiding framework. Two particular manifestations of self-regulation are of interest at this point. First, I will consider self-regulation as the basis for at least some forms of higher-order skill development. This is important because such skill development is one of the goals of most training programs. Second, I will consider self-regulation as manifested in the use of strategies. Both of these manifestations, I will argue, are central to any consideration of the role of self-regulation in training.

Etelapelto (1993) argued that on many tasks, those individuals who perform best are those who are more aware of their own cognitive processes and engage in higher levels of self-monitoring. That is, people who think about their own thinking (are possessed of high metacognitive awareness) are likely to develop more complex cognitive representations of a domain, and be better able to access the elements of such a domain. The suggestions made by Etelapelto (1993) are important because they allow us to expand our consideration of the role of self-regulation during training beyond the bounds of the formal training program itself, and consider its long-term outcomes. If self-regulatory activity is, as Etelapelto suggests, related to higher-order skill development within a given domain, it does not require a large inferential leap to suggest that we should encourage self-regulatory activity during training.

The centrality of strategies to learning has been noted by many authors (e.g., Ames & Archer, 1988). One mechanism by which strategies may operate in learning environments is via self-regulation, as developing and implementing strategies is inherently a self-regulatory activity. Individuals must monitor their environment, come to an understanding of the task, and make decisions about how best to approach the challenges presented by the task with which they are faced. A multitude of studies have discussed strategy use during training or other learning activities, including Garcia and

Pintrich (1994), Meece (1994), Pintrich and DeGroot (1990), Schunk (1994), Bandura and Wood (1989), Curtis (1992), Earley, Lee, and Hanson (1990), and others. The contexts in which strategies have been applied makes it clear that they are critical to a variety of complex learning activities, and the nature of strategies makes the conclusion that they are manifestations of heightened self-regulatory activity a reasonable one to reach. Conceptualizing strategies as one manifestation of self-regulatory activity again allows us to better see the role self-regulation plays in learning, this time in terms of the processes in which learners or trainees are likely to engage.

The relevance of considering both higher-order skill development and strategy use as indicators or manifestations of self-regulatory activity should be clear. While the manner in which the two phenomena manifest themselves are different, the argument that self-regulation underlies both of them is interesting, and should further encourage us to consider self-regulation as a central element of training design efforts. In the next section, I will review a model of the self-regulatory system proposed by Kozlowski et al. (1997). This model serves to break down self-regulation into cognitive, behavioral, and affective components, and may be used to guide us in identifying indicators for each of the aspects of self-regulation.

The Self-Regulatory System

Kozlowski et al. (1997) developed a model of training with its origins in the work of Bandura (1991), suggesting that self-regulation is actually a system composed of three interlocking elements. The most common element of self-regulation is self-monitoring, the extent to which individuals engage in cognitive analysis of what they have done and what they need to do to meet their goals. Kozlowski et al. argue that the actual practice in which individuals engage is also reflective of self-regulation, as trainees may change what they are doing to ensure that they meet their goals, and that the self-evaluations made about performance (in terms of both attributions and self-efficacy) are critical as well. All three of the elements of what Kozlowski et al. (1997) term the "self-regulation system" are hypothesized to work together in determining the extent to which critical outcomes may be reached. See Figure 1 for a graphical display of the three elements of the system.

The distinction Kozlowski et al. (1997) draw among cognitive, behavioral, and affective domains is not pure, however; the separation of the elements is in some senses heuristic. What we do affects what we feel, what we feel affects what we think, what we think affects what we do, and so forth. The system, the authors propose, is more than the sum of its parts, but it is by studying the parts – thinking, feeling, and doing – that we can come to the most meaningful understanding of self-regulation as a whole. Hence, there are reciprocal links among the three domains such that influences on any one will likely affect the others; the distinctions are useful, primarily, for conceptual and measurement reasons.

The simplest place to begin is with the cognitive component of self-regulation, self-monitoring. Self-monitoring is the allocation and application of attentional resources to the task (Kanfer & Ackerman, 1989), monitoring goal discrepancies and the ongoing process of questioning whether the current strategic approach to the task is optimal (Kozlowski et al., 1997). The cognitions that are triggered during the learning process are among the most salient and forceful manifestations of the individual's experiences, and may be what stays with the trainee the most strongly because of the effort involved in their production. The requirement that trainees actively consider what they are doing as they perform the task forces them to learn at a deeper level than would otherwise occur, and enhances the quality of the conclusions they reach by having preliminary conclusions questioned as a regular part of the process. Clearly, when trainees are encouraged or required to reflect on what they are doing on the task, and how they can improve their performance, it is unlikely that they will lose motivation, stagnate, and eventually quit the task. Instead, they will develop more complex cognitive representations of the task, which should enable them to better adapt what they have learned to other environments.

The affective, self-evaluative elements of self-regulation may be almost as salient as cognitions to trainees, and are certainly afforded the same importance in Kozlowski et al.'s (1997) model. Self-evaluation, to the authors, includes both self-efficacy resulting from training and attributions made about training performance.

Self-efficacy (Gist & Mitchell, 1992) is the belief on the part of an individual that he or she is capable of accomplishing a specific task. The task can be as simple as walking a mile, or as complex as landing an F-14 on an aircraft carrier. Self-efficacy arises primarily from past experiences, though it can also arise from vicarious experience and trainees' knowledge of their skill in a given area, and forms the basis for later trainee performance. Recent research has begun to suggest that the effects of self-efficacy may occur in part because of its importance to self-regulation. Kanfer and Ackerman (1989) found that task-relevant self-efficacy was absolutely essential if self-regulatory activities were to occur, a finding supported by Miller et al. (1993) as well as Bandura (1991). That is, if people do not believe they are able to accomplish the task (they have low self-efficacy), then they are unlikely to engage any self-regulatory mechanisms and therefore create a self-fulfilling prophecy in which low efficacy leads to low performance (see Lindsley, Brass, & Thomas, 1995, for a discussion of efficacy-performance spirals).

Attributions about past experiences and about the training experience itself serve a similar function to self-efficacy. Trainee expectations, whether of success or failure, are based in part on the attributions made about past performance. Trainees who attribute past failures to external causes may be more likely to work hard at a task and actively self-regulate because they believe themselves capable of succeeding, while those who attribute past performance to internal causes are less likely to see themselves as capable and therefore less likely to engage the other elements of the self-regulatory system, self-monitoring and practice (Martocchio & Dulebohn, 1994). Similarly, within training the attributions that are made by trainees about their experiences are likely to impact their processing and retention of information, which will ultimately affect the entire self-regulation process (Hastie, 1984). Trainees with low self-efficacy, or those who make poor attributions, are likely to become demotivated and not try as hard at the task.

The third domain of the self-regulation system as discussed by Kozlowski et al. (1997) is the behavioral component, practice. The literature presents multiple benefits of practice, including increased retention of information from training to transfer (Hastie, 1984), increased persistence (Forsterling, 1985), and increased positive affect (Carver & Scheier, 1990).

Multiple methods are available to utilize practice to encourage the activation of other components of the self-regulation system. First, Frese and Altmann (1989) suggest that trainees be instructed to engage in active hypothesis testing. This activity will invoke cognitive monitoring elements, as well as efficacy judgments based on the quality of the hypotheses tested, and will force the trainee to practice different elements of the task as hypotheses are chosen, tried, and discarded. While some studies have not supported the importance of hypothesis testing activities to adaptive transfer (e.g., Smith, 1996), the issue remains open and the rationale to expect activities such as hypothesis testing to be important to transfer remains solid. In addition, errors have seen increasing use as training tools. Sometimes they are built into training scenarios to encourage alterations in the way trainees practice and think about the task, while in other situations trainees are encouraged to make errors while practicing and observe the consequences (Lord & Levy, 1994; Frese & Altmann, 1989; Ivancic & Hesketh, 1995). Using errors as practice manipulations can be particularly useful, Ivancic and Hesketh (1995) point out, when problem solving and hypothesis testing skills are desired. It should therefore be clear that what gets practiced, and how, has an impact on the likelihood that trainees will be able to solve novel problems when the task is altered.

The three elements of the self-regulation system do not work in isolation from one another. Appropriate practice can stimulate trainees to think about different elements of the task and can shape how they feel about their performance. Appropriate self-monitoring can direct trainees toward appropriate elements of the task to practice, and can give them accurate information on which to base their self-evaluations. And appropriate self-evaluations increase the likelihood that trainees will continue to practice and monitor the task to the fullest extent of their ability and to develop the resilience to deal with setbacks. In order to adapt, trainees must monitor the appropriate elements of the task, practice them in a manner that allows them the greatest comprehension, and make self-evaluations about their progress and performance that enhance later adaptability of what they have learned. What kinds of indicators might we then look at, to determine the extent to which individuals are activating the various elements of the self-regulatory system?

In considering behavioral elements of self-regulation, the most direct approach to assessment involves either observing the behaviors of trainees who are asked to self-regulate, or to ask them to report the activities in which they engaged that reflect self-regulatory activity. Because many training instances do not allow for substantial one-on-one contact between trainer and trainee (i.e., they are done in large group, classroom-type settings), the second option may be better. That is, in determining the type of self-regulatory behaviors in which trainees engaged, we might be advised to ask them questions about what they were thinking about while they were learning the material, and what strategies they employed to help them learn and master the material.

The affective elements of self-regulation are also relatively straightforward. As a result of their experiences during training, individuals will begin to evaluate their own capacities with respect to the training material. This is clearly parallel, as was discussed above, to self-efficacy (Gist & Mitchell, 1992). Hence, when we are concerned about whether the affective elements of the self-regulatory system have been activated for trainees, the easiest way to assess this should be a measurement of their task-relevant self-efficacy.

The extent to which individuals engage in self-monitoring may be inferred from the extent to which they have learned the material from training. Controlling for the effect of cognitive ability on learning declarative information, it is reasonable to expect that individuals who engage in greater self-monitoring of their own progress learning the material should, in fact, learn the material better than those who do not monitor their learning. Hence, we may expect that the learning trainees engage in over the course of training should allow us to draw inferences about the extent to which they were monitoring their own progress on the cognitive components of the training task.

In this section, I have attempted to accomplish several goals. First, I reviewed self-regulation in a general sense, defining the construct and talking about its applications in the literature. Then I turned to a consideration of those elements of the training environment which might be manipulated to enhance self-regulatory activity among trainees. Goals, specifically mastery/learning goals (Ames & Archer, 1988) were presented as a foundation on which training could be built to encourage self-regulation. Other manipulations, such as variability of practice, were discussed as possessing the potential to enhance self-regulation as well. The potential non-redundancy of feedback and goals was then considered, and the argument was put forth that velocity feedback might provide an additional "push" to trainees that might enhance self-regulatory activity beyond simply matching the feedback directly to the mastery goals provided. Moving to the other end of the model (so to speak), I then considered potential manifestations of self-regulatory activity, including strategy use and skill development. I concluded this section with a discussion of the self-regulatory system model proposed by Kozlowski et al. (1997), including a consideration of how the various elements of that system might manifest themselves in ways that could be assessed within the bounds of a training program. In the next section of this paper, I will take up a more detailed discussion of the specific manipulations selected for this study, including their theoretical underpinnings, prior research and theory involving the constructs, and how this research allows us to make predictions of what may happen in training programs.

Training Manipulations

Thus far, I have briefly reviewed the literature on training transfer, to allow the reader an idea of what kinds of goals are desired, and I have reviewed the literature on self-regulation, to provide one explanation as to how we may best be able to reach those end-states. If the logical progression is followed in this manner, the next question should be, "How can we stimulate trainee self-regulation?" The best way to accomplish this is through appropriate design of our training programs.

It was mentioned at the outset that any number of manipulations/design components are available to trainers. However, Kozlowski et al. (in press) note two specific training design elements that should receive increased attention, practice and feedback. In this section, I will examine each of these literatures in order to develop an understanding of what we know, as well as what we still need to know about how such manipulations operate.

Practice

Psychologists have long recognized that what (and how) people practice should have an influence on both learning and skill development (e.g., Kerr, 1982a, 1982b). Recently, Kozlowski et al. (in press) have postulated that practice is one of the two elements of the training environment which can most easily be leveraged in order to obtain desired outcomes. That is, what (and how) trainees practice during training is almost completely under the control of those individuals who design the training program. As such, specific alterations of the practice opportunities can have pronounced effects on what trainees take away from training.

The influence of practice has been examined in a variety of contexts. Kerr (1982a, 1982b) examined the effects practice had in relatively basic motor-skill learning tasks. Catalano and Kleiner (1984) utilized a task in which trainees were asked to light-based stimuli presented at either set intervals or random intervals, with the ultimate criterion being the speed with which they were able to respond to a similar stimulus presented at novel intervals during a generalization trial. Practice has also been examined for its effects on geometrical problem-solving (Paas & van Merrienboer, 1994), the ability of trainees to make judgments about digital logic gates (Carlson, Sullivan, & Schneider, 1989), children (rather than adult) motor skill learning (Clifton, 1985) and various sport-related skills (Green, Whitehead, & Sugden, 1995; Kozar, Vaughn, Lord, & Whitfield, 1996). The bulk of the manipulations utilized in the literature cited above involve the distinction between variable and constant practice, a reasonable place to start. There are potential benefits to providing either variable or constant practice opportunities for trainees, depending on the specific goals.

If the training program is designed to teach people a single task, which is unlikely to vary substantially (for example, a motor skill task such as putting chips into a circuit board on an assembly line), it makes sense to train people on a single version of the task, which they repeat ad nauseum until they can perform it to near automaticity. This type of task is one which involves relatively little self-regulation.

However, modern jobs are increasingly prone to variation. People must adjust to changes in their environments and be prepared for the unexpected. The individual mechanically putting chips into a circuit board will end up creating no end of problems if the wrong bin of chips is put down beside him, or if his supervisor accidentally requisitions the wrong circuit board, or if someone up the line rotates a board the wrong way while installing a separate chip, or if the production scheme changes markedly for the line on which he works. To prevent breakdowns in post-training performance, it may be useful to provide trainees with variable practice opportunities. That is, instead of having trainees put a single chip in a single circuit board, provide them with a variety of chips, which require either a separate placement in the same board, or a different board altogether. This should allow for a more complex cognitive representation of the task to be established, the specific mechanisms for which will be discussed shortly.

The utility of variable practice becomes more clear when we move beyond (relatively) simple motor tasks. In tasks where cognitive effort must be expended (e.g., tasks requiring vigilance), we do not want our trainees to fall into a "routine" in which they are tempted to do the same thing every time they perform their task. Rather, we want them constantly thinking about the best way to approach their task, about what elements of the environment need to be monitored, and so forth. In other words, providing variable practice opportunities should encourage trainee self-regulatory activity.

This contention finds support in recent writings by Schmidt and Bjork (1992). The authors argue that, "variable practice alters the practice context to force a change in behavior from trial to trial, encouraging additional information processing activities about the lawful relationships among the task variants" (p. 214). The increased information processing requirements of a task which is practiced in a variable, rather than constant, fashion, should be expected to stimulate additional self-regulation on the part of trainees.

The relevance of the constant vs. variable practice argument to applied domains should be clear based on the examples provided above. One of the main concerns of trainers, as noted repeatedly, is the transfer of knowledge and skills from training back to the job. The type of transfer desired should help to define what type of practice trainees should be engaging in.

If trainees simply need to retain what they have learned, in an identical form to what they were presented with in training, then constant practice should suffice. However, if trainees must be able to adapt their skills, to generalize what they have learned in training to the job, and beyond, then variable practice should be more beneficial. Because there is an apparent push in many organizations for increasingly adaptive workers, variable practice opportunities may be increasingly required, and their utility will be explored in this study.

An important question must be considered if we are to recommend variable practice is this: From a theoretical standpoint, why should variable practice advantage trainees, relative to constant practice? Increased self-regulation is one important element of the answer, but the argument can be made that such self-regulation is actually an effect of yet another psychological process, and not the ultimate cause of the observed effects. Examining the literature on practice points us to another, much more foundational theory, that involving schemas.

Johnson and McCabe (1982), drawing on the work of Schmidt (1975, 1976) suggested that schema theory might serve to explain observed findings regarding the efficacy of variable (as opposed to constant) practice in the development of generalizable skills. Though their discussion centers primarily around motor learning, it is reasonable to translate their logic into cognitive terms. For example, the authors argue that what gets stored in memory as a result of practice is not specific movements, but rather the abstracted relationships among different types of information, including the initial conditions, the response specifications, the sensory consequences, and the actual outcomes of the movement. It does not require a great deal of effort to translate their discussion from motor to cognitive terms.

In any work environment, certain conditions are going to exist which require a response. These initial conditions, in motor terms, are simply the conditions under which movement occurred, but generalize to the conditions under which any response is made to a given stimulus, or set of stimuli. The response specifications in motor terms involve the organization of the movement generated in response to the initial conditions. From a cognitive perspective, this is simply the organization of potential mental and physical (depending on the nature of the task) responses to the stimulus. In both the motor and cognitive cases, the sensory consequences are the sensory feedback received by the trainee as a result of the response produced, and the actual consequences consist of information regarding the result/outcome of whatever action was taken.

The schema an individual has about how to complete a task is a set of relationships (which can range from relatively basic, to extremely complex) which allows them to generate response specifications and expected sensory consequences when presented with a set of initial conditions. In cases where trainees are provided with constant practice opportunities, their schemas will be relatively basic. They will know the one appropriate response to one set of initial conditions. However, if they are provided with variable practice opportunities (which translate roughly to variations on the same initial condition), then they are going to develop more complex schemas. These more complex cognitive representations of their environments should allow them to better deal with changes in their tasks, as well as ambiguities that are introduced into their work environments. In order to make maximally effective use of these schemas, however, trainees have to be aware of the different potential response options to various initial conditions, and be able to select the appropriate way to approach a given task, based on what they know (i.e., they must self-regulate).

The logic of variable practice, then, is as follows. Providing trainees with variable practice opportunities should result in the development of more complex cognitive representations (schemas) of the task domain. Because their representations of the task domain are more complex, trainees will necessarily engage in greater self-regulation when performing their tasks. This will enable them to identify contingencies which might alter how they should perform their jobs, and allow them to better adapt their skills beyond the training environment, to the job environment. Hence, because of the complexities of the schemas that should be encouraged by providing variable practice opportunities, trainees should be more likely to develop into the adaptive learners that organizations increasingly require.

In the next section, I will conduct a similar review of feedback. I will begin with a basic discussion of what feedback is, and the role it plays in training design. I will discuss different types of feedback, and then discuss one whose effects should be similar in some respects to those of variable practice. I will discuss how and why such feedback is likely to provide us with more adaptive learners, again with emphasis on potential increases in self-regulatory activities among trainees, and demonstrate why the manipulation has been selected for this study.

Feedback

For practice to have value for trainees, it is necessary that its effects be translated into meaningful terms. Without some indication that their practice is allowing for the enhancement of knowledge and skills, trainees may become frustrated and reduce the effort they are willing to expend learning the task. As such, feedback - information given to trainees about their progress toward whatever goal the training ultimately pursues - is invaluable as a tool for trainers. It is easily configured, and can present information that varies in terms of amount, quality, and level of detail. It can be purely descriptive ("You did [x]. You did not do [y]."). It can be evaluative ("You did well while attempting to [z]."). It can also provide guidance for the trainee ("You might want to focus on [q] in the future, to help you better succeed at the task."). It is one of the most flexible tools available to trainers in how they design their training programs. It is also the second of the two training design elements Kozlowski et al. (in press) argue are likely to be central to future training design initiatives.

It is not unreasonable to argue that feedback is essential for learning and skill development to occur. Practice, in a vacuum, will simply turn into repetition. Without some idea how they are doing, learners/trainees will not be able to focus their attentional resources appropriately, nor will they be able to learn from their mistakes (because they will not know, for the most part, that mistakes have been made). Feedback can be made available to trainees in a variety of formats, and stimulate a variety of cognitive, affective, or behavioral responses depending on how it is structured. A recent review of the literature on feedback (Kluger & DeNisi, 1996) makes clear how much work has been done in this area, and the variety of approaches that have been taken to providing feedback to trainees.

Kluger and DeNisi (1996) point out that the element of feedback that most people have come to expect is knowledge of results. That is, how did I do on the task? But such knowledge, they argue, is only one element of the broader process by which feedback has its effects. They discuss a more general theory of feedback interventions which, they would claim, possesses a great deal more explanatory capacity than the studies focusing on knowledge of results that have dominated the feedback literature since the first published studies nearly a century ago.

According to their feedback intervention theory, feedback is useful in the regulation of behavior because it allows trainees to compare their current state to whatever goals or standards they have been given. For our purposes, this involves a comparison between how trainees are told they are doing in training, and what goals they have been given to pursue. The notion of a comparator process operating between goals and feedback, and directing behavior, is one which is not new to the literature. Carver and Scheier (1982, 1990, 1998) developed their control theory of behavior around a similar notion. This theory will be discussed in more detail shortly.

Beyond the notion of the comparator process, Kluger and DeNisi's (1996) feedback intervention theory has several other interesting components. It assumes that attention is limited, and that therefore only those discrepancies between feedback and goals which receive attention will influence the regulation of behavior. This is a safe assumption to make, and is interesting on several levels. We already understand that human learners possess limited cognitive resources (Kanfer & Ackerman, 1989). Therefore, not every element of the environment will be attended to, nor will all of the information that is available to trainees be utilized. What we need to be able to do is structure our feedback, relative to the goals of the training program, in such a way that trainees will attend to the areas where the most important discrepancies are likely to arise, and thereby guide their self-regulatory activities. As Kluger and DeNisi (1996) note, the direction of attention is unpredictable if left to trainees, and any feedback intervention allows trainers to more tightly focus the elements of the environment on which the trainees are focusing.

Hence, while questions about feedback can center around how much feedback, or what kind of feedback, it is probably of greater utility to ask questions about how we can best utilize feedback to encourage trainees to think about the appropriate elements of the training environment, to perform the critical behaviors that will lead to successful skill development, and to feel as though they are making progress on the task. This is particularly important when we want trainees to develop skills that are adaptable to other environments. Trainees need to be engaging in appropriate cognitive, behavioral, and affective practices during training in order to develop generalizable skills for the workplace. Feedback can do this by pointing out to trainees the appropriate elements of the task on which to focus. One type of feedback which has recently begun to gain prominence in the literature, and which seems especially suited to the task described above, is velocity feedback.

Velocity feedback is that which allows trainees to track their progress over the course of training (Kluger & DeNisi, 1996; Hsee & Abelson, 1991). The capacity to observe improvement over the course of a training program is likely central to individuals' beliefs regarding their potential to deal with the material from training and any changes which might arise in its generalization, and is also likely to provide more of a directive influence. Hsee and Abelson (1991) discuss the effects of such feedback in terms of displacement – that is, the directional difference between the current level of performance and some reference level. In our terms, that would be the difference between the feedback received and the goals of the training program. When trainees are able to observe the change in this discrepancy over time, then we have provided them with access to information about the velocity (in terms of change over time) of their improvement on the task.

The mechanism by which velocity feedback operates is thus a familiar one to those familiar with the feedback literature. Hsee and Abelson (1991) discuss the effects of velocity information in terms of displacement between the current and reference levels, which they expect to have an affect on satisfaction. We may derive from this that those individuals who perceive favorable velocities – who see favorable distinctions between their current and reference levels – will likely be more motivated during training, and will work harder at achieving their goals.

More generally, however, the framework established by Carver and Scheier (1982, 1992, 1998) with their Control Theory provides substantial explanatory power. According to Control Theory, behavior is controlled through a process of comparison, in which current states are compared to desired states. An example often used to describe control theory is the thermostat, which is provided with a setting that defines its comparator, the desired end state. The thermostat then activates the heater (if the sensed temperature is too low) or the air conditioner (if the sensed temperature is too high) to bring the ambient temperature to the appropriate level. The temperature is re-checked periodically, and the "behavior" of the thermostat, in terms of whether it leaves the air conditioner or heater on, is adjusted accordingly based on the current temperature, until the current temperature reaches the desired end state. A similar mechanism, the authors argue, is in place in human learners; given a desired end state (a goal), we modulate our behavior (learning activities) to attempt to reach that end state, observe our results (in the form of feedback), and continue observing and modulating until the goal is reached.

Based on this understanding of how goals and feedback may operate, it is clear that velocity feedback provides one fairly straight-forward application of their ideas. Given a goal, trainees who are provided with sufficient information to determine whether they are progressing toward that goal should, over time, approach it more easily. Moreover, based on Hsee and Abelson's (1991) work, as well as further speculation by Carver and Scheier (1998), they should have more positive affective reactions to the experience, provided they are able to actually observe the change over time in their own behavior.

It may be noted that based on the literature, we might expect the primary effects of velocity-type feedback to be affective. However, it is impossible to fully disentangle trainees' cognitive, behavioral, and affective reactions to the training environment, since one will necessarily influence the other two (Kozlowski et al., 1997). We should also expect trainees who receive velocity feedback to be more satisfied . However, because they will be more actively considering their learning and performance on a task, those individuals should also show increased cognitive activity (manifesting in such things as increased learning and self-regulation) as well as an increased likelihood of appropriate behaviors to enable better learning. Velocity feedback should thus be beneficial to trainees not only because of the increased satisfaction that other authors have discussed at length, but also because of the concomitant increases in self-regulatory (cognitive and behavioral) activities that should accompany increased satisfaction with their progress during training.

The implications for training design are fairly straightforward. If one of our goals, within the confines of a training program, is to increase trainee self-regulation around the training topic, then velocity feedback (or feedback with velocity components) is almost certainly an appropriate direction to go. Not only can it lead to increases in satisfaction, but it can help guide and shape the cognitions and behaviors trainees engage in during the training process. Feedback in general has the capacity to direct a great deal of the trainee's focus, and velocity feedback provides a finer form of the manipulation, allowing more precise direction of trainee attention than might otherwise be the case.

The two focal manipulations for this study, then, center around the variability of practice experiences provided to trainees, and the feedback trainees are given following each practice session. Each of these manipulations has the potential to increase trainee self-regulatory activity, which should allow for the development of trainees who are better able to adapt what they have learned in training to other environments.

A question that may be asked, however, is whether we can actually measure the potential adaptability that has been discussed throughout the opening sections of this paper. It is relatively easy to infer, from standard end-of-training assessments, whether trainees have learned what they were supposed to in training, and whether they can use the skills they have gained. It is more difficult to infer whether they will be able to adapt their skills when they return to the job. One measurement technology that has recently gained attention in the selection literature, situational judgment testing, holds the potential to remedy this deficiency. Because situational judgment tests provide respondents with hypothetical situations of the type they might encounter on the job, their framework provides an ideal mechanism by which the capacity of trainees to adapt what they have learned to other contexts may be tested. The specifics of situational judgment testing will be discussed in detail in the following section.

Situational Judgment Tests: Measuring Adaptive Knowledge

At the end of training, trainees should have learned something about the training material. Such learning, at its most basic level, may simply take the form of declarative knowledge. Do trainees remember facts about what they learned, or how to do things? However, as we have repeatedly noted, we want our trainees to be adaptive. We are thus interested in whether trainees possess adaptive knowledge – that knowledge base which allows trainees to generalize their skills from one domain to another.

If adaptability is based on knowledge of and experience with the content domain, situational judgment tests are a promising assessment device. Within a relatively limited paper-and-pencil framework, SJTs allow for the presentation of detailed information regarding potential situations, as well as requiring respondents to discriminate among a number of potentially valid responses. Scenarios can easily be constructed which require the use of the knowledge and skill components from training, but which alter key elements of the situation in ways that require respondents to adapt what they have learned about the task. For example, in this task two defensive perimeters are present. However, there is no reason why a third perimeter might not be defined, and trainees forced to make decisions about how to deal with threats approach three, rather than two, perimeters. This is a step up in complexity from the original task, but is a logical extension of what has been learned. Similarly, trainees might be presented with scenarios in which certain key pieces of strategic information (e.g., speed) are absent, and be forced to make decisions about what information available within the task constitutes the best substitute for the lost information. The flexibility of the SJT, and its capacity to alter the presentation of the task in subtle but meaningful ways that require trainees to adapt what they know to slightly different situations, makes it an ideal mechanism for assessing adaptive knowledge. The relevance of SJTs should become more clear as we consider in greater detail how they are typically constructed.

The procedure utilized by Motowidlo, Dunnette, and Carter (1990) in the development of their low-fidelity simulation is in many ways one with the potential to generalize beyond their content domain. The first step of their development process involves a review of previous job analyses to determine the core skills necessary for the performance of the task(s) to be trained. Such prior documentation is useful, but it is not necessary if time and money are available to conduct a job analysis for the express purpose of developing an SJT. In a training context, the core skills will have been identified in the training goals and built into the training program itself; hence, while a job analysis may have been conducted at some point prior to the training program to assist in program development, it is not strictly necessary as the trainer will certainly possess a great deal of knowledge about the goals and intent of training. For our purposes, consider the "job analysis" to have focused on the kinds of self-regulatory activities central to Kozlowski et al.'s (1998) framework. Hence, we are interested in trainees being able to (1) engage in active thought about the task, (2) use strategies and comprehend the complexities of the task, and (3) adapt to changes within the rules or difficulty of the task.

Once the core skill dimensions have been identified, the next step in the development process involves developing critical incidents of performance based on the training task(s). Depending on the expertise level of the trainer, this step may or may not require outside assistance. Again, if the goals of the training program are clear, then it should not be unrealistic to expect the trainer to be able to generate critical incidents of good and poor performance of the skills that are focal to training. The kinds of critical incidents designed for the SJT utilized here focused on combining the three general competencies abstracted above, when considered in the context of specific mastery goals relevant to the task of interest.

With critical incidents collected, the next step in the development of a situational judgment test involves writing descriptions of task situations. These situations should reflect the behavioral categories determined by the job analysis. In general terms, trainers should consider the contexts in which the elements of training may need to be applied, and write descriptions of situations corresponding to those types of contexts. Plausible alternative responses should then be considered, and framed as response options to the situations.

After the response options have been selected, the next step in such an effort involves asking subject matter experts (SMEs) to evaluate the relative effectiveness of the alternate strategies for each task situation. Any individual with expertise in the subject matter may serve this role for the trainer. If a specific task is being used during training, for example a word processing task, then individuals who have a great deal of experience with the task should be recruited to assess the quality of the potential responses. The best and worst alternative strategies must be identified, and all options are rated as to their effectiveness. From these data the most and least effective response options are determined.

The scoring system is dualistic, in the sense that respondents are asked to rate the response option they would most likely choose as well as that which they would least likely choose. The option determined to be the "best" via the responses of the SMEs is assigned a score of +1 if it is the "most likely" response for an individual, and a score of -1 if it is the "least likely" response. Similarly, the "worst" item is assigned a score of +1 if it is the "least likely" response, and -1 if it is the "most likely." All other responses are coded as zero, so the score on any given item ranges from -2 to +2.

The procedure and scoring system outlined above, while described in Motowidlo et al. (1990) can obviously generalize to a variety of situations. It is not content-driven, and as such has the potential for broad applicability.

That self-regulation is critical to the development of adaptability should be clear based on the literature review presented above. Potential behaviors in which trainees may engage are considered and rated by SMEs, such that appropriate responding to the SJT indicates that trainees engage in the same basic processes surrounding the self-regulation of their own behaviors that more experienced performers do. Trainees must also be able to monitor their cognitions appropriately, and determine the important information that must be abstracted from a scenario and how to use it, and they must believe themselves to be capable of performing well on the task if they are to perform well on a simulation of it. The inferences we wish to make about the importance of self-regulation to appropriate responding on the SJT are reinforced to a large extent by the role self-regulation must play in the development and assessment of the questions that make up the test itself.

To this point, I have mentioned a large number of constructs. In the next section I am going to review the critical constructs for this research, and then move on to a discussion of my specific research hypotheses, which should follow naturally from the preceding review.

Construct Definitions

Self-Regulatory Skill

Individual differences should exist in the capacity to self-regulate appropriately (Pintrich, Smith, Garcia, & McKeachie, 1993). How these manifest depends on the operationalization of self-regulatory activity. In this study, self-regulatory activity is defined in terms of the extent to which trainees self-monitor their goals, feedback, learning, performance, and progress on the task. Self-regulatory skill, for the purposes of this study, is therefore the extent to which trainees generally tend to monitor goals, feedback, learning, performance, and progress, independent of context.

Cognitive Ability

The general mental capacity of individuals has consistently been shown to be predictive in a variety of domains. While cognitive ability is not a focal IV or DV in this study, it is reasonable to expect it to have an impact on task performance due to the complex, cognitively-loaded nature of task performance. As such, cognitive ability will be assessed for use as a covariate in this study.

Mastery Goal Orientation

The literature on educational psychology draws a distinction between two primary types of goal orientation. Individuals with a mastery goal orientation tend to adopt goals which focus on improving skills and increasing competence (Duda & Nicholls, 1992). They also tend to prefer challenging tasks, which require them to learn new information or skills (Button, Mathieu, & Zajac, 1996).

Performance Goal Orientation

Individuals who adopt a performance goal orientation, by contrast, then to focus on goals designed to help them perform well and to look good in comparison to others (Meece, 1994). They are more concerned with demonstrating competence, rather than developing competence. They tend to prefer tasks where they know they will be able to perform well, and where they will receive praise for their efforts (Button et al., 1996).

Practice Variability

The literature supports the contention that providing trainees with variable practice results in the development of more generalizable skills than having them practice the same version of a task every time (e.g., Hatano & Inagaki, 1986; Holyoak & Spellman, 1993). Practice variability will be accomplished in this experiment by altering the position and meaning of targets across 9 training scenarios. While the difficulty will not be altered as a result, the nature of the practice experience will vary as trainees attempt to map task features onto the different scenarios.

Velocity Feedback

Velocity feedback is that which allows trainees to track their progress over the course of training (Kluger & DeNisi, 1996; Hsee & Abelson, 1991). In this study, velocity feedback will be based on feedback provided to trainees following each training session which should allow them to gauge their progress in a variety of areas. Trainees will be provided with score information, where score is computed by adding 100 points for every target prosecuted correctly and subtracting 100 points for every target prosecuted incorrectly. 10 additional points will be subtracted for every target crossing a defensive perimeter during a training trial. Information on the three components of score, as discussed above, will also be provided. Trainees will also be able to track the number of targets engaged (total, correct, and incorrect), the number of times they zoomed, and the number of pop-up targets engaged. This information will allow trainees several metrics they can use to track progress over the course of training. Moreover, trainees provided with such information will be provided with a "progress record sheet" on which they are asked to make estimates of their progress on the task (perceived percent improvement), further strengthening the velocity manipulation.

Self-Efficacy

Self-efficacy (as popularized by Bandura (1991) and others) is a trainee's task-specific belief in his or her capacity to perform. For the purposes of this study, it includes task-focused self-perceptions centering on trainees' capability to cope and develop methods for dealing effectively with the challenges, information, and decisions involved in the task (Kozlowski, Gully, Smith, Brown, Mullins, & Williams, 1996).

Self-Regulatory Activity

A review of the recent literature on self-regulation reveals similarities across approaches to its measurement which allow us to derive a general assessment of self-regulatory activity based on what trainees self-monitor. Kanfer and Ackerman (1989) assessed self-regulation in part via trainee monitoring of goals, feedback, performance, and progress. Smith (1996) developed a similar measure, in which the monitoring of goals, progress, performance, learning, and feedback were all assessed. Brown, Mullins, Weissbein, Toney, and Kozlowski (1997) utilized a measure of self-regulation in which items assessed the extent to which trainees monitored their goals, their progress, and their strategies. Finally, Ford, Smith, Weissbein, Gully, and Salas (1998) measured self-regulation in part by assessing trainee monitoring of progress, goals, learning, and performance.

In all four cases, trainee self-monitoring around goals and progress (in terms of where mistakes were made, where practice was needed, or both) were considered important aspects of self-regulatory activity. Actual monitoring of performance was assessed in three of the scales, while the monitoring of learning and feedback were assessed in two of the four scales. Based on the literature, then, self-regulatory activity as a construct will be treated as the amount of self-monitoring trainees do with respect to their goals, feedback, learning, performance, and progress on the task.

Declarative Knowledge

For this study, foundational knowledge about target cue values and the structure of decisions on the task must precede any other form of knowledge or skilled performance. Without a thorough understanding of how decisions can be made, and what the pieces of information that can be gathered to make these decisions mean, it is impossible for trainees to proceed. The declarative knowledge construct in this study therefore centers around knowledge of target cue values and knowledge of how decisions may be made in TEAMS/TANDEM.

Adaptive Knowledge

Trainees may be able to adapt what they have learned during training to other contexts. The literature suggests that such alterations may be in the objectives trainees must pursue, or the constraints placed on their existing knowledge base (Ren & Sheridan, 1995). Changing objectives may focus trainees on facets of the task that were previously not central. Constraints may involve the removal or alteration in meaning of information available within the task. Trainees will be forced to demonstrate knowledge of how to adapt to both changing objectives and knowledge constraints.

Basic Performance

Basic performance is the trainee's capacity to prosecute targets accurately. This is based on a thorough knowledge of the cue values and an understanding of how decisions are made in TEAMS/TANDEM. Basic performance is reflected by score on the task, excluding defensive perimeter intrusion penalties. Such penalties are not considered part of basic performance because they reflect attention to strategic components of the task. Basic performance is therefore equal to the number of targets prosecuted correctly, minus the number prosecuted incorrectly, times 100.

Strategic Performance

Strategic performance is reflected in the trainee's attention to elements of the task which allow him/her to make decisions about which targets are most important to prosecute. The number of times participants zoomed out, the number of marker targets hooked, the number of target speed queries at both inner and outer defensive perimeters, the number of inner and outer defensive perimeter intrusions, and the number of "high priority" targets engaged all reflect the use of strategies related to target prioritization and situational assessment.

Hypotheses

The hypotheses will be discussed in an order corresponding to their appearance in the theoretical model (see Figure 2). The model is intended to serve as a guide to the hypotheses. All of the elements of the model are represented in the hypotheses that follow. The training manipulations (practice variability and velocity feedback) are first hypothesized to influence the process variables (self-regulatory activity and self-efficacy). These process variables are then hypothesized to affect proximal training outcomes, which in turn affect distal training outcomes. The process variables are also hypothesized to mediate the relationship between the training manipulations and the proximal training outcomes, as the proximal training outcomes should mediate the relationship between the process variables and the distal training outcomes. Each of these hypotheses will be discussed in turn.

Practice Variability - Self-Efficacy. Self-efficacy is the trainee's assessment of his or her task-specific competencies (Bandura & Wood, 1989; Gist & Mitchell, 1992). Because trainees in variable practice conditions are going to be exposed to a broader array of tasks, it is reasonable to suggest that they will develop a greater degree of confidence that they are capable of meeting the challenges of the simulation. The presentation of challenges in variable training episodes is more likely to give the appearance of skill-building than will the presentation of an identical training experience with different goal sets applied over the course of the training program.

The argument might also reasonably be made that the consistency inherent in practicing the task in exactly the same way every time might increase trainee efficacy because consistency increases their familiarity and comfort with the task. In training situations we want our trainees to be adaptable, and capable of generalizing their skills, so we are more concerned that they develop dynamic self-efficacy (i.e., "I feel confident that I can meet any challenges that might arise from changes in this task"). It is therefore reasonable to hypothesize a positive relationship between practice variability and self-efficacy.

Hypothesis 1: Exposure to variable practice will be predictive of high self-efficacy among trainees.

Practice Variability - Self-Regulatory Activity. Recent training literature has begun to consider self-regulatory activity as an important element of training (e.g., Kanfer & Ackerman, 1989; Ford, Smith, Weissbein, Gully, & Salas, 1998; Smith, 1996; Brown, Mullins, Weissbein, Toney, & Kozlowski, 1997). This literature suggests that such activity is reflected in trainees' monitoring of several elements of training. They must monitor (a) the goals they are given, (b) the feedback they receive, (c) the learning in which they engage, (d) their performance, and (e) their progress on the task. These elements are all present in at least two of the studies cited above.

Schmidt and Bjork (1992) suggest that, "variable practice alters the practice context to force a change in behavior from trial to trial, encouraging additional information processing activities about the lawful relationships among the task variants" (p. 214). It is expected that processing about the relationships among scenarios centers around the self-monitoring activities listed above. Trainees should be monitoring their goals, feedback, learning, performance, and progress across scenarios. Individuals who do are exposed to constant practice scenarios will engage in less of the appropriate self-monitoring than will variable-practice trainees, as Schmidt and Bjork's (1992) argument would suggest.

Hypothesis 2: Exposure to variable practice will be predictive of increased self-regulatory activity among trainees relative to constant practice scenarios.

Velocity Feedback - Self-Efficacy. Velocity feedback, as discussed above, is information which allows individuals to make judgments about their progress on a task (Carver & Scheier, 1990; Hsee & Abelson, 1991; Kluger & DeNisi, 1996). The capacity to observe improvement over the course of a training program is likely central to individuals' beliefs regarding their potential to deal with the material from training and any changes which might arise in its generalization. Hence, we might expect that velocity feedback would predict self-efficacy.

Hypothesis 3: Exposure to velocity feedback will be predictive of high self-efficacy among trainees.

Velocity Feedback - Self-Regulatory Activity. The feedback individuals receive is linked to the self-regulatory activities in which they engage (Carver & Scheier, 1982, 1990). Feedback is also one of the elements of the training environment included as a focal point of self-monitoring in measurements of self-regulation (e.g., Kanfer & Ackerman, 1989; Smith, 1996). In some situations, feedback may reflect trainee performance relevant to the goals of training. Self-regulatory activity may be enhanced, however, by providing feedback which augments the goals of the training program. By providing velocity feedback in addition to mastery goals and sequenced mastery feedback we might expect that trainee self-regulatory activity should be focused on the changes that occur in their behavior and cognitions over time. Specifically, they should be focusing on what they are doing differently with respect to meeting their goals, utilizing their feedback, learning the task, performing on the task, and improving in all of those domains. This should occur in part because of the presence of information directly related to performance that velocity feedback provides. Their self-regulatory activity should thus be increased beyond those who do not receive velocity feedback, based on the increased focus provided on understanding how their performance and mastery of the material has developed over time.

Hypothesis 4: Exposure to velocity feedback will be predictive of increased self-regulatory activity among trainees.

Self-Efficacy - Proximal Training Outcomes. The literature contains substantial evidence of a link between self-efficacy and performance (e.g., Gist, Schwoerer, &

Rosen, 1989). Hypotheses 5 through 8 break down performance into two aspects of cognitive performance and two aspects of behavioral performance.

In terms of cognitive performance, two types of knowledge should be gained by trainees who are high in self-efficacy. First, trainees who believe themselves to be capable of performing the task should learn more basic declarative information (the basic information components and decision structure underlying training performance) than should individuals who are low in self-efficacy. Individuals who do not believe themselves to be capable of performing on the task will pay less attention to basic declarative information, and will therefore not learn it as well.

Hypothesis 5: Self-efficacy for the training task will be predictive of trainee declarative knowledge.

The second aspect of cognitive performance is represented by trainees' capacity to demonstrate adaptive knowledge. This is the capacity to take what was learned in training and apply it to situations in which the task has been altered. The literature suggests that such alterations may be in the objectives trainees must pursue, or the constraints placed on their existing knowledge base (Ren & Sheridan, 1995). In either case, a different context is created which should cause trainees to reconsider how to best proceed in order to reach their goals. Only trainees who believe themselves to be capable of performing the task will be able to adapt their knowledge to questions posed in a manner which requires adaptation.

Hypothesis 6: Higher self-efficacy for the training task will be predictive of high trainee adaptive knowledge.

Parallel predictions can be made about the behavioral components of task performance as well. First, basic task performance should be more likely to develop in individuals who believe themselves to be capable of performing the task. Basic performance is rooted in trainee information processing. It reflects the trainee's capacity to gather information and to make appropriate decisions based on that information. Trainees who possess low self-efficacy are unlikely to engage in the substantial information processing required for basic task performance.

Hypothesis 7: Higher self-efficacy for the training task will be predictive of high basic training performance.

Strategic training performance is the collection of behaviors in which trainees engage which allow us to infer their comprehension and utilization of advanced task strategies. Such advanced strategies are necessarily complex. A sense of personal competence arising from high self-efficacy is likely to promote greater exploration of such strategies relative to individuals with lower efficacy.

Hypothesis 8: Higher self-efficacy for the training task will be predictive of high strategic training performance.

Self-Regulatory Activity - Adaptive Knowledge. The self-regulatory activity hypothesized to result from the manipulations emphasized monitoring several aspects of the training scenarios. Trainees should, as a result of the manipulations, monitor their learning, performance, goals, feedback, and progress. If they monitor these things, we may expect that they will be better equipped to adapt what they have learned, based on the development of a deeper understanding of the training task and their skills in relation to it. Trainee self-regulatory activity should thus predict adaptive knowledge.

Hypothesis 9: Greater self-regulatory activity during training will be predictive of higher trainee adaptive knowledge.

Self-Regulatory Activity - Strategic Training Performance. A similar argument can be made for strategic performance as predicted by self-regulatory activity. Individuals who engage in the types of self-monitoring described above are more likely to have seen the necessity for adopting a strategic approach to the task, in order to have a general method for approaching the task as presented across scenarios. Individuals who actively monitor their goals, feedback, learning, performance, and improvement on the training task should come to a deeper understanding of the strategic elements of the task (these are reflected particularly in the goals and feedback), and should therefore have their strategic training performance enhanced.

Hypothesis 10: Greater self-regulatory activity during training will be predictive of higher strategic training performance.

Declarative Knowledge - Adaptive Knowledge. In order to develop adaptive knowledge about the training task, trainees must first possess basic declarative information about the task. That is, before trainees can adapt what they know, they must first know something. It is reasonable to expect that the more they know, the more advantaged they will be in this regard.

Hypothesis 11: Greater declarative knowledge about the training task should be predictive of higher adaptive knowledge about the training task.

Declarative Knowledge - Basic Generalization Performance. Declarative knowledge about the task should also be predictive of basic task performance during the generalization scenario. Recall that basic task performance is rooted in trainee information processing. Declarative knowledge about the task forms the basis for such information processing activities, and should thus be predictive of basic performance during the generalization scenario.

Hypothesis 12: High declarative knowledge about the training task should be predictive of high basic performance during the generalization scenario.

This hypothesis will be examined both in terms of the simple effect of declarative knowledge on basic generalization performance, and in terms of its effect when controlling for basic performance at the end of training.

Hypothesis 12a: High declarative knowledge about the training task should be predictive of high basic performance during the generalization scenario, controlling for basic performance at the end of training.

Adaptive Knowledge - Strategic Generalization Performance. Individuals who possess adaptive knowledge (the capacity to utilize what they have learned about the training domain when objectives change or constraints are introduced) will be more likely to demonstrate high strategic task performance during the generalization scenario. They have already shown that they are able to adapt what they know in a cognitive sense. This is one of the primary requirements for performing well during generalization. It should also be predictive of those behaviors which indicate a strategic approach to the task has been adopted.

Hypothesis 13: High adaptive knowledge about the training task should be predictive of high strategic performance during the generalization scenario.

An interesting question arises when we consider the prediction of strategic performance during generalization with adaptive knowledge. Is the adaptive knowledge test capable of predicting such performance better than it could be predicted with strategic training performance alone? If the measure of adaptive knowledge is to have any value, we must assume such to be the case. Utilizing the adaptive knowledge measure, we should be capable of predicting strategic generalization performance even when we control for strategic training performance. Hence this hypothesis will be tested as hypothesis 12 was, considering both the simple effects of adaptive knowledge on strategic generalization performance, as well as its ability to increment the variance explained by prior strategic performance.

Hypothesis 13a: High adaptive knowledge about the training task should be predictive of high strategic performance during the generalization scenario, controlling for strategic performance at the end of training.

<u>Training Performance - Generalization Performance</u>. The model suggests that if we want to predict generalization performance, we should first consider with trainee performance during training. This is consistent with long-standing theory in I/O psychology (e.g., Wernimont & Campbell, 1968).

Hypothesis 14: Basic performance at the end of training will be predictive of basic generalization performance.

Hypothesis 15: Strategic performance at the end of training will be predictive of strategic generalization performance.

The more interesting aspects of these linkages deal with the potential of the two knowledge measures for predicting generalization performance beyond training performance (hypotheses 12a and 13a).

Mediational Hypotheses. As a result of the manipulations, two primary processes are triggered in trainees which allow them to perform well on the various aspects of the task. First, trainee self-efficacy is increased, due to the trainees' exposure to different elements of the task and the presence of feedback that allows them to track their progress over time. Second, trainee self-regulatory activity is enhanced, with respect to the critical elements of the training task identified from the literature. These intervening mechanisms allow us to better understand how training manipulations lead to proximal training outcomes. Training manipulations such as these succeed because trainees believe themselves to be capable of performing on the task, and self-regulate an appropriate amount. Consistent with this logic, I propose that self-efficacy and self-regulatory activity mediate the relations between the training manipulations and the proximal outcomes of training.

Hypothesis 16: Self-efficacy and self-regulatory activity will mediate the relationship between the training manipulations (practice variability and velocity feedback) and the proximal training outcomes (declarative knowledge, adaptive knowledge, basic training performance, and strategic training performance).

Similarly, self-regulatory activity and self-efficacy should be expected to have effects on generalization performance. Individuals who self-regulate more, and are more efficacious, should be expected to perform better when the task changes on them. As above, though, these effects should occur primarily through the mediating mechanisms of the proximal training outcomes.

Hypothesis 17: The proximal training outcomes (declarative knowledge, adaptive knowledge, basic training performance, and strategic training performance) will mediate the relationship between the process variables (self-efficacy and self-regulatory activity) and the distal training outcomes (basic generalization performance and strategic generalization performance).

Method

Design

Overview. The experiment utilized a 2 (practice; variable vs. constant scenarios) x 2 (feedback; mastery vs. mastery and velocity) fully-crossed between subjects design. All participants received sequenced mastery training goals onto which manipulated parameters (practice and velocity feedback) were applied. The experiment took place in a single session lasting approximately three and one-half hours. Participants engaged in nine practice scenarios spread across three blocks, with each practice scenario lasting four minutes. Within-subjects factors therefore included blocks (3) and scenarios (9). Following the training blocks, participants took part in a single four-minute post-training trial which was identical for all conditions, followed by a generalization scenario in which the workload was increased and the rules underlying the task were modified. The generalization scenario was also identical for all conditions.

Simulation. The PC-based naval radar simulation TEAMS/TANDEM (Kozlowski, 1996; Weaver, Bowers, Salas, & Cannon-Bowers, 1995; Weaver, Morgan, Hall, & Compton, 1993) was used as an experimental platform for this research. This simulation is an ideal platform for training research because of its capacity to examine learning and skill acquisition in complex, dynamic environments. Participants must gather information from their radar screens by selecting ("hooking") a target, gathering information about that target, and making a decision about the disposition of that target. They must also make strategic decisions about which targets to engage. Some targets will prove more threatening than others and must therefore be dealt with first. These aspects of the task make it possible to examine two dimensions of performance, one based on information processing, and the other based on strategic understanding of the task.

Four decisions must be made about each target, in the appropriate order. First, trainees must make a decision about whether the target is an Aircraft, Submarine, or Surface vessel. This is the "Type" decision, and is made using target speed, target communication time, and target altitude as the critical cues. Second, trainees must decide whether a target is civilian or military (the "Class" decision). Here, the critical cues are direction of origin, maneuvering pattern, and intelligence. Third, trainees must decide whether the target is peaceful or hostile (the "Intent" decision) using countermeasures, threat level, and response cues. Once the Type, Class, and Intent decisions have been made, trainees must make the final engagement decision by shooting hostile targets or clearing peaceful targets.

<u>Skill components</u>. The comprehensive manual available to all participants throughout training documents three skill sets: basic functionality, declarative knowledge, and strategic knowledge.

Basic functionality on the task involves developing an understanding of the features of the program (hardware and software) that make it possible to perform on the task. These features include hooking targets, accessing cue menus, and "zooming" to alter sensor ranges. PC features such as the appropriate use of a mouse and keyboard also fall under "basic functionality." All elements of basic functionality must be developed early in training, to ensure trainees have the opportunity to learn and practice the more complex task components.

The declarative knowledge component is required if trainees are to process information and render appropriate decisions. It includes (a) cue information for target decisions and (b) the structure of the underlying decision model. The cue information is accessed from pull-down menus, and three cues are available for each of three component decisions. Knowledge of the meaning of these cues is essential for later skill development because the cues form the basis for the appropriate prosecution of targets. The TEAMS/TANDEM decision model involves understanding those component decisions and the order in which they must be made. Trainees are instructed to make the decisions in a certain order: first target Type (air, surface, submarine); then target Class (civilian or military); and last, target Intent (peaceful or hostile). The final decision depends solely on the target's Intent. The final decision (shoot or clear the target) can only be made after all three of the subdecisions are made in the appropriate order. The structure of the decision sequence is therefore relevant to the order in which the subdecisions are made.

Five skills are relevant to strategic performance on the task. Participants need to use the zoom function in order to "zoom out" to assess the situation beyond the radius of their initial radar screen. This is critical because of the presence of two defensive perimeters with which trainees must concern themselves. The inner defensive perimeter is located at 10 nautical miles, and is visible as a cross-hatched region at the center of the initial radar display. The starting radius of the radar display is only 32 nautical miles, so trainees have no way of knowing how many targets are approaching their outer defensive perimeter at 256 nautical miles. Because targets crossing either of the two defensive perimeters (at 10 or 256 NM) result in penalties (a deduction of 10 points/crossing during the training trials), it is essential trainees learn where these perimeters are. While the inner perimeter is clearly visible, there is no marking for the outer defensive perimeter. Stationary "marker" targets are just inside the invisible outer perimeter. Trainees can hook these targets and then zoom out to 512 NM to determine where on their screen the outer perimeter is located. In this way, they are better able to identify those targets likely to cross the outer perimeter. Trainees must also decide which targets constitute the greatest threats to their defensive perimeters, and which perimeter is more critical to monitor. Faster targets are of higher priority, since they are more likely to penetrate a perimeter than slow-moving targets. Trainees generally need to be able to "trade-off" targets approaching their inner and outer defensive perimeters. Here, strategic decisions revolve around the number of targets near each perimeter, their priority, and their "cost" in points if they penetrate.

Performance Dimensions. Two types of performance can be assessed using data collected with TEAMS/TANDEM. These performance dimensions parallel the two types of knowledge (declarative and strategic) discussed above. The first is basic performance. This is reflected in trainee score based on targets prosecuted correctly and incorrectly. This variable is non-identical to the score trainees in velocity feedback conditions receive as part of their feedback, because it is computed without attention to penalty circle intrusions. Hence, basic performance is simply the number of targets prosecuted correctly, minus the number of targets prosecuted incorrectly, times 100. In order to obtain high basic performance, trainees must learn the cue values associated with the decisions to be made, along with the decision structure for the task.

Strategic performance deals with the behaviors in which trainees engage during training that indicate strategy use. For the purposes of this research, five types of strategic performance are relevant. Each was discussed in the previous section in terms of strategic knowledge. My discussion here will expand them to demonstrate how strategic performance can be assessed using information available within TEAMS/TANDEM.

The number of times participants zoom out is an indicator of their attention to elements of the task beyond the scope of their initial radar display. Potentially threatening targets may appear at any point on the radar screen. Trainees must learn to monitor their entire radar screen if they are to prosecute such targets before they penetrate a defensive perimeter. The importance of preventing perimeter intrusions is stressed in the operating manual given to all trainees. A high number of times a trainee zooms out indicates a strategy focusing on understanding the scenario as a whole, and preventing targets from crossing either defensive perimeter.

Second, the number of marker targets hooked is indicative of trainee attention to the outer defensive perimeter. As with zooming out, hooking marker targets (stationary targets located just inside the outer defensive perimeter) indicates a trainee strategic focus on assessing the situation. A high number of hooked marker targets allows us to infer that trainees have adopted a strategy in which they are focusing on stopping targets from crossing defensive perimeters. The hooking of marker targets allows trainees to make strategic decisions about which targets are approaching the outer defensive perimeter, and must therefore be dealt with.

The number of target speed queries at both inner and outer defensive perimeters is also of strategic importance. Speed queries are a critical strategic element of the task. They reflect trainee attention to target prioritization. Targets which move fast are more likely to penetrate a defensive perimeter, and should therefore be assigned a higher priority than targets that move slowly. A high number of speed queries is indicative of a strategy focusing on identifying and prosecuting those targets most likely to penetrate a defensive perimeter.

The number of inner and outer defensive perimeter intrusions allowed is an indicator of strategy effectiveness. Allowing few defensive perimeter intrusions indicates that trainees have adopted a strategy in which they are focusing on preventing targets from crossing their defensive perimeters, and are selecting targets based on the likelihood that they will do so.

Finally, the number of "high priority" targets the trainee engages is an indicator of strategy use. Targets are of higher priority if they are (a) moving fast, and (b) close to a defensive perimeter. A total of 7 "high priority" targets were present in each scenario, with 4 such targets near the inner defensive perimeter and 3 such targets near the outer defensive perimeter. Identifying and prosecuting high priority targets rather than low priority targets is an indicator of high-level strategy use and game comprehension on the part of trainees.

Thus, four indicators are relevant to our assessments of strategic performance. The number of times participants zoomed out, the number of marker targets hooked, the number of target speed queries at both inner and outer defensive perimeters, and the number of inner and outer defensive perimeter intrusions all reflect the application of strategies.

Procedure

Participants. Undergraduate students at Michigan State University were recruited from the psychology subject pool and through visits to classes. 332 individuals took part in the study; as pre-study power analyses based on Cohen's (1988) power tables provided an estimate of statistical power between .96 and .99 for 200 participants, it is reasonable to expect that statistical power was ensured by collecting data from additional experimental participants. 14 participants were discarded from all analyses for one of several reasons. Participants were removed from the dataset if they (1) indicated they had attended an experiment in that lab prior to the current experiment, (2) did not complete the experiment, or (3) demonstrated motivational or other problems during the course of the experiment, which were noted in the experimenter's log and were deemed severe enough to warrant excluding the participant from the dataset. Of the 317 remaining participants, 79 were in the variable practice/velocity feedback condition, 79 were in the variable practice/no velocity condition, 78 were in the constant practice/velocity feedback condition, and 82 were in the constant practice/no velocity condition.

Informed consent. Consistent with UCRIHS guidelines, prior to the beginning of the experiment all subjects were required to read, sign, and date a consent form providing a general description of the study, as well as its risks and benefits. Following the study, participants were debriefed. The consent form is presented in Appendix A, and the debriefing sheet is in Appendix B. Permission was granted by UCRIHS for the conduct of this experiment.

Experimental training/demonstration. Following completion of the initial questionnaires, trainees were provided with a brief (five minutes) training session in which the experimenter demonstrated basic task features. The experimenter demonstrated use of the mouse for hooking targets and using the pull-down menus, and explained the basic decision structure of the game. The feedback screens were explained, as was the manner in which trainees progress through the experiment. They were told that they would go through three blocks of study, practice, and feedback cycles, followed by an opportunity to demonstrate how much they learned on a more difficult and challenging version of the task.

Experimental protocol. When all participants had arrived (or at five minutes past the scheduled start time), introductory materials were read and they were asked to read and sign a consent form. Once the consent form was completed, the initial scales were distributed. These scales included demographic, self-regulatory skill, and goal orientation items. After trainees completed these scales, the Wonderlic Personnel Test was administered. When all measures were completed, a demonstration of the task was conducted. Manuals were distributed, and participants were given five minutes to familiarize themselves with the manual.

After the five minutes were up, participants were given the mastery goal sheets for session 1 and given two minutes to study the manual to determine how to best meet the goals for the first session. After two minutes elapsed, participants were instructed to begin the first scenario. The training scenarios each lasted four minutes. Three training scenarios (i.e., trials) was conducted in each of three training sessions, for a total of nine scenarios. Each scenario was preceded by a two-minute study period, and followed by a two-minute period in which participants had the opportunity to review feedback from that scenario. An experimental diary, in which trainees were asked to report the goals they sought to achieve during the previous session, was completed prior to the presentation of feedback. This diary served as a supplemental assessment of self-regulatory activity, and was collected prior to feedback to ensure that the feedback did not serve to prime diary entries.

After the end of the first block and the end of the third block, trainees were given questionnaires to answer, including a declarative knowledge test and the situational judgment test assessing adaptive knowledge. They were also given measures designed to assess their self-regulatory activities, with respect to the self-monitoring of their goals, feedback, learning, performance, and progress. Their self-efficacy was also assessed. Once these tests were completed following the first and third blocks, trainees were given a short (five minutes or less) break.

After the break following the third block, participants were told that they had one final opportunity to practice their skills before moving to the generalization trial. All participants then took part in an identical post-training trial. This trial was included to allow the end-of-training performance measures to be endogenous relative to the paper-and-pencil measures collected following the ninth scenario. All study materials were removed for the purposes of this post-training trial. Once the post-training trial was completed, trainees were given instructions regarding the generalization scenario; they were told that the final scenario is more difficult, that the rules of engagement have changed and that there are many more targets to deal with. They were then given two minutes to look over a sheet detailing the changes in the task and develop a strategy.

Training scenarios. Each training scenario contained 22 targets. Of these targets, 15 first appeared in the region between the inner and outer defensive perimeters, and 7 initially appeared outside the outer defensive perimeter. The scenarios were scripted so that 4 targets would penetrate the inner defensive perimeter and 3 targets would penetrate the outer defensive perimeter, if no action were taken against any target. The number of targets, their placement relative to the perimeters, and the proportion that cross each defensive perimeter were constant across all scenarios and conditions.

Generalization scenario. Following the nine training scenarios, trainees were given detailed information regarding the generalization scenario. In the generalization scenario, the number of targets increased from 22 to 60 (a 172% increase), and the rules of engagement were modified. The inner defensive perimeter became worth 175 points, and the outer defensive perimeter became worth 125 points (per target that crossed the perimeter). In training, each target that crossed either defensive perimeter resulted in a deduction of 10 points from the trainee's score. In addition, more "pop-up" targets, which appear suddenly on the screen, were included, more targets attempted to cross the defensive perimeters, many of the "pop-ups" appeared very close to the defensive perimeters, and perimeter intrusions were differentially distributed, with many more targets approaching the outer than the inner perimeter. Increasing the difficulty and modifying the rules enables us to determine the extent to which trainees are able to adapt the skills they gained during training to more complex situations.

Goals. All trainees were provided sequenced mastery goals. A set of goals were given to trainees at the beginning of each of the three blocks of scenarios. The first goal set (scenarios 1-3) instructed trainees to learn target cue values, learn how to make correct engagement decisions, and explore the game and get familiar with their equipment. The second goal set (scenarios 4-6) instructed trainees to learn how to regularly "zoom-out" to see the "big picture," learn to find "markers" to check targets just outside their outer perimeter, and learn to defend their inner and outer perimeters. The final goal set (scenarios 7-9) instructed trainees to learn prioritization strategies and learn how to "trade-off" targets approaching their inner and outer perimeters. Learning advice on how to best accomplish these goals was also provided to all trainees.

Incentives. Participants were informed of awards offered for two categories of task proficiency at the beginning of the experiment. They were told that the first award would be made for the players who did the best on the final, more difficult version of the task at the end of the practice sessions. They were told that the second award would be made for the players who were most adept at answering the questions presented throughout the task. This award was based on a composite score computed for each participant on the declarative and adaptive knowledge measures by adding together scores on the final administrations of each test. For each award, monetary incentives were offered for the top four participants, meaning that eight total monetary awards were given out. Written instructions detailing the incentives were provided at the beginning of the experiment, and participants were reminded of the incentives prior to the generalization scenario. The instructions are presented in Appendix C.

Manipulations

Practice. The literature suggests that the extent to which individuals are exposed to variable, as opposed to constant, practice opportunities, will affect the development of knowledge and skills (Hatano & Inagaki, 1986). Individuals receiving variable practice scenarios should develop skills that are more capable of generalizing than should individuals who practice the same scenario every time. One condition (constant practice) practiced the same scenario every time; this scenario presented targets at the inner and outer defensive perimeters and provided the opportunity for trainees to practice all of the critical skills as they learned them.

Participants in the variable practice condition practiced a scenario that looked different every time. The scenarios were presented in the variable practice condition to allow trainees to attend to less complicated elements of the task first. The apparent complexity of the task increased in a manner consistent with trainees' experience of the task domain. The number of targets initially visible changed, as did the location and meaning of targets on the radar screen. The absolute number of targets did not change, however, nor did the proportion of targets that began inside and outside of the defensive perimeters. The number of targets that crossed the defensive perimeters did not change, though these crossings may be more salient in some scenarios than in others, again reflecting changes in trainee focus that will naturally take place across training. The difficulty of the scenarios was therefore constant, though the necessity to engage in variable practice should enhance trainee self-regulatory activity by allowing a broader array of experiences. The final training scenario was identical for all participants, as was the generalization scenario. This allows statements to be made about relative performance across conditions at the conclusion of training and during generalization.

Feedback. Feedback was provided using the FASTBACK program developed for use with this research paradigm. All participants received feedback relevant to the mastery goals. Half of the participants received additional velocity feedback reflecting their score on the task. Score was computed by the program by adding 100 points for every target prosecuted correctly, subtracting 100 points for every target prosecuted incorrectly, and subtracting an additional 10 points (during training) for each target that crossed the defensive perimeter. Both score and the constituent elements of score were provided to participants in the velocity feedback conditions, as was other information which should allow them a sufficient basis to track their progress over the course of training. Individuals receiving velocity feedback were also asked to complete a "Progress Record Sheet," on which they were instructed to make an estimate of how much progress they'd seen in their game-play on TAG from one trial to the next. This was included to strengthen the velocity manipulation, and to ensure that trainees were thinking of the feedback they received in "velocity" terms (i.e., change over time). Mastery feedback was sequenced to parallel the goals for both the velocity and no-velocity conditions, to ensure that the only velocity information trainees receive comes from the score information and its components. A listing of all potential feedback information is contained in Appendix D.

Control Measures

Demographic information. Age, sex, computer experience, and other relevant demographic information were collected at the beginning of training to ensure the comparability of conditions and for potential use as covariates.

Cognitive ability. The Wonderlic Personnel Test was used as an index of cognitive ability. The test reflects multiple domains of cognitive functioning, and the user's manual for the test (Wonderlic, 1992) offers acceptable levels of validity (.63) and reliability (ranging from .73 to .95 based on the type of reliability estimated). This test was administered at the beginning of training.

Goal orientation. In order to control for dispositional influences on the manipulations, I gathered information on trainee goal orientation using two 8-item scales developed by Button, Mathieu, and Zajac (1996). Responses to these scales were made on five-point Likert scales ranging from "Strongly Agree" (5) to "Strongly Disagree" (1). Coefficient alpha reliability estimates for this and all other scales are included in the correlation matrix in Table 2. These scales, and all others, are included in Appendix E.

Goal commitment. Seven-item measures of goal commitment (Hollenbeck, Williams, & Klein, 1989) were collected at the conclusion of each pre-training goal manipulation. Responses to this scale were made using a 5-point response format identical to the format utilized for the Button et al. (1996) goal orientation measure described above. This scale is included in Appendix E.

Self-regulatory skill. A set of items were written to parallel the self-regulatory activity items at a more general level. Eleven items were written based on their relevance to self-regulatory skills important to learning. A sample item is, "When I'm practicing a new skill, I monitor how well I'm learning its requirements." Responses to this scale were made using a 5-point response format ranging from "Not At All True of Me" to "Very True of Me." This scale is included in Appendix E.

Process and Outcome Measures

Self-efficacy. Self-efficacy was assessed following scenarios three, six, and nine, utilizing an 8-item self-report measure developed specifically for this research paradigm (see Kozlowski et al., 1996). This measure uses a Likert-type scale rather than confidence ratings, with self-efficacy operationalized in terms of task-focused self-perceptions with item content centering on trainees' capability to cope and develop methods for dealing effectively with the challenges, information, and decisions involved in the task. Previous research has estimated the internal consistency reliability of the scale to be between .84 and .95 (Mullins, Brown, Toney, Weissbein, & Kozlowski, 1998; Kozlowski et al., 1996). This scale is included in Appendix E, and was collected at the end of each scenario block (following scenarios 3, 6, and 9).

Basic task knowledge. Basic declarative knowledge regarding the task was also assessed following scenario 3 and scenario 9. Nineteen multiple-choice items focusing on the extent to which participants had learned basic declarative information necessary to performance on the task were utilized, focusing on target cue values and the structure of the decision sequence required by the task. This measure is presented in Appendix E.

Adaptive task knowledge. A measure of adaptive knowledge was developed for use in this study, utilizing situational judgment questions. These questions presented respondents with game-play scenarios and asked for the identification of the most and least effective potential responses. Questions were developed around the training goals that focused on the types of strategic skills necessary for adaptive performance to develop. This measure was structured in such a way as to require trainees to move beyond their direct experience with the task. It forced them to adapt their knowledge and skills with TEAMS/TANDEM to new situations or task features. A pilot test of this measure prior to data collection for the full experiment ensured the a priori keying of the items corresponded to independent expert judgments of the correct adaptive responses to the scenarios. Four experts were provided copies of the measure, and asked for their responses to the items. Any item on which at least three of the four experts did not agree with the author's *a priori* coding of the item was rewritten to clarify the item intent. Nine items were used. These items are presented in Appendix E.

Self-regulatory activity. A review of the recent literature on self-regulation reveals similarities across approaches to its measurement which allow us to derive a general assessment of self-regulatory activity based on what trainees self-monitor. Kanfer and Ackerman (1989) assessed self-regulation in part via trainee monitoring of goals, feedback, performance, and progress. Smith (1996) developed a similar measure, in which the monitoring of goals, progress, performance, learning, and feedback were all assessed. Brown et al. (1997) utilized a measure of self-regulation in which items assessed the extent to which trainees monitored their goals, their progress, and their strategies. Finally, Ford et al. (1998) measured self-regulation in part by assessing trainee monitoring of progress, goals, learning, and performance.

In all four cases, trainee self-monitoring around goals and progress (in terms of where mistakes were made, where practice was needed, or both) were considered important aspects of self-regulatory activity. Actual monitoring of performance was assessed in three of the scales, while the monitoring of learning and feedback were assessed in two of the four scales. Consonant with the literature, then, a scale was written which tapped these five domains within self-regulatory activity. Because the scale is constructed in such a manner as to reflect what the literature treats as indicative of self-regulatory activity, higher scores on the scale may be taken to mean that trainees are self-regulating more. This scale is included in Appendix E.

A supplemental assessment of the relevance of trainee self-regulation was collected following each training scenario. Trainees were asked to record, in an "experimental diary," the goal or goals they focused on during the previous session. It is reasonable to expect that trainees who reported focusing on the goals they had been assigned for a specific scenario block, rather than other goals, are engaging in self-regulatory activities that are more relevant to the task. Any reported goal corresponding to one of the mastery goals trainees were assigned for that session was scored +2. Reported goals corresponding to a mastery goal from any other scenario will be scored +1. All other responses will be scored 0. A second coder was trained to ensure reliable coding of responses. This supplemental assessment was purely exploratory, and was included to determine if this represented a valid approach to identifying the relevance of trainee self-regulatory activity. As such, it was not included as an explicit part of the experimental model or hypotheses.

Post-Experimental Screening Measures

Two scales were included to allow the identification of trainees whose data might be of questionable utility. Trainee motivation is critical in this regard. Trainees who report being demotivated at the end of the experiment may have provided questionable data. The same may be said of trainee satisfaction with the feedback provided. The data of participants whose motivation or feedback scores fell more than three standard deviations below the mean were discarded from all analyses.

Motivation. Trainee motivation for the experiment was assessed using four items administered following the generalization scenario. A sample item is, "I tried to make good choices in determining the best and worst options on the sample scenarios I was presented." This scale is included in Appendix E.

Feedback satisfaction. Trainee satisfaction with the feedback provided was assessed using ten items administered following the generalization scenario. This scale is included in Appendix E.

Analyses

The analysis plan for this study is detailed in Table 1. For each hypothesis, the specific analysis relevant to understanding the relevant effect is detailed. All analyses centered around the use of regression or MANCOVA-based analyses.

Table 1: Hypotheses, Constructs, Measures, and Analysis Plan

Hypothesis	Constructs	Measures	Expected Outcome/Analyses
H1: Variable practice will lead to increased self-efficacy, relative to consistent practice.	Practice Variability, Self-Efficacy	Practice Variability: Manipulated – identical scenarios each time, or scenarios varying across trials. Self-Efficacy: 8-item scale. Task-focused self-perception of the trainee's capability to cope and deal with the simulation's challenges (Kozlowski, Gully, Smith, Brown, Mullins, & Williams, 1996).	Regression predicting self-efficacy with both training manipulations should demonstrate both are significant predictors.
H2: Variable practice will lead to greater self-regulatory activity than will consistent practice.	Practice Variability, Self-Regulatory Activity	Practice Variability: As above Self-Regulatory Activity: 6-item scale focusing on the extent to which trainees monitored their goals, their improvement on the task, their performance, their learning, and the feedback provided.	Regression predicting self-regulatory activity with both training manipulations should demonstrate both are significant predictors.
H3: Velocity feedback will enhance the development of self-efficacy relative to a no velocity feedback condition.	Velocity Feedback, Self-Efficacy	Velocity Feedback: Manipulated – velocity (score) feedback information is either available or not available. Self-Efficacy: As above.	Regression predicting self-efficacy with both training manipulations should demonstrate both are significant predictors.
H4: Velocity feedback will enhance self-regulatory activity relative to a no velocity feedback condition.	Velocity Feedback, Self-Regulatory Activity	Velocity Feedback: As above. Self-Regulatory Activity: As above.	Regression predicting self-regulatory activity with both training manipulations should demonstrate both are significant predictors.

table continues

Table 1, continued

Hypothesis	Constructs	Measures	Expected Outcome
H5: Self-efficacy at the end of training will predict declarative knowledge at the end of training.	Self-Efficacy, Declarative Knowledge	Self-Efficacy: As above. Declarative Knowledge: 19-item measure constructed to assess trainee knowledge of TANDEM cue values and decision structure.	Regression in which self-efficacy significantly predicts declarative knowledge at the end of training.
H6: Self-efficacy at the end of training will predict adaptive knowledge at the end of training.	Self-Efficacy, Adaptive Knowledge	Self-Efficacy: As above. Adaptive Knowledge: Situational judgment-type test constructed to tap into procedural and strategic task knowledge domains.	Regression predicting adaptive knowledge with self-efficacy, declarative knowledge, and self-regulatory activity should demonstrate all are significant predictors.
H7: Self-efficacy at the end of training will predict basic task performance (training skill) in the final training trial.	Self-Efficacy, Basic Task Performance (training)	Self-Efficacy: As above. Basic Task Performance: Score on the simulation, as computed by adding 100 points to trainee score for ever target engaged correctly, and subtracting 100 points for every target engaged incorrectly. Collected during the final training trial.	Regression in which self-efficacy significantly predicts basic task performance at the end of training.
H8: Self-efficacy at the end of training will predict strategic task performance in the final training trial.	Self-Efficacy, Strategic Task Performance (training)	Self-Efficacy: As above. Strategic Task Performance: The number of times trainees used the "zoom out" feature, hooked marker targets, made speed queries, and allowed defensive perimeter intrusions. Collected during the final training trial.	Regression predicting strategic task performance with both self-efficacy and self-regulatory activity should demonstrate both are significant predictors.

table continues

Table 1, continued

Hypothesis	Constructs	Measures	Expected Outcome
H9: Self-regulatory activity at the end of training will predict adaptive knowledge of the training domain at the end of training.	Self-Regulatory Activity, Adaptive Knowledge	Self-Regulatory Activity: As above. Adaptive Knowledge: As above.	Regression predicting adaptive knowledge with self-efficacy, declarative knowledge, and self-regulatory activity should demonstrate all are significant predictors.
H10: Self-regulatory activity at the end of training will predict strategic task performance (training skill) in the final training trial.	Self-Regulatory Activity, Strategic Task Performance (training)	Self-Regulatory Activity: As above. Strategic Task Performance: As above.	Regression predicting strategic task performance with both self-regulatory activity and basic task performance (all at the end of training) should demonstrate both are significant predictors.
H11: Declarative knowledge at the end of training will be predictive of adaptive knowledge at the end of training.	Declarative Knowledge, Adaptive Knowledge	Declarative Knowledge: As above. Adaptive Knowledge: As above.	Regression predicting adaptive knowledge with self-efficacy, declarative knowledge, and self-regulatory activity should demonstrate all are significant predictors.
H12: Declarative knowledge at the end of training will be predictive of basic task performance during generalization.	Declarative Knowledge, Basic Task Performance (generalization)	Declarative Knowledge: As above. Basic Task Performance: As above, but collected during the generalization trial.	Regression predicting basic task performance during generalization with both declarative knowledge and basic task performance during training should demonstrate both are significant predictors.

table continues

Table 1, continued

Hypothesis	Constructs	Measures	Expected Outcome
H13: Adaptive knowledge at the end of training will be predictive of strategic task performance during generalization.	Adaptive Knowledge, Strategic Task Performance (generalization)	Adaptive Knowledge: As above. Strategic Task Performance: As above, but collected during the generalization trial.	Regression predicting strategic generalization performance with both adaptive knowledge and strategic task performance during training should demonstrate both are significant.
H14: Basic task performance at the end of training will be predictive of basic task performance during generalization.	Basic Task Performance (training), Basic Task Performance (generalization)	Basic Task Performance: As above, collected during both training and generalization.	Regression predicting basic task performance during generalization with both declarative knowledge and basic task performance during training should demonstrate both are significant predictors.
H15: Strategic task performance at the end of training will be predictive of strategic task performance during generalization.	Strategic Task Performance (training), Strategic Task Performance (generalization)	Strategic Task Performance: As above, collected during both training and generalization.	Regression predicting strategic generalization performance with adaptive knowledge, strategic task performance (training), and basic generalization performance should demonstrate all are significant.
H16: Self-efficacy and self-regulation will mediate the relationship between the training manipulations and the proximal outcomes of the training program.	Practice Variability, Velocity Feedback, Self-Efficacy, Self-Regulatory Activity, Declarative Knowledge, Adaptive Knowledge, Basic Task Performance (training skill), Strategic Task Performance (training skill)	All as above.	Hierarchical multiple regression analysis in which the effects of practice variability and velocity feedback on the outcomes will be nonsignificant when self-efficacy and self-regulatory activity are entered after the manipulations.

Results

The model (Figure 2) specified that two manipulations (the presentation of variable vs. constant practice scenarios, and the provision of velocity feedback in addition to mastery feedback) would influence trainee self-regulatory activity and self-efficacy, both of which were treated as indicators of psychological processes for the purposes of this study. These process indicators were then hypothesized to influence proximal training outcomes (knowledge and skills at the end of training) which, in turn, were hypothesized to influence more distal training outcomes (skill demonstration during a generalization scenario).

Means, standard deviations, intercorrelations, and internal consistency reliabilities for all variables are presented in Table 2. Examination of the intercorrelations and prior work suggested that several variables be treated as covariates in all analyses. Both mastery and performance goal orientations have been shown in previous studies to be related to learning and performance using the TEAMS/TANDEM task, and will be used as covariates in this study as well. Cognitive ability has also been used as a covariate in previous studies, because of the complex nature of the task and the high cognitive requirements for learning the elements of the task. Examining the intercorrelation matrix suggested that participant gender might need to be controlled for as well. One-way ANOVAs indicated that significant gender effects were present during the first six training trials for basic performance, as well as during the generalization trial ($F_{1,315}$ = 8.266, $p < .01$). Moreover, every training trial demonstrated significant gender effects on strategic performance, with a significant effect during generalization as well ($F_{1,315}$ = 25.86, $p < .01$). These effects uniformly favored males over females. As such, gender

Table 2

Means, Standard Deviations, Intercorrelations, and Internal Consistency Reliability Estimates

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Situational Judgment, T1	6.05	4.10	(.55)													
2. Situational Judgment, T3	7.05	4.41	*.47*	(.62)												
3. Knowledge Test, T1	12.99	3.15	*.39*	*.31*	(.71)											
4. Knowledge Test, T3	14.70	3.17	*.38*	*.43*	*.73*	(.75)										
5. Cognitive Ability	23.62	4.71	*.34*	*.30*	*.47*	*.43*	(---)									
6. Final Training Score	663.1	402	.13	.12	*.25*	*.24*	.07	(---)								
7. Transfer Score	-463.4	1062	*.28*	*.34*	*.54*	*.50*	*.28*	*.60*	(---)							
8. Final Training Basic Perf.	693.7	397	.12	.10	*.24*	*.23*	.06	*.99*	*.58*	(---)						
9. Transfer Basic Performance	1337	760	*.22*	*.23*	*.46*	*.42*	*.20*	*.73*	*.90*	*.72*	(---)					
10. Gender	---	---	-.09	-.08	*-.26*	-.13	*-.17*	-.09	*-.22*	-.08	*-.16*	(---)				
11. Age	---	---	-.03	.04	-.06	-.03	-.06	*-.18*	*-.17*	*-.18*	-.14	-.04	(---)			
12. GPA	---	---	.12	*.16*	*.24*	*.27*	*.26*	.09	*.16*	.08	.09	-.13	-.09	(---)		
13. Video Game Playing	---	---	.08	.06	*.18*	.11	.12	.10	*.16*	.09	.11	*-.47*	-.00	-.11	(---)	
14. Mastery Goal Orn.	4.10	.46	-.02	.02	-.03	.00	-.03	-.06	.02	-.06	.01	-.14	*.16*	.06	.03	(.81)

(table continues)

Table 2, cont.

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15. Performance Goal Orn.	3.82	.55	-.11	-.03	-.11	*-.15*	-.06	.04	.02	.04	.03	.04	-.02	-.06	.04	*-.15*
16. Self-Regulatory Skill	23.35	3.15	.02	.04	-.01	.02	.01	.06	.07	.06	.09	-.07	.13	.07	.06	*.63*
17. Self-Regulation, T1	24.15	3.67	*.15*	.12	*.17*	.12	*.16*	.07	*.17*	.07	*.19*	*-.14*	-.03	.06	*.13*	*.31*
18. Self-Regulation, T2	23.19	3.88	*.16*	.06	*.15*	*.24*	.07	*.20*	*.27*	*.19*	*.28*	-.08	-.02	.08	.11	*.37*
19. Self-Regulation, T3	23.32	4.02	*.14*	*.18*	.12	*.23*	.11	.06	*.24*	.05	*.18*	-.14	.05	.08	*.14*	*.40*
20. Goal Commitment, T1	25.37	3.22	.11	.08	.06	*.14*	.00	.12	*.23*	.12	*.24*	-.05	.05	-.01	.05	*.39*
21. Goal Commitment, T2	25.45	3.33	.10	.09	.10	*.17*	.01	.09	*.21*	.08	*.23*	-.05	.04	-.01	.07	*.38*
22. Goal Commitment, T3	25.16	3.91	.10	.07	.08	*.19*	-.01	.10	*.24*	.09	*.23*	-.06	.07	.01	.10	*.36*
23. Self-Efficacy, T1	31.84	4.96	*.21*	*.15*	*.41*	*.25*	*.31*	*.15*	*.36*	*.14*	*.33*	*-.33*	-.08	.14	*.30*	*.24*
24. Self-Efficacy, T2	27.98	6.39	.06	-.01	*.18*	*.20*	.09	*.17*	*.28*	*.16*	*.31*	*-.26*	-.05	.00	*.19*	*.30*
25. Self-Efficacy, T3	28.65	6.86	.08	.07	*.20*	*.25*	.05	*.20*	*.38*	*.19*	*.34*	*-.27*	-.02	-.01	.14	*.29*
26. Feedback Satisfaction	25.20	3.57	.11	*.17*	.13	*.15*	.05	.10	*.29*	.08	*.19*	-.03	-.13	.02	.04	.06
27. Motivation	4.29	.60	*.18*	*.20*	*.17*	*.30*	.07	*.15*	*.26*	*.15*	*.25*	-.02	.04	.04	.08	*.37*
28. Marker Targets, EOT	1.65	1.18	*.19*	*.17*	*.36*	*.25*	*.30*	.06	*.38*	.05	*.29*	*-.20*	-.08	.09	.11	.07

(table continues)

Table 2, cont.

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
29. Decision Points Lost, EOT	110.41	165	*-.17*	*-.16*	*-.22*	*-.26*	-.06	*-.70*	*-.39*	*-.71*	*-.50*	-.06	.06	**-.13**	.07	.03
30. Inner Speed Queries, EOT	4.01	2.38	*.16*	*.20*	**.14**	*.18*	.08	*-.27*	-.01	*-.29*	**-.12**	.02	.05	.01	.00	.07
31. Targets Correct, EOT	8.04	3.02	.07	.05	*.19*	*.16*	.05	*.93*	*.55*	*.92*	*.67*	**-.13**	*-.20*	.04	*.16*	-.06
32. Outer Speed Queries, EOT	1.50	1.87	*.30*	*.37*	*.40*	*.42*	*.34*	-.06	*.42*	-.08	*.17*	*-.17*	.02	**.13**	**.13**	.09
33. High Priority Targets, EOT	4.70	1.59	*.25*	*.34*	*.41*	*.42*	*.27*	*.29*	*.62*	*.25*	*.38*	*-.22*	*-.17*	*.15*	*.21*	.07
34. Zooming Out, EOT	7.98	5.33	*.21*	*.33*	*.42*	*.39*	*.26*	.05	*.40*	.03	*.17*	*-.19*	-.01	*.19*	*.19*	.05
35. High Priority Targets, Trns	7.81	5.48	*.26*	*.41*	*.48*	*.43*	*.34*	*.16*	*.72*	**.13**	*.40*	*-.27*	*-.15*	*.19*	*.18*	.05
36. Inner Speed Queries, Trns	8.39	5.08	*.15*	*.15*	.08	**.14**	.07	*-.30*	-.11	*-.31*	*-.20*	.01	.08	-.00	.02	.02
37. Marker Targets, Trns	1.61	1.21	*.22*	*.27*	*.41*	*.33*	*.30*	.07	*.49*	.05	*.30*	*-.26*	-.04	**.12**	.10	.05
38. Zooming Out, Trns	18.60	15.5	*.21*	*.28*	*.38*	*.28*	*.21*	-.03	*.39*	-.05	**.13**	*-.21*	-.04	.07	**.14**	.07
39. Outer Speed Queries, Trns	4.86	5.83	*.26*	*.40*	*.43*	*.41*	*.33*	-.03	*.51*	-.05	*.21*	*-.26*	-.02	**.14**	*.16*	.07
40. Total Speed Queries, Trns	28.66	20.8	*.18*	*.22*	*.17*	*.23*	*.16*	*-.25*	.04	*-.26*	-.10	.01	.05	.06	.04	.05
41. Decision Points Lost, Trns	484.86	383	*-.31*	*-.31*	*-.40*	*-.43*	*-.20*	*-.25*	*-.57*	*-.25*	*-.59*	.04	-.05	-.10	.05	-.06
42. Strategic Perf., EOT	---	---	*.31*	*.41*	*.50*	*.47*	*.35*	**.14**	*.61*	**.11**	*.33*	*-.25*	**-.11**	*.18*	.09	.00
43. Strategic Perf., Trns	---	---	*.29*	*.37*	*.46*	*.39*	*.34*	-.07	*.45*	-.09	*.19*	*-.28*	-.02	**.12**	*.15*	-.04
44. Experimental Diary	12.92	5.21	*.18*	*.31*	*.17*	*.24*	*.22*	**.12**	*.20*	.11	*.15*	.03	.01	**.13**	-.10	.02

(table continues)

Table 2, cont.

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
15. Performance Goal Orn.	(.79)													
16. Self-Regulatory Skill	-.05	(.78)												
17. Self-Regulation, T1	.07	*.32*	(.85)											
18. Self-Regulation, T2	-.04	*.37*	*.51*	(.88)										
19. Self-Regulation, T3	-.03	*.37*	*.51*	*.71*	(.90)									
20. Goal Commitment, T1	.04	*.40*	*.35*	*.46*	*.42*	(.79)								
21. Goal Commitment, T2	-.03	*.37*	*.43*	*.44*	*.45*	*.76*	(.78)							
22. Goal Commitment, T3	-.02	*.39*	*.41*	*.50*	*.49*	*.71*	*.79*	(.82)						
23. Self-Efficacy, T1	.01	*.22*	*.55*	*.32*	*.33*	*.29*	*.35*	*.37*	(.91)					
24. Self-Efficacy, T2	-.09	*.28*	*.25*	*.44*	*.38*	*.30*	*.33*	*.46*	*.43*	(.95)				
25. Self-Efficacy, T3	-.10	*.25*	*.23*	*.48*	*.55*	*.32*	*.35*	*.45*	*.42*	*.76*	(.96)			
26. Feedback Satisfaction	-.10	.05	*.15*	*.20*	*.22*	*.15*	.14	*.17*	*.21*	*.18*	*.31*	(.72)		
27. Motivation	-.06	*.29*	*.36*	*.44*	*.55*	*.42*	*.45*	*.51*	*.34*	*.35*	*.46*	*.32*	(.82)	
28. Marker Targets, EOT	.06	.01	*.20*	.13	*.15*	.06	.07	.02	*.30*	.09	*.16*	.10	.12	(---)

(table continues)

Table 2, cont.

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
29. Decision Points Lost, EOT	.13	-.03	-.07	*-.20*	-.11	*-.16*	-.13	-.13	-.01	-.08	-.11	-.04	-.13	-.04
30. Inner Speed Queries, EOT	-.10	-.04	.03	-.00	.04	-.05	.00	.04	.02	.03	.07	.11	.07	.04
31. Targets Correct, EOT	.13	.06	.05	.14	.01	.06	.04	.06	*.18*	*.17*	*.19*	.10	.12	.04
32. Outer Speed Queries, EOT	-.06	.02	.09	.13	*.21*	.10	.09	.10	*.20*	.08	*.24*	*.27*	*.16*	*.43*
33. High Priority Targets, EOT	-.00	.11	.06	*.22*	*.21*	.13	.10	.13	*.24*	.13	*.31*	*.34*	*.19*	*.30*
34. Zooming Out, EOT	.02	.02	.14	*.16*	*.21*	.11	.09	.12	*.18*	.09	*.18*	*.23*	.14	*.32*
35. High Priority Targets, Trns	-.00	.02	.11	*.17*	*.26*	.13	.11	.12	*.30*	*.15*	*.30*	*.34*	*.20*	*.51*
36. Inner Speed Queries, Trns	-.13	-.07	-.01	-.04	-.01	-.06	-.00	.01	.02	.04	.07	.09	.03	.03
37. Marker Targets, Trns	.03	-.00	.13	.14	*.20*	.06	.05	.05	*.28*	.12	*.23*	*.22*	.12	*.61*
38. Zooming Out, Trns	-.02	.06	.12	.12	*.16*	.13	.11	.08	*.17*	.09	*.18*	*.16*	.10	*.30*
39. Outer Speed Queries, Trns	-.06	-.01	.09	.12	*.22*	.08	.08	.11	*.22*	.09	*.26*	*.29*	*.17*	*.40*
40. Total Speed Queries, Trns	*-.16*	-.07	.02	.01	.06	-.05	.04	.04	.06	.01	.09	.13	.09	*.18*
41. Decision Points Lost, Trns	.13	-.10	*-.16*	*-.29*	*-.27*	*-.29*	*-.29*	*-.30*	-.16	*-.16*	*-.21*	-.11	*-.19*	*-.21*
42. Strategic Perf., EOT	.00	.06	.14	*.21*	*.25*	.12	.11	.12	*.29*	*.15*	*.31*	*.32*	*.21*	*.57*
43. Strategic Perf., Trns	-.04	.01	.14	.13	*.21*	.09	.09	.08	*.26*	.13	*.25*	*.25*	.14	*.53*
44. Experimental Diary	*-.15*	.02	-.00	.11	.13	.01	-.00	.01	.01	.02	.09	*.16*	.13	.10

(table continues)

Table 2, cont.

	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
29. Decision Pts Lost, EOT	(---)															
30. Inner Spd Queries, EOT	.09	(---)														
31. Targets Correct, EOT	*-.39*	*-.33*	(---)													
32. Outer Spd Queries, EOT	-.02	*.39*	-.12	(---)												
33. High Priority Tgts, EOT	-.05	*.26*	*.31*	*.65*	(---)											
34. Zooming Out, EOT	*-.17*	*.20*	-.06	*.51*	*.52*	(---)										
35. High Priority Tgts, Trns	-.08	*.16*	.13	*.70*	*.75*	*.62*	(---)									
36. Inner Spd Queries, Trns	*.15*	*.85*	*-.32*	*.34*	*.17*	.07	.05	(---)								
37. Marker Targets, Trns	-.07	*.15*	.03	*.57*	*.49*	*.46*	*.73*	.02	(---)							
38. Zooming Out, Trns	-.11	*.18*	-.13	*.50*	*.48*	*.76*	*.63*	.05	*.51*	(---)						
39. Outer Spd Queries, Trns	-.04	*.40*	-.09	*.81*	*.63*	*.59*	*.81*	*.32*	*.63*	*.56*	(---)					
40. Total Spd Queries, Trns	.07	*.73*	*-.30*	*.52*	*.32*	*.23*	*.28*	*.79*	*.23*	*.20*	*.57*	(---)				
41. Decision Pts Lost, Trns	*.60*	*-.15*	.00	*-.34*	*-.22*	*-.32*	*-.33*	-.04	*-.34*	*-.38*	*-.36*	*-.19*	(---)			
42. Strategic Perf., EOT	-.07	*.43*	.11	*.79*	*.86*	*.73*	*.82*	*.31*	*.65*	*.63*	*.78*	*.47*	*-.32*	(--)		
43. Strategic Perf., Trns	-.05	*.43*	-.14	*.75*	*.60*	*.67*	*.81*	*.33*	*.84*	*.77*	*.84*	*.51*	*-.41*	*.81*	(--)	
44. Experimental Diary	*-.15*	.10	.06	*.23*	*.26*	*.23*	*.23*	.08	*.19*	*.17*	*.25*	*.20*	*-.18*	*.26*	*.24*	(.96)

Table 2 Notes:

Values in bold type are significant at the .05 level; values in bold italics are significant at the .01 level. Values in parentheses are internal consistency reliabilities, except the experimental diary, which is an interrater reliability coefficient; Perf. = Performance; Orn. = Orientation; T1 = Trial 1; T2 = Trial 2; T3 = Trial 3; EOT = End of Training; Trns = Transfer; Spd = Speed; Pts = Points; Tgts = Targets was covaried in all analyses. Additionally, it appeared that video game experience was potentially related to performance on the task; this was also verified through one-way ANOVAs which demonstrated significant effects for video game experience on both basic and strategic performance throughout training and generalization. In this section, the hypothesis tests will be discussed first. Then we will consider the effects of the manipulations on the outcomes of interest, to determine whether this will further inform future research, and consider possible revisions to the model if such prove necessary. Finally, we will consider a supplemental analyses to determine the utility of the situational judgment methodology as a tool for training evaluation, and to examine the self-regulation diary utilized in the study.

Hypothesis Tests

Hypothesis 1 postulated that variable practice would lead to increased self-efficacy, relative to constant practice. Hypothesis 3 predicted that the presentation of velocity feedback would also lead to increased self-efficacy, relative to individuals who did not receive velocity feedback. Hypothesis 2 predicted that variable practice would lead to greater self-regulatory activity, relative to individuals who received constant practice opportunities, and hypothesis 4 suggested that the presentation of velocity feedback would lead to increased self-regulatory activity, relative to no velocity feedback. A repeated-measures MANCOVA was run, with the covariates listed above, to examine the effects of the two manipulations on self-regulatory activity and self-efficacy at the end of training. The results of this analysis are reported in Table 3.

Table 3: Multivariate Effects of Control Variables and Manipulations on Self-Efficacy and Self-Regulation at End of Trial Blocks 3, 6, and 9

	df	F	Pillai's Trace
Cognitive Ability	4, 305	19.023**	.200
Trait Mastery Orientation	4, 305	22.625**	.229
Trait Performance Orientation	4, 305	.903	.012
Gender	4, 305	4.775**	.059
Video Game Experience	4, 305	2.720*	.034
Practice Manipulation	4, 305	3.938**	.049
Feedback Manipulation	4, 305	5.300**	.065
Block x Practice	8, 301	2.725**	.068
Block x Feedback	8, 301	4.773**	.113
Practice x Feedback	4, 305	.777	.010
Block x Practice x Feedback	8, 301	.989	.026

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Self-Efficacy (EOT) = Self-Efficacy at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

In examining the results of the overall RM-MANCOVA, it is clear that the manipulations, as well as many of the covariates, did in fact affect the self-efficacy and self-regulation variables over the course of training. However, the main effects are difficult to interpret in the presence of the two significant interactions noted above, the block by practice and block by feedback interactions. Examining the univariate tests, we find that the block x practice effect primarily acts on the self-regulation DV ($F_{2,308} = 3.27$, $p < .05$), with the univariate effect on self-efficacy being non-significant ($F_{2,308} = .532$, ns), while the block x feedback effect acts on self-efficacy ($F_{2,308} = 5.03$, $p < .01$), with the univariate effect on self-regulation being non-significant ($F_{2,308} = 1.17$, ns).

Considering the profile plots (Figures 3 and 4) for these interactions revealed interesting trends. On self-regulation (Figure 4), trainees in the constant practice condition began higher on self-regulation than trainees in the variable practice condition, with the difference disappearing over time (this is supported by an examination of the between-subjects effects in a MANCOVA designed to explore the difference across conditions). Note that the results here are reversed from what was hypothesized (variable practice was expected to advantage trainees, relative to constant practice).

Looking at the effects on self-efficacy (the block x feedback interaction; Figure 3), virtually no difference was present between the feedback manipulations at time 1, while larger differences emerged at times 2 and 3. The mean differences of the results favored trainees who received velocity feedback over those who did not receive velocity feedback.

For both self-regulation and self-efficacy, trainee means unexpectedly dropped from time 1 to time 3. An examination of the decline in scores on self-regulation and self-efficacy demonstrated something interesting. The mean difference from time 1 to time 3 on self-regulation was -.3625 for trainees in the variable practice condition (with an SD of 3.58 units) while the mean difference for trainees in the constant practice condition was -1.2975 units (SD of 4.03). The difference between these means is significant (t (316) = 2.188, $p < .05$), indicating that trainees in the constant practice condition showed larger decrements in reported self-regulation than did trainees in the variable practice condition. Hence, individuals in the variable practice evidenced less overall decline in self-regulation.

Similarly, the mean difference from time 1 to time 3 on self-efficacy was -4.0124 units for trainees in the no velocity condition (SD of 6.97) while the mean difference for trainees in the velocity feedback condition was -2.3376 (SD of 6.06). Again, these means are significantly different (t (316) = -2.284, $p < .05$), with larger decrements in self-efficacy being found for individuals who did not receive velocity feedback. Thus, for both manipulations, trainees decreased their engagement in self-regulatory processes and on self-efficacy over time, but these effects were minimized for trainees who received the manipulations which were hypothesized to be beneficial.

The relationship among the manipulations and the process variables was thus more complex than originally hypothesized. The manipulations significantly affected the processes, as shown by the multivariate analysis. Examination of the significant trial block by manipulation interactions indicated that over time, the feedback manipulation resulted in two distinct groups, with individuals who received velocity feedback demonstrating higher efficacy, on average, than those who did not. Moreover, while both groups declined overall from trial block one to trial block three, individuals receiving velocity feedback declined less in self-efficacy than did individuals who did not receive velocity feedback. The practice manipulation interacted with trial block in such a way that while both groups declined over time, the decline was more pronounced for individuals who received constant practice than for those who received variable practice opportunities. The somewhat counter-intuitive nature of these findings (the general decline of both efficacy and self-regulation) will be addressed in more detail in the discussion section.

Hypotheses 5 through 11 dealt with the prediction of the proximal training outcomes (learning and end-of-training performance). For these, I will follow the hypotheses through, as they were presented in the text, and briefly discuss each of the findings.

Hypothesis 5 predicted that self-efficacy would be predictive of declarative knowledge at the end of training. A regression was run testing this hypothesis, the results of which are presented in Table 4.

Table 4: Predicting Declarative Knowledge at the End of Training (H5)

	ΔR^2	df	F	Beta
Covariates	.206	5, 312	16.22**	
Mastery Orn.				-.072
Performance Orn.				-.109*
Cognitive Ability				.409**
Gender				.022
Video Game Exp.				.049
Predictor(s)	.051	1,311	21.32**	
Self-Efficacy (EOT)				.244**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Self-Efficacy (EOT) = Self-Efficacy at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

The analysis demonstrated significant effects for two of the covariates (trait performance orientation and cognitive ability), as well as for self-efficacy, on declarative knowledge at the end of training. This supports hypothesis 5. Consistent with the literature, trainees who were more efficacious did, in fact, learn more about the task than those who lacked efficacy.

Hypotheses 6, 9, and 11 dealt with the prediction of adaptive knowledge at the end of training. For the purposes of this study, adaptive knowledge was measured with a nine-item situational judgment measure constructed for this research paradigm. For each question, respondents were required to read a scenario which presented them with a problem of the type they could encounter in the task (or a modified version of the task) and select the most and least appropriate potential responses to the scenario.

Hypothesis 6 specified that self-efficacy would predict adaptive knowledge. That is, trainees who were more efficacious should be better able to demonstrate the capability to adapt what they knew. Hypothesis 9 specified that self-regulatory activity should predict adaptive knowledge, since individuals who tend to be more active, from a self-regulatory standpoint, should have engaged in the deeper reflection necessary to adapt what they have learned. Hypothesis 11 specified that declarative knowledge should predict adaptive knowledge, verifying that some degree of positive manifold exists among the different types of knowledge. These three hypotheses were tested with a single regression, per the model, the results of which are presented in Table 5.

Table 5: Predicting Adaptive Knowledge at the End of Training

	ΔR^2	df	F	Beta
Covariates	.093	5, 312	6.42**	
Mastery Orn.				-.001
Performance Orn.				.028
Cognitive Ability				.130*
Gender				-.033
Video Game Exp.				-.263
Predictor(s)	.124	3,309	16.37**	
Self-Efficacy (EOT)				-.108†
Self-Regulation (EOT)				.132*
Dec. Knowledge (EOT)				.374**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Self-Efficacy (EOT) = Self-Efficacy at End of Training; Self-Regulation (EOT) = Self-Regulation at End of Training; Knowledge (EOT) = Declarative Knowledge at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Of the covariates, only cognitive ability was predictive of adaptive knowledge at the end of training. That it was predictive should not be surprising. Individuals who possess higher cognitive ability should be better at most written tests, such as the adaptive knowledge test, than individuals of lower cognitive ability. Hypothesis 6, that self-efficacy would predict adaptive knowledge at the end of training, received only marginal support. This finding is also reflected in the correlation matrix; self-efficacy at the end of training exhibited a low zero-order correlation ($\underline{r}$ = .07, ns) with situational judgment performance at the end of training. Hypotheses 9 and 11, however (that self-regulation and declarative knowledge, respectively, would predict adaptive knowledge) were supported. It appears that efficacy is not useful in predicting the development or presence of adaptive knowledge, whereas trainee self-regulation and declarative knowledge may be quite useful in that regard.

Hypothesis 7 specified that self-efficacy would be predictive of basic task performance at the end of training. The results of the regression run to test this hypothesis are presented in Table 6.

Table 6: Predicting Basic Performance at the End of Training (H7)

	ΔR^2	df	F	Beta
Covariates	.017	5, 312	1.07	
Mastery Orn.				-.119*
Performance Orn.				.046
Cognitive Ability				.038
Gender				-.005
Video Game Exp.				.053
Predictor(s)	.042	1,311	13.75**	
Self-Efficacy (EOT)				.221**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Self-Efficacy (EOT) = Self-Efficacy at End of Training
† = $\underline{p}$ < .10 * = $\underline{p}$ < .05 ** = $\underline{p}$ < .01

Trait mastery orientation was predictive (albeit negatively) of basic performance at the end of training, as was self-efficacy. Individuals who were higher on self-efficacy at the end of training were more likely to have developed the skills they needed to prosecute targets correctly. Because end-of-training efficacy was predictive of basic performance at the end of training, Hypothesis 7 was supported.

Hypotheses 8 and 10 dealt with the prediction of strategic performance at the end of training. Strategic performance is a cluster of behaviors performed by trainees which indicate the adoption or use of key strategies for succeeding at the game. These are: zooming out; hooking marker targets; querying target speed; allowing perimeter intrusions; and engaging high priority targets. These five behaviors were entered into an exploratory factor analysis with the two elements of basic performance (points correct and points incorrect) to ensure that the basic and strategic performance elements clustered appropriately. At the end of training, a principal components factor analysis employing varimax rotation indicated that the seven variables (five strategic and two basic performance components) split cleanly into two appropriate factors. This provides support that the performance dimensions selected represent distinct elements of the overall performance domain.

Table 7: Rotated Factor Matrix, Trial 9 Performance Dimensions

	Factor 1	Factor 2
Points Correct	.008	.924
Points Incorrect	-.133	.618
Zooming Out	.613	-.101
Hooked Marker Targets	.532	-.117
Speed Queries	.765	-.269
Penalty Points Allowed	.782	.436
High Priority Targets Engaged	.841	.336

The five strategic performance indicators clustered together cleanly, as demonstrated by their rotated factor loadings above, as did the two basic performance indicators. To simplify the analysis and presentation of the data, a summary variable was created for overall strategic performance by creating a standardized version of each element of strategic performance and then forming a unit-weighted composite (with penalty points assigned a negative weight, as more penalty points indicates less strategy use). This single indicator of strategic performance was then used in this, and all other analyses in which strategic performance is a dependent variable. A basic performance composite was created as well. For the sake of clarity, the elements of strategic performance are still presented in the correlation matrix found in Table 2.

Hypotheses 8 and 10 were tested with a regression in which the effects of self-regulation and self-efficacy were examined on strategic performance at the end of training.

Table 8: Predicting Strategic Performance at the End of Training (H8, H10)

	ΔR^2	df	F	Beta
Covariates	.177	5,311	13.34**	
Mastery Orn.				.005
Performance Orn.				.051
Cognitive Ability				.312**
Gender				-.100†
Video Game Exp.				.074
Predictor(s)	.060	2,309	12.05**	
Self-Efficacy (EOT)				.229**
Self-Regulation (EOT)				.062

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Self-Efficacy (EOT) = Self-Efficacy at End of Training; Self-Regulation (EOT) = Self-Regulation at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

In addition to a significant effect for cognitive ability, a marginal gender effect was demonstrated in the prediction of strategic performance. More importantly, self-efficacy was significantly predictive of strategic performance, indicating that trainees who believed themselves to be more capable of performing the task were, as hypothesized, better able to do so, thereby supporting hypothesis 8 . Hypothesis 10 (that self-regulation would predict strategic performance) was not supported.

It is worth noting again at this point that discussions of performance at "end of training" denote performance on the tenth training trial. This tenth trial was included in order to ensure that all participants practiced an identical trial at the end of training, to ensure comparability of scores from the variable and constant practice groups. The end-of-training efficacy, self-regulation, and knowledge measures were collected immediately following trial nine, to ensure that they were temporally prior to the performance measures, which were therefore endogenous for purposes of testing the model in Figure 2.

Hypotheses 12 through 15 dealt with the influence of proximal training outcomes (declarative knowledge, adaptive knowledge, basic performance, and strategic performance, all at the end of training) on distal training outcomes (basic and strategic performance during generalization). Hypotheses 12 and 14 dealt with the prediction of basic generalization performance with declarative knowledge and basic training performance in trial 10, respectively. The results of the regression run to test these hypotheses are presented in Table 9.

Table 9: Predicting Basic Performance During Generalization (H12, H14)

	ΔR^2	df	F	Beta
Covariates	.059	5,311	3.89**	
Mastery Orn.				.049
Performance Orn.				.053
Cognitive Ability				.046
Gender				-.073†
Video Game Exp.				-.017
Predictor(s)	.542	2,309	209.62**	
Basic Perf. (EOT)				.656**
Dec. Knowledge (EOT)				.253**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Basic Perf. (EOT) = Basic Performance at End of Training; Dec. Knowledge (EOT) = Declarative Knowledge at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Of the covariates, only gender affected basic generalization performance, and then only marginally. However, both basic performance and declarative knowledge were predictive of basic generalization performance, indicating that prior performance on the task is predictive of basic generalization performance and supporting both hypotheses 12 and 14. Hypothesis 12a specified that even controlling for basic performance at the end of training, declarative knowledge would be predictive of basic performance during generalization. Separating basic performance at the end of training and declarative knowledge into separate steps in the regression, we find that)R^2 is .048 ($p < .01$) when declarative knowledge is entered after basic performance, indicating support for hypothesis 12a as well.

Considering the strategic elements of performance, hypotheses 13 and 15 predicted that strategic performance and adaptive knowledge at the end of training would influence strategic performance during generalization. The most stringent test of hypothesis 13 (and the one which best reflects the model) involves testing it in combination with strategic performance at the end of training. This analysis is presented in Table 10.

In this analysis, adaptive knowledge was unable to predict significant variance in strategic generalization performance when strategic performance at the end of training was included in the analysis. Thus, hypothesis 13a is not supported, although if a regression is run predicting strategic performance during generalization with the covariates and adaptive knowledge by itself, the beta weight for adaptive knowledge becomes a significant .283 ($p < .01$), thus supporting hypothesis 13. This is relatively less important than hypothesis 13a, however, which better reflects the model. Adaptive knowledge has some predictive power with respect to adaptation, but its effects are minimized in the presence of prior strategic performance. While hypothesis 13a was not supported, hypothesis 15, which predicted that strategic performance at the end of training would predict strategic generalization performance, was.

Table 10: Predicting Strategic Performance During Generalization with Adaptive Knowledge and Strategic Performance at End of Training (H13, H15)

	ΔR^2	df	F	Beta
Covariates	.167	5, 311	12.44**	
Mastery Orn.				-.005
Performance Orn.				-.031
Cognitive Ability				.045
Gender				-.099*
Video Game Exp.				-.059
Predictor(s)	.496	2,309	227.63**	
Adpt. Knowledge (EOT)				.038
Strat. Perf. (EOT)				.762**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation; Adpt. Knowledge (EOT) = Adaptive Knowledge at End of Training; Strat. Perf. (EOT) = Strategic Performance at End of Training
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Hypothesis 16 suggested that the process variables (self-efficacy and self-regulation) would mediate the relationship between the manipulations and the proximal training outcomes. Hypotheses 1-4 were tested using a multivariate approach, which was deemed more appropriate because of the need to understand how the manipulations affected the psychological processes of trainees over time. Adopting a static approach to the analysis of those hypotheses involves testing a pair of regressions, predicting terminal self-efficacy and terminal self-regulation with the two manipulations. The results of these regressions are presented in Tables 11 and 12.

Table 11: Manipulation Effects on Self-Efficacy at End of Training

	ΔR^2	df	F	Beta
Covariates	.141	5, 312	10.26**	
Mastery Orn.				.250**
Performance Orn.				-.061
Cognitive Ability				.017
Gender				-.215**
Video Game Exp.				.031
Manipulations	.011	2, 310	2.03	
Feedback				.101†
Practice				-.032

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

No significant effects emerged from the regression in which our manipulations were used to predict self-efficacy. Thus, it is inappropriate to test an hypothesis which treats efficacy as a mediator of the relationship between the manipulations and the proximal outcomes of training.

Table 12: Manipulation Effects on Self-Regulation at End of Training

	ΔR^2	df	F	Beta
Covariates	.192	5, 312	14.86**	
Mastery Orn.				.406**
Performance Orn.				.033
Cognitive Ability				.104*
Gender				-.018
Video Game Exp.				.112†
Manipulations	.001	2, 310	.206	
Feedback				-.029
Practice				-.016

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = p < .10 * = p < .05 ** = p < .01

Again, because the manipulations were not predictive of self-regulation in this regression, it is inappropriate to test the mediation proposed in hypothesis 16. Thus, hypothesis 16 was not supported. The process variables, while potentially quite important (based on the analyses reported earlier), do not mediate the effects of the manipulations on the proximal training outcomes.

Hypothesis 17 suggested that the proximal training outcomes would mediate the relationship between the process variables (self-regulation and self-efficacy) and the distal training outcomes (basic and strategic generalization performance). Standard tests of mediation were conducted to test this hypothesis; regressions were first run predicting basic performance or strategic performance with a process variable. Then a separate regression was run to determine if the addition of a proximal training outcome altered the relationship between the process variable and the distal training outcome. In only one case (self-regulation no longer significantly predicted basic transfer performance when declarative knowledge was included in the regression) was any evidence of mediation obtained. In all other regressions, the predictive status of the process variable was not altered by the inclusion of the "mediating" proximal training outcome. Hypothesis 17 was therefore also rejected.

The hypothesis tests only represent the first stage of analysis, however. Because some elements of the model were not supported, or remain unclear, in the next section we will examine a decomposition of the observed effects, looking first at what the manipulations were actually able to predict, and then at the overall results of the study (what elements of the study's nomological network were predictive of other elements?).

<u>Manipulation Effects</u>

In terms of looking at the "big picture" of the results, it is useful to ask several other questions. First, did the manipulations affect the outcomes of the training program? Regressions were run predicting basic and strategic skill both at the end of training and during the generalization trial to examine this question. Tables 13 through 16 are presented in the following pages. The regressions indicated, as will be seen, that the manipulations did possess some effects on the outcomes of interest, though they did not affect the process variables as the model predicted. Because of the lack of prediction of the process variables by the manipulations, they were not controlled for in the hypothesis tests presented in the preceding pages. However, the hypothesis-testing regressions were run a second time, including an additional step in which the manipulations were entered as control variables, and the effects were such that the inclusion of the manipulations did not alter the significance tests in almost any case. The only exception to this is the marginal effect for self-efficacy on adaptive knowledge, which dropped even further when the manipulations were covaried. Because no difference aside from this emerged when the manipulations were covaried, the results are not going to be re-reported.

While the manipulations accounted for significant variance in basic performance at the end of training, beyond what was accounted for by the covariates, this effect was carried by the feedback manipulation. The effect favored velocity feedback trainees over no-velocity trainees. It does not appear that the practice manipulation significantly affected basic performance at the end of training.

Table 13: Effects of Manipulations on Basic Performance At End of Training

	ΔR^2	df	F	Beta
Covariates	.017	5, 311	1.07	
Cognitive Ability				.058
Mastery Orn.				-.061
Performance Orn.				.034
Gender				-.052
Video Game Exp.				.059
Manipulations	.026	2, 309	4.22*	
Practice				.075
Feedback				.142*

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Beyond significant cognitive ability and gender covariate effects, the feedback manipulation was the only manipulation to significantly affect performance at the end of training. This time, however, the effect is reversed. The mean differences on the components of strategic performance, as well as on the composite variable, favor trainees who did <u>not</u> receive velocity feedback over those who did. Individuals who did not receive velocity feedback tended to perform more strategic behaviors than individuals who did receive such feedback.

Regressions were also run predicting basic and strategic generalization performance with the manipulations. Tables 15 and 16 contain the results of these analyses.

Table 14: Effects of Manipulations on Strategic Performance At End of Training

	ΔR^2	df	F	Beta
Covariates	.177	5, 311	13.34**	
Cognitive Ability				.309**
Mastery Orn.				.088†
Performance Orn.				.038
Gender				-.150*
Video Game Exp.				.088
Manipulations	.015	2, 309	2.78†	
Practice				-.043
Feedback				-.112*

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Table 15: Effects of Manipulations on Basic Performance During Generalization

	ΔR^2	df	F	Beta
Covariates	.059	5, 311	3.89**	
Cognitive Ability				.196**
Mastery Orn.				.010
Performance Orn.				.045
Gender				-.113†
Video Game Exp.				.036
Manipulations	.033	2, 309	5.62**	
Practice				.122*
Feedback				.133*

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Here, both manipulations affected the DV of interest (basic performance during generalization), and both were in the predicted direction (favoring variable practice and velocity feedback trainees, respectively). As with the previous analysis, a significant covariate effect for cognitive ability emerged, as well as a marginal gender effect.

Table 16: Effects of Manipulations on Strategic Performance During Generalization

	ΔR^2	df	F	Beta
Covariates	.167	5, 311	12.44**	
Cognitive Ability				.282**
Mastery Orn.				.065
Performance Orn.				-.002
Gender				-.213**
Video Game Exp.				.009
Manipulations	.048	2, 309	9.46**	
Practice				-.027
Feedback				-.218**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Cognitive ability and gender again accounted for most of the variance in the covariates. As with strategic performance at the end of training, strategic generalization performance was also predicted by the feedback manipulation, with the mean difference favoring no-velocity trainees over velocity trainees. Individuals who received velocity feedback engaged in fewer strategic activities than did individuals who did not receive such feedback. Again, while the manipulations did have some effects on the outcomes of interest, their inclusion in the regressions did not alter the effects of the other, hypothesized variables on the terminal effects.

Decomposition of Model Linkages (Exploratory)

To further explore the results, regressions were run in which basic generalization performance, then strategic generalization performance, were predicted with all the cognitive, affective, and behavioral predictors available within the confines of the task (that is: self-efficacy, self-regulation, declarative knowledge, adaptive knowledge, and end of training basic and strategic performance). The results of these regressions are presented in tables 17 and 18. It should be noted that elements of tables 17 and 18 are redundant with the tests of hypotheses 12 through 15, as those dealt with the effects of various elements of the model on the two types of generalization performance. However, the tables also present unique information in terms of what effects other, non-hypothesized variables had on generalization performance.

In Table 17, betas are reported at each step in the regression, as well as in the final step. This is done to allow a better understanding of the potentially unique portion of variance each element of the model can explain, as well as the extent to which performance at the end of training may mediate the effects of the remainder of the model on generalization performance. In addition to the feedback effect (noted above), strategic generalization performance was predicted by both types of knowledge, self-efficacy, and both types of performance at the end of training. Hence, each of these has the potential to predict strategic performance, although all of them but the feedback effect become non-significant in the final step, when the performance variables are entered. Interestingly, the gender effect remains significant even in the presence of all the other variables in the final step of the model.

Note that the nature of the effects described in Table 17 does make it appear that the end-of-training performance variables may be mediating the relationship between the knowledge and process measures and strategic generalization performance.

In predicting basic generalization performance (Table 18), the practice and feedback manipulations (as noted above) demonstrated utility. Additionally, declarative knowledge, self-efficacy, and both types of performance at the end of training were predictive of basic generalization performance.

Betas are presented at step and in the final version of the model for the variables in tables 17 and 18. The results are somewhat more robust than those for strategic generalization performance, as even in the presence of the two end-of-training performance variables, significant effects are present for the practice manipulation, declarative knowledge, and self-efficacy. No evidence was found for the linkage between the process and knowledge measures and basic generalization performance being mediated by end-of-training performance.

The unexpected nature of some of the results led to a series of regressions, designed to examine other potential structures for the model. The goal was to develop a more parsimonious model, with the potential to explain some of the unexpected findings in the study, and to offer a way to approach future research in this vein.

Each potential DV was regressed on all of the potential IVs (that is, all of the variables that came before it in the model, or were entered originally in the same step as the DV). Anything from the same step was then dropped, and the potential effects were again examined. This was done for each element of the original model.

Table 17: Effects of Process, Knowledge, and Performance Variables on Strategic Generalization Performance

	ΔR^2	df	F	Beta (at step)	Beta (Final)
Covariates	.167	5, 311	12.44**		
Cognitive Ability				.302**	.041
Mastery Orn.				.063	-.023
Performance Orn.				-.002	-.020
Gender				-.214**	-.100**
Video Game Exp.				.144	-.049
Manipulations	.048	2, 309	9.46**		
Practice				-.027	.019
Feedback				-.218**	-.109**
Knowledge Meas.	.097	2, 307	21.53**		
Declarative				.220**	.017
Adaptive				.192**	.042
Process Indicators	.020	2, 305	4.61*		
Self-Efficacy				.163**	.041
Self-Regulation				-.006	.000
Performance	.377	2, 303	195.63**		
Basic (EOT)				-.178**	-.178**
Strategic (EOT)				.746**	.746**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Table 18: Effects of Process, Knowledge, and Performance Variables on Basic Generalization Performance

	ΔR^2	df	F	Beta (at step)	Beta (final)
Covariates	.059	5, 311	3.89**		
Cognitive Ability				.177**	.041
Mastery Orn.				.005	.003
Performance Orn.				.044	.046
Gender				-.115†	-.029
Video Game Exp.				.036	-.027
Manipulations	.033	2, 309	5.62**		
Practice				.122*	.080*
Feedback				.133*	.050
Knowledge Meas.	.142	2, 307	28.53**		
Declarative				.395**	.164**
Adaptive				.063	.023
Process Indicators	.051	2, 305	10.93**		
Self-Efficacy				.272**	.125**
Self-Regulation				-.044	.006
Performance	.352	2, 303	147.44**		
Basic (EOT)				.624**	.624**
Strategic (EOT)				.133**	.133**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

The regressions run, and what they revealed, will be discussed below, beginning with the terminal end of the model and considering revisions working toward the front.

Recall that table 17 summarized the effects of all the elements of the model on strategic generalization performance. Another regression was run in which all of the elements in table 17 were considered, with the addition of basic generalization performance as a potential predictor of strategic generalization performance. Entered in a final step by itself, basic generalization performance possessed a beta weight of .090 ($p > .05$), indicating that no good reason existed to separate the elements of performance in the last step of the model.

Table 18 reviews the effects on basic performance during generalization, which includes everything with potential causal priority that was included in the model. The next step back in the model involves a more detailed consideration of the effects on basic and strategic performance at the end of training.

Examining the Tables 19 and 20, it becomes apparent that the knowledge measures are in fact predictive of performance at the end of training; hence, the model probably needs to be revised to reflect the causal priority of this knowledge to end-of-training performance. While the logic of the original model may still be argued (knowledge and performance are both types of outcomes from training, and might reasonably be considered in the same "step" for model definition), the data indicate that the knowledge outcome is a necessary (though not necessarily sufficient) condition for the performance outcome to occur. This, then, represents one potential change to the model from what was originally hypothesized.

Table 19: Effects on Basic Performance at End of Training

	ΔR^2	df	F	Beta
Covariates	.017	5, 311	1.07	
Mastery Orn.				-.078
Performance Orn.				.074
Cognitive Ability				-.035
Gender				-.005
Video Game Exp.				.050
Manipulations	.026	2, 309	4.22*	
Feedback				.126*
Practice				.074
Process Variables	.038	2, 307	6.37**	
Self-Efficacy				.192**
Self-Regulation				-.074
Knowledge Measures	.037	2, 305	6.40**	
Adaptive Know.				.040
Declarative Know.				.207**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Table 20: Effects on Strategic Performance at End of Training

	ΔR^2	df	F	Beta
Covariates	.177	5, 311	13.34**	
Mastery Orn.				.044
Performance Orn.				.086†
Cognitive Ability				.136**
Gender				-.093†
Video Game Exp.				.066
Manipulations	.015	2, 309	2.78†	
Feedback				-.113*
Practice				-.044
Process Variables	.065	2, 307	13.32**	
Self-Efficacy				.209**
Self-Regulation				-.026
Knowledge Measures	.124	2, 305	30.53**	
Adaptive Knowledge				.220**
Declarative Knowledge				.262**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

With this modification in place, the next question that must be addressed is whether this means the knowledge measures should be entered in the same step, for model-testing purposes, as the process variables, or whether there is some causal ordering we can infer from further analyses, using the knowledge measures as DVs.

Table 21: Predicting Declarative Knowledge

	ΔR^2	df	F	Beta
Covariates	.206	5, 312	16.22**	
Mastery Orn.				-.107*
Performance Orn.				-.116*
Cognitive Ability				.397**
Gender				.013
Video Game Exp.				.036
Manipulations	.001	2, 310	.198	
Feedback				-.025
Practice				.039
Process Variables	.062	2, 308	13.14**	
Self-Efficacy				.187**
Self-Regulation				.127*

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

The fact that both self-efficacy and self-regulation are predictive of declarative knowledge, combined with the fact that they are collected temporally prior to the knowledge measure, might reasonably lead us to conclude that the process variables are, in fact, causally prior to declarative knowledge, and hence do not belong in the same step for model-testing purposes. Identical analyses were run for adaptive knowledge, revealing that self-regulation (but not self-efficacy) was predictive of this form of knowledge (see Table 22). This provides further evidence that the process variables should be considered causally prior to the knowledge variables.

Table 22: Predicting Adaptive Knowledge

	ΔR^2	df	F	Beta
Covariates	.093	5, 312	6.42**	
Mastery Orn.				-.041
Performance Orn.				-.015
Cognitive Ability				.273**
Gender				-.025
Video Game Exp.				-.001
Manipulations	.007	2, 310	1.29	
Feedback				-.079
Practice				.016
Process Variables	.020	2, 308	3.58*	
Self-Efficacy				-.027
Self-Regulation				.171**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

It is interesting to note, in Tables 21 and 22, that self-regulation is predictive of both types of knowledge. This finding, in combination with the fact that self-regulation was directly predictive of little else in the study, will be taken up further in the discussion section.

Recalling from the earlier tables that there were no effects on self-efficacy or self-regulation at the end of training, from a regression sense, but that each was affected by one of the manipulations when the effects of the manipulations were examined over time (the block by manipulation interactions), there is no reason to alter the front end of the model. Summarizing what elements of the model were predictive of others, then, we have the following.

Summary

Practice variability affects only basic performance during generalization. It also interacts with time to affect self-regulation. Velocity feedback interacted with time to affect self-efficacy. Additionally, it affected both basic and strategic performance at the end of training, and strategic performance during generalization. This is the only variable which had an effect on strategic generalization performance that was not mediated by strategic training performance.

Self-efficacy affects declarative knowledge, basic and strategic performance at the end of training, and basic generalization performance. Self-regulation affects both declarative knowledge and adaptive knowledge, only one of which was hypothesized. Declarative knowledge affected basic and strategic performance at the end of training, as well as basic generalization performance. Adaptive knowledge affected strategic training performance. Basic and strategic performance during training, and basic performance during generalization, were predicted by much the same things; however, no justification existed for putting the three of them in a single step in the model, as basic generalization performance was not predictive of strategic generalization performance.

Both basic and strategic performance at the end of training predicted both basic and strategic performance during generalization. In addition, strategic training performance mediated the relationship between the knowledge measures, efficacy, and strategic generalization performance. Effects exist for all of these on strategic generalization performance before strategic training performance is entered in the regression, at which point the effects disappear. This is classic statistical mediation.

Based on these analyses, it appears that a revision of my original model would include those relations depicted in Figure 5. The model is far from perfect, and will need to be refined through further research to determine the precise nature of the effects observed. The model represents the causal ordering that emerged from more detailed analyses of the data from this study. *Post hoc* analyses of the data thus offer potential directions for refinements to the model which, as always, are the purview of future research.

Supplemental Analyses

The situational judgment methodology used to measure adaptive knowledge represents an important methodological contribution of this study. One of the key ways to determine whether this new measurement technique will prove beneficial is its capability to explain variance in performance beyond what we can explain with other tools already at our disposal. To test this, I entered the control variables, followed by declarative knowledge, and finally situational judgment performance, in a hierarchical regression predicting strategic generalization performance. Even with cognitive ability, declarative knowledge, and the other variables in the mix, adaptive knowledge as measured by the situational judgment test explained a significant increment in variance ($\Delta R^2 = .036$, $p < .001$), lending credence to the idea that this may be a useful tool for predicting the more complex elements of training performance and, perhaps more importantly, the capacity to transfer those complex elements to other environments.

The experimental diary utilized in this study was designed to provide an alternate measure of trainee self-regulation to the Likert-type scale used to assess self-regulation following trials 3, 6, and 9. A second rater was trained to score the diaries, utilizing the scoring rules described in the method section. Interrater reliability for overall diary score was .96. In addition, the diary only correlated $r = .13$ ($p < .05$) with the other measure of self-regulation at the end of training, indicating that while some overlap exists across the measures of self-regulation, the actual shared variance across the assessments is minimal.

Several of the analyses were re-run using the diary in place of the other self-regulation measure, with surprising results. First, the tests of hypotheses 2 and 4 were run again, using the diary as the measure of self-regulation to be predicted by the manipulations. As can be seen from table 23, both of the manipulations were predictive of diary score.

Table 23: Manipulation Effects on Self-Regulation Diary at End of Training

	ΔR^2	df	F	Beta
Covariates	.081	5, 312	5.530**	
Mastery Orn.				.025
Performance Orn.				-.128*
Cognitive Ability				.233**
Gender				.022
Video Game Exp.				-.120*
Manipulations	.070	2, 310	12.761**	
Feedback				-.105*
Practice				.246**

Notes: Mastery Orn. = Trait Mastery Orientation; Performance Orn. = Trait Performance Orientation;
† = $p < .10$ * = $p < .05$ ** = $p < .01$

Both of the manipulations are significantly predictive of self-regulation diary score, although the feedback effect is, as has been noted throughout, inverted such that individuals who received no velocity feedback scored higher on the measure of self-regulation than individuals who received velocity feedback. This effect was nonsignificant when predicting the Likert-type measure of self-regulation. More importantly, the practice manipulation, which was also nonsignificant in the previous analysis, significantly affected self-regulation diary score, such that individuals who received variable practice opportunities did in fact get higher scores on the self-regulation diary (that is, they reported attempting to engage in more of the goals of the training program than did individuals who received constant practice scenarios). This would seem to indicate that participants who practiced variable versions of the task were more likely to be aware of and focusing on the goals of training than individuals who practiced the same task every time, supporting hypothesis 2.

In addition, controlling for the manipulations as well as the other covariates, diary score was significantly predictive of strategic performance at the end of training (beta = .221, $p < .01$), with EOT strategic performance mediating the relationship between self-regulation and strategic generalization performance. Diary score was not, however, predictive of basic performance either at the end of training or during generalization. The diary was also significantly predictive of adaptive knowledge at the end of training, with a stronger beta weight (.227, $p < .01$) than that found for the other measure of self-regulation used in the study, and was predictive of declarative knowledge at the end of training as well. In many respects, then, the diary measure of self-regulation performed more in line with theoretical predictions than did the Likert-type measure, a finding which will be taken up in the discussion section.

Discussion

This study was designed to enhance our understanding of how the presentation of variable practice opportunities and velocity feedback influenced behavioral and cognitive outcomes, both at the end of training and during generalization. A model was proposed in which the effects of the two manipulations of interest were proposed to occur through self-regulatory mechanisms, consistent with a growing body of literature which treats self-regulation as central to learning and skill development (e.g., Kanfer & Ackerman, 1989). While variable practice and velocity feedback have both received attention in elements of the psychological literature in the past, they had not been examined, separately or in combination, in an experiment focused on training individuals on a complex cognitive task like the one utilized for this study. Hence, the study sought to increase our understanding of how these two manipulations might operate to produce the kinds of outcomes desired by trainers in a simulated real-world environment.

Overview of Results

Ten of the seventeen hypothesized relationships emerged when the data were analyzed, with support found for hypotheses 2 (variable practice predicting self-regulatory activity), 3 (velocity feedback predicting self-efficacy), 5 (self-efficacy predicting declarative knowledge at the end of training), 7 (self-efficacy predicting basic training performance), 8 (self-efficacy predicting strategic training performance), 9 (self-regulatory activity predicting adaptive knowledge at the end of training), 11 (declarative knowledge predicting adaptive knowledge), 12 (declarative knowledge predicting basic task performance), 14 (basic training performance predicting basic generalization performance), and 15 (strategic training performance predicting strategic generalization performance). Hypotheses 1 (variable practice predicting self-efficacy), 4 (velocity feedback enhancing self-regulatory activity), 6 (self-efficacy predicting adaptive knowledge), 10 (self-regulatory activity predicting strategic training performance), 13a (adaptive knowledge predicting strategic generalization performance), 16 and 17 (the mediational hypotheses) were not supported. These will be discussed below.

Because of the nature of the data, hypotheses 1 through 4 were examined longitudinally. The support found for hypotheses 2 and 3 was based on significant trial block by manipulation interactions, which were then decomposed to determine what occurred across conditions, over time. It is interesting that the only significant effects over time emerged for feedback on self-efficacy, and for practice on self-regulation. If we consider the nature of the manipulations, however, this may not be overly surprising. For explanatory purposes, I'm going to consider hypotheses 3 and 4 first, and then move back to hypotheses 1 and 2.

Feedback is, in many instances, designed to focus trainee attention on critical elements of the task and to provide information about how trainees are doing on those elements. Such information will inherently affect trainee self-perceptions; if the information they receive indicates that they are accomplishing their goals, then their efficacy should be increased, while if the information they receive indicates that they are failing to accomplish their goals their efficacy should be diminished. While the velocity feedback is not inherently evaluative in nature, it is reasonable to expect that trainees assigned evaluative meaning to the scores they received, representing their feedback, and made further evaluations based on the progress they observed over time on the task. Thus, it makes sense that hypothesis 3, which postulated a link between feedback and self-efficacy, should have been supported. The observed effect presented in an interaction of the feedback manipulation with time, such that over the course of the experiment, trainees who received velocity feedback demonstrated less decline in efficacy than did trainees who did not receive velocity feedback. Thus, the velocity manipulation was advantageous with respect to efficacy.

By the logic outlined above, feedback should have also had an effect on self-regulation, per hypothesis 4. It was expected that the addition of velocity feedback would augment trainee cognitive activity, and allow them to self-regulate "better" (in terms of doing more of the appropriate activities – monitoring goals, progress, performance, learning, and feedback), yet this did not occur. Instead, the effect may have been one of interference, rather than augmentation. Trainees were provided with velocity (score) feedback that was not directly relevant to the goals of the training program. It is possible that they were distracted from their established goals by the velocity feedback, and set their own goals. This goal shift could easily result in the reallocation of their self-regulatory activity to domains other than those covered by the scale used to assess self-regulation in this study. To assess this possibility, I examined the amount of time trainees spent reviewing the feedback screens, as well as the contents of their experimental diaries. Interestingly, trainees receiving velocity feedback spent significantly <u>more</u> time reviewing the non-velocity (i.e., directly goal-relevant) feedback screens than did trainees who received velocity feedback, according to a series of one-way ANOVAs. This was true across all nine training trials.

In addition, examining the experimental diaries of the participants reveals that individuals who received the variable practice manipulation tended to be able to self-report more of the goals of training than did individuals who received the constant practice manipulation (this difference was significant), and the individuals who did <u>not</u> receive velocity feedback tended to report attempting to reach more of the goals of training in their diaries than did individuals who received velocity feedback. This indicates that individuals who received the variable practice manipulation and who did not receive the velocity feedback manipulation reported attempting to attain the goals of the training program significantly more than individuals who received constant practice or velocity feedback. This suggests two things. First, that variable practice encourages trainees to focus on the specific goals of training, and second, that the presence of the velocity feedback may distract trainees from the goals of the training program. The fact that individuals who looked at the feedback directly relevant to strategic performance more ultimately did worse on strategic performance, both at the end of training and during generalization, with the only difference being that they also received velocity/score information, might reasonably lead us to argue that the presence of the velocity feedback modified how the non-velocity feedback was perceived and utilized by trainees.

With respect to hypotheses 1 and 2, which dealt with the influence of practice variability on self-efficacy and self-regulation, only hypothesis 2 was supported. Trainees receiving variable practice demonstrated less decline in their self-regulatory activity over time than did individuals who received constant practice (see Figure 4). However, the mean difference across groups actually showed that overall, trainees who received constant practice self-regulated more than trainees who received variable practice.

If we examine trends in the data, it does appear that while the means overall favored constant practice over variable practice trainees on self-regulation, this difference primarily occurred early in training, and became minimal at the end of training. It is possible that in a longer-term experiment trainees in the variable practice condition would have demonstrated higher self-regulatory activity than trainees in the constant practice condition, but the time parameters of this research, along with the complexity of the task to be learned, kept them from engaging in the more advanced self-regulation the measure was designed to assess.

There was no significant effect (either main effects or interactions) for the practice manipulation on self-efficacy (Hypothesis 1). This may have been due in some part to the manipulation itself. While it was emphasized early in the experiment that trainees would receive variable practice opportunities (for individuals in the appropriate condition), the nature of early portions of the task is fairly repetitive, in terms of having to perform the same basic operations (hook a target, make decisions, find another target), and might not lead to efficacy gains relative to individuals who have identical scenarios to practice every time. If the differences across trials were more pronounced, or if the potential benefits of variable practice opportunities were stressed more, then larger efficacy gains might have resulted for individuals in the variable practice condition.

A further consideration of the declines in self-regulation and self-efficacy may be warranted, to explore the findings. Both self-efficacy and self-regulation were at their highest following the first trial block. Mean self-efficacy at that point was 31.8, and mean self-regulation was 24.1. Both dropped following the second trial block, to 28.0 and 23.2, respectively, before recovering slightly (28.7, 23.3) following the final trial block. The declines occurred in spite of overall improvements in both knowledge and skill domains. Mean declarative knowledge scores rose from 13.0 to 14.7 questions correct, and mean adaptive knowledge scores rose from 6.0 to 7.0. In addition, a general upward trend, reminiscent of traditional learning curves, was observed in data on task performance, and is demonstrated in Figure 6.

Examining Figure 6, it becomes clear that within each 3-trial block, improvement took place in how well trainees performed the task. The bulk of the improvement in trainee score occurred early in training, as is typically the case with learning curves, and the improvement became less pronounced as trainees moved into the more complex, strategic goals of the latter portions of the training program.

It may be that the change in rate of improvement is responsible for the observed decrements in the process variables. In the case of self-efficacy, trainees make initial estimates of their own competence based on what they've seen of their performance. If they do not feel that they are doing as well (and there does appear to be a slight decline in performance from the end of each trial block to the beginning of the next), then their efficacy may drop. Another possibility is the goals trainees are given. Early in the training process, the goals are simple, but become more complex as training progresses. The shift in apparent complexity of the goals may be responsible for declines in efficacy, as trainees may believe themselves to be less able to meet the more complex goals than they were to meet the relatively simple goals of the first trial block. This would account for the initial decrease in efficacy following trial block two, where the goals became much more complex, and the slight increase in efficacy beyond that which was observed in trial block three, where the goals were still complex, but trainees had experience with complex goals and felt better about how they'd done than during their first exposure to such goals. Hence, efficacy would logically have been highest for the simplest goals, and would have been lower for the more complex goals from trial blocks two and three.

Declines in efficacy are not unheard-of, from a training perspective. Hesketh (1997) warned that one of the dilemmas inherent in the design of any training program is when to introduce the more difficult elements of training, to ensure that trainees have had sufficient time to learn the simple elements and become comfortable with them. Introducing the difficult elements too early, Hesketh warns, may "disrupt growing self-efficacy for the learning task" (p. 330). Based on the trends in the data, it does appear that the decline in efficacy began when the goals shifted from relatively simple goals, to more complex goals. Saks (1997) points out that one of Bandura's (1986) four mechanisms by which self-efficacy can be influenced is mastery experiences, in which trainees have the opportunity to successfully perform training tasks; declines in efficacy may thus be due to a lack of closure for trainees on any of the skills they have learned. If trainees do not have the opportunity to successfully perform the training task, or do not receive feedback that they have been successful at the task (either of which might constitute a "mastery experience"), then they may not develop appropriate levels of self-efficacy. They may need some form of closure before changing goals. Hence, the declines in self-efficacy, while not necessarily the norm for training research, might be due to factors that have been noted previously in the literature, and which can therefore be dealt with as further research is conducted.

A similar argument could be used to explain the decline in self-regulation. In the early stages of training, it was relatively easy for trainees to monitor their goals, progress, performance, learning, and feedback, because the focus was on simpler elements of the task. However, as the goals become more complex, it is not unreasonable to expect that trainees will report less active monitoring of the five elements of self-regulation assessed in this study, since their attention should be increasingly taken up by more complex goals. This possibility could be addressed in future research by assessing beta and gamma change in the scale over time. Such an exploration would allow us to determine if the meaning of the scales changes over time.

In some respects, these findings mirror Kanfer and Ackerman's (1989) resource allocation perspective, in that the limited cognitive resources of trainees become an issue. Moreover, Hesketh (1997) notes that when the attentional demands of a training task are high, trainees may not possess enough spare cognitive capacity to engage in the kinds of cognitive activities necessary for self-monitoring. The training program in this study was designed in such a way as to minimize the cognitive requirements for the initial three-trial block, by focusing on simple declarative information, but the attentional demands were increased markedly when defensive perimeters and marker targets were introduced in the second trial block. Now, in addition to simply making decisions about what targets are, trainees were required to attend to the overall context of the scenario, to make decisions about which targets were important to prosecute first, and to locate an outer boundary which was functionally invisible. With these new elements of the task to focus on, we may argue that they did not have the capacity left for self-monitoring. However, this possibility cannot be uniquely addressed in this research.

A second explanation for the declines in self-regulation is found in potential frustration with progress. Again, over time (Figure 6) trainee progress begins to slow. The fact that they have plateaued is not lost on trainees, who may decide that the experiment is no longer worth their full attention, and stop self-regulating to the same level that they did in the first trial block when they stop seeing the same levels of improvement, or when the goals become more difficult to achieve. Thus, we can explain the declines over time in terms of either increased complexity taking up limited resources, or increased complexity inducing frustration in trainees. It is also worth noting that scale-based self-regulation ultimately predicted only cognitive (i.e., learning) outcomes in this study.

Hypotheses six, nine, and eleven all dealt with the prediction of adaptive knowledge, a relatively unstudied construct, in spite of its theoretical relevance to issues of training transfer. Hypothesis eleven, that declarative knowledge would predict adaptive knowledge, was supported. Because the basics of the game (which are subsumed under declarative knowledge about the decision process) must be understood before more complex strategic behaviors can be meaningfully implemented, it makes sense that declarative knowledge should predict adaptive knowledge, which deals with applying strategic information to novel situations.

Hypothesis nine, that self-regulatory activity would predict adaptive knowledge, was also supported. When we note that self-regulatory activity was assessed (as above) by asking trainees to report the extent to which they engaged in various types of monitoring, it makes sense that this should be linked to cognitive outcomes. Also, recall that Table 21 demonstrated that self-regulatory activity was predictive of declarative knowledge. These two knowledge measures were the only things that the self-regulation measure significantly predicted. With its focus on monitoring, the measure may have been tapping only cognitive elements of self-regulation, and thus only predicted cognitive outcomes. This might explain why hypothesis 10, that self-regulatory activity would predict strategic training performance, was not supported; the types of self-regulatory activity tapped by the measurement were primarily cognitive, rather than behavioral, and thus were not predictive of the behavioral outcomes. While it is certainly not the case that strategic training performance was a purely behavioral construct (it did require cognitive underpinnings), the performance constructs represented the most behavioral of the criteria in the experiment. In support of the cognitive/behavioral outcome split, the experimental diary (a more behavior-focused measure of self-regulatory activity) was predictive of behavioral (i.e., performance) outcomes.

Hypothesis six, that self-efficacy would predict adaptive knowledge, was not supported. This may be due to the greater complexity of adaptive knowledge, relative to declarative knowledge, which self-efficacy successfully predicted. However, the lack of an effect for self-efficacy on adaptive knowledge is somewhat troubling, as the efficacy measure specifically includes items such as, "I believe I can develop methods to handle changing aspects of this task." The lack of effect may be due to the primarily affective nature of the efficacy judgment, as opposed to the cognitive nature of the adaptive knowledge test; it is relatively easy for trainees to guess that they can adapt what they have learned, but it is clearly another thing entirely for them to actually do so. If this were not the case, training transfer would not be nearly the critical concern in the literature that it is. Nonetheless, a better understanding of the link between efficacy and the adaptation of knowledge must be obtained. As has already been noted, however, the efficacy measure <u>was</u> able to predict strategic performance during generalization; hence, although the cognitive version of adaptability was not predicted by the efficacy measure, the behavioral version was. The more basic version of task knowledge was, however, predicted by self-efficacy, thereby supporting hypothesis five. Hypotheses seven and eight, which suggested that self-efficacy would predict basic and strategic training performance, were also supported.

The prediction of generalization performance (both basic and strategic) is one of the areas in which interesting results emerged. One such finding was the mediation of the effects on strategic generalization performance by strategic training performance. Hypothesis 13a (that adaptive knowledge would predict strategic generalization performance when controlling for basic generalization performance) was not supported. The revised model presented at the conclusion of the results section should serve to guide future research attempting to understand how knowledge affects strategic generalization performance, as it places knowledge assessments in a step of the model causally prior to end-of-training performance.

The other hypothesized knowledge-performance link, that declarative knowledge would predict basic task performance (hypothesis 12) was supported. In addition, hypothesis 13, that adaptive knowledge would predict strategic generalization performance in the absence of information on end-of-training strategic performance information, was supported as well. Hypotheses 14 and 15, which predicted that end of training performance (both basic and strategic) would predict generalization performance, were supported as well. The remaining hypotheses, 16 and 17, were both mediational, and did not find support from the data.

Hypothesis 16 suggested that the process variables (self-efficacy and self-regulation) would mediate the relationship between the manipulations and the proximal training outcomes, while hypothesis 17 predicted that the proximal training outcomes would mediate the relationship between the process variables and the distal training outcomes. For hypothesis 16 to be tested as written would have required direct main effects on the terminal process outcomes by the manipulations, which did not emerge in the data (recall that the effects were interactional in nature, involving manipulation by time effects). It appears, based on the exploratory analyses conducted, that both direct and indirect effects were present from the manipulations to the proximal training outcomes, but that too much was going on in the model to uniquely identify those effects. Some degree of decomposition has been accomplished, in terms of better specifying the likely causal sequence and identifying which elements of the model are able to predict other elements. However, it may require studies focused on smaller portions of the model to identify the specific conditions under which the manipulations will lead to the outcomes desired.

The mediation suggested by hypothesis 17 was also not fully supported, although the only true mediation found in the study was through strategic performance at the end of training, to strategic generalization performance. It appears that the relationships among the elements of the model are more complex than can be accounted for by a simple mediational system. With the causal ordering better established, a more thorough decomposition of the elements of the model will need to be conducted through studies focused around specific sections of the model.

The proposed model did not ultimately provide a good fit to the data, but revisions of the model are being considered, and further analyses are being conducted to reveal trends which might inform future model-building activities. In the next few pages, I would like to address some of the contributions of the study. I will then address the limitations, and conclude with a consideration of potential avenues for new research that may open as a result of this study.

Contributions

The study offers several potentially important contributions to the literature. These fall into measurement, theoretical, and practical domains.

On the measurement front, one of the things this study did was provide a mechanism through which adaptive knowledge could be assessed. The situational judgment test developed for this study, per the guidelines developed by Motowidlo et al. (1990), offered a tool that was relatively distinct from traditional declarative knowledge, and which explained significantly more variance in strategic generalization performance than declarative knowledge explained on its own. Further refinement of the measurement technology appears to be necessary if such tests are going to be able to out-predict prior strategic performance. However, the delay between the end of training performance measure and the generalization trial was relatively small, meaning that it is possible the strength of the observed effects for prior performance generalization performance might be inflated beyond what we would see in other training programs. With a longer delay between the end of training performance measure and the assessment of skill generalization, we might find the link between the two types of performance diminished, while the predictive power of the test itself did not. While the data from this study cannot directly address this possibility, it remains an option for future research to consider.

The measurement of self-regulation is another area that was clarified (in some ways) by this research. Based on the results of the study, it appears that the assessment of self-regulation that was used for this research may have been too heavily cognition-oriented. That is, it may have ignored the more affective and behavioral components of self-regulation, focusing solely on monitoring, and therefore been able to predict only cognitive outcomes. The possibility that written measures of self-regulation may only tap cognitive components of self-regulation is one that must be considered as further self-regulatory measurement tools are devised.

An additional possibility regarding the Likert-type measure of self-regulation used in this study arose when the data from the experimental diaries were examined. In considering the diary data, it became clear that the diary behaved much more in the manner the literature would suggest an assessment of self-regulation should behave than did the scale-based measure. The difference between these two measures, in many respects, is the extent to which they differentially require trainees to actively self-regulate. The scale-based measure, while asking questions about self-regulation, may not require a great deal of self-regulation to actually answer, since trainees need only bubble in sections of a scantron sheet. The diaries, however, require that trainees actually reflect on the task and their approach to the task, and report those goals which they treated as focal. Hence, the measure of self-regulation that required more self-regulation, the diary, seems to have performed better for the purposes of the study. It predicted both cognitive and behavioral outcomes, and allowed a more detailed look at what trainees were focusing on across conditions. While it is reasonable that the better measure of self-regulation should be the one which actually requires increased self-regulation, this has not been discussed in the literature, and the contrast between the two different measures of self-regulatory activity is an interesting one.

With respect to self-regulation, this study also attempted to further explore the role of self-regulation in training skill development. It is clear, from the cognitive literature, that some level of self-regulatory activity may be necessary for appropriate skill development to occur. While there were not direct scaled-based self-regulation – skill linkages in this study, self-regulation was definitely related to the development of both declarative and adaptive knowledge, lending credence to the idea that such activity is crucial to trainees gaining the necessary knowledge base from the training process. The version of self-regulation tested by the experimental diary was related to the development of strategic skill, indicating that the linkage between self-regulation and training outcomes may depend in part on how self-regulation is assessed.

Beyond the issues above, the study increased our potential understanding of the role of velocity feedback in training design, while simultaneously raising new, interesting questions. Individuals who were given velocity feedback spent more time looking at the other feedback information they were provided than did individuals who were not given velocity feedback. However, this did not result in the desired outcomes. Instead, it seems to have created a situation in which trainees took the velocity feedback (which may have oriented them much more toward performance) and examined the feedback relevant to the sequenced mastery goals in that light, potentially creating a frame of reference distinct from that which would have been provided by either mastery or performance feedback on its own. Velocity information thus represents one mechanism by which increased attention to all of the feedback provided in a training program may be obtained.

This allows us to reconsider the results of Mullins et al. (1999), who found that individuals who received both mastery and performance (velocity) feedback did best on the generalization trial, as opposed to individuals who received either type of feedback individually. Referring back to the results of that study, Mullins et al. (1999) found that the best scores during generalization were obtained by individuals who received both mastery and performance feedback. This effect was replicated in this study, with basic performance during both training and generalization performance maximized by individuals who received both sequenced mastery feedback as well as velocity feedback. The additional information afforded about where trainee attention was actually focused in these conditions (increased attention to the other elements of feedback in addition to the velocity information) allows us to begin to speculate about theoretical mechanisms which might be responsible for the findings of both studies. The construction of schemata (a sense-making mechanism on the part of trainees) is one potential explanation. This explanation is consistent with the observed effects of velocity feedback. One interpretation of those data would suggest that trainees who received no velocity feedback developed a cognitive representation of the training environment which emphasized the training goals (ultimately in terms of strategy development and usage), while trainees who received velocity feedback developed a separate cognitive representation of the environment in which they considered everything in terms of the velocity feedback, and modified their knowledge structures to allow for strategy use in a velocity-heavy environment. The diary findings tend to support this assertion. However, since they tell us that trainees who received velocity feedback reported fewer training goals, the question of whether different schemata will be developed based on the presence or absence of velocity feedback is one that must be taken up in future research. Ultimately, it remains unclear what is actually happening with respect to trainee attention, and this will be another focus for future research.

Another potential contribution of the study is its ability to offer an initial explanation for the efficacy declines noted in the Kozlowski, Mullins, Toney, and Bell (in preparation) study. The fact that efficacy declined while performance improved, overall, is interesting. It appears that the efficacy declines may be related to the shifts in goals over the course of training, as each goal shift was related to a concomitant (if only temporary) decline in performance, which might have led to efficacy declines over the course of training (see Figure 6). This will be taken up in more detail in my discussion of the limitations of the study, since while the data offer a slightly better understanding of what is going on with efficacy, the efficacy declines were not predicted and as such represent both a positive and a negative element of the findings.

Having considered both measurement and theoretical contributions of the study, we are left with the contributions the study makes to practitioners. First, the study may have implications for training design. Providing trainees with variable, as opposed to constant, practice opportunities was shown to be advantageous with respect to self-regulatory activity. This is particularly true for the diary-based assessment of self-regulation, where the practice manipulation had a significant main effect on diary score, rather than the interaction with time that was observed for the scale-based assessment of self-regulation. If a goal of training is for trainees to be more aware of and focus on the specific goals of the training program, we might utilize variable practice opportunities, rather than constant. In addition, it is clear that feedback shapes the focus of trainee attention. The addition of velocity feedback did increase the amount of time trainees spent attending to other feedback. However, because the velocity feedback did not match the focus of the mastery feedback, it may have distracted trainees or forced them to refocus their attention. It is conceivable that trainees who received velocity feedback in this study may have adopted more of a performance orientation than a mastery orientation, although the data from this study do not allow this possibility to be uniquely addressed.

In considering the declines in efficacy and self-regulation observed in the study, it may be that designing modular training programs, in which each set of goals is addressed in a single module, may prevent such declines. The data indicate that within each block of three trials, trainee performance rose. However, no opportunity for closure was offered to trainees, and this may have been discouraging (made them feel as though they did not accomplish their goals before moving on, which could have affected efficacy judgments) and distracting (having to shift attention from one element of the task to another without understanding whether the first element has been understood or completed properly could affect self-regulatory activity). Well-defined modules might allow for this closure, and thus prevent declines in efficacy and self-regulation by providing distinct experiences when different goals are being addressed over the course of training.

The study also has implications for training evaluation. The situational judgment test designed for this study, which assessed adaptive knowledge, is a step toward developing a paper-and-pencil assessment measure which will allow us to approximate what trainees are going to be required to do on the job without actually having to send them into a different environment. Through further iterations of this technology, we should be able to develop assessment tools that will accurately predict whether our training programs will provide trainees with the ability to utilize the knowledge and skills they have gained on the job, even when the task changes or becomes ambiguous. The results of this study are encouraging; the situational judgment test of adaptive knowledge was able to significantly predict strategic generalization performance, even when controlling for cognitive ability and declarative knowledge.

Limitations and Implications

In terms of limitations and problems with the study, these can be summarized under several headings. First, the assessment of self-efficacy may not have captured all of the relevant variance in the construct, based on the model. More specifically, multiple types of efficacy might need to be assessed to adequately test the theoretical model. Second, while time appears to have been a critical variable, it was not an hypothesized portion of the model. Third, the two measures of self-regulation functioned differently with respect to the model, leading to questions as to whether they measured the same construct. Fourth, the velocity feedback manipulation seemed to distract trainees from the training goals they were assigned. Fifth, the practice manipulation may have been too weak to obtain the desired effects, or the time frame might have been too narrow. Finally, the sequencing of the goals may have affected the development of self-efficacy and self-regulatory activity. Each of these issues will be discussed in turn.

An initial concern raised by an examination of the results and the model centers around the assessment of self-efficacy. The efficacy assessment was designed to predict performance on the task, with emphasis on generalization of knowledge and skills to the more difficult version of the task. In the theoretical model, only indirect links from self-efficacy to generalization performance were included. Moreover, direct links were included from self-efficacy to the two knowledge measures. While the knowledge measures were critical variables (and efficacy did in fact predict declarative knowledge), a question that must be asked is why self-efficacy did not predict adaptive knowledge as well. In this case, I would argue that the motivational variable, self-efficacy, may simply have not been predictive of knowledge. Many things influence the development of knowledge, particularly complex knowledge as assessed by the adaptive knowledge measure, and while motivation may be important, it may not be the primary force that allows such knowledge to develop. The implication to be drawn from this centers around the possibility that we might need to expand our thinking to include other factors which might be relevant to the development of knowledge, in terms of experience, learning style, and other potentially important factors.

Second, the analyses of hypotheses 1-4 centered around time-based effects. In any study of training that involves learning or skill development (which, ideally should be <u>any</u> study of training), time may be an important variable. People <u>should</u> change, over the course of training. However, while the analyses reflect attention to time, the hypotheses for this study did not. To some extent, a focus on outcomes of training is appropriate. However, the model for this study included process components, which implied change over time. This should have been included in the hypotheses. The data collected and analyses conducted did allow for the critical time-based questions to be asked, however, so while the initial conceptualization of the study did not focus on time, the final product did take temporal factors into account. Considering implications of this finding, it is clear that change over time is an area training research should consider in more detail. Examining outcomes is critical, but if we do not understand how those outcomes are obtained, if we cannot grasp the process, then we will fall short of understanding how training operates.

A third critical point is that the two assessments of self-regulation – the scale-based measure and the diary measure – functioned differently, with respect to the model. The self-regulation diary, in which trainees were asked to self-report the goals they had adopted during training, was predicted by both manipulations, although the feedback effect was reversed here, as everywhere else, such that the effect favored individuals who did not receive velocity feedback over those who did. No main effects for either manipulation were obtained on the scale-based measure of self-regulation. The diary was also predictive of strategic performance at the end of training, an hypothesized effect that did not emerge with only the scale-based measure of self-regulation included in the model.

While the inconsistency of measurement of what should ostensibly be the same construct across two measures first appears to be a limitation to the study, however, it may be one of the more interesting findings to emerge. A critical difference between the scale-based measure of self-regulation and the diary is the extent to which the two types of assessments require differential amounts of reflection. Little reflection on the task is required for the scale-based measure, which simply asks trainees to bubble in the appropriate circle to represent how much they did or did not do certain things. Bubbling is a low-cognition activity. The diary, however, asked trainees to reflect on the previous trial and self-report what goals they were attempting to obtain during that trial. Clearly, more reflection is required by one method of assessing self-regulation than the other, and we should not be surprised that the diary, which required more reflection (and therefore more self-regulation) provided an assessment of self-regulatory activity more in line with what should, theoretically, have been obtained.

Fourth, the effects of the velocity feedback manipulation seem to have involved interference with the learning goals, rather than augmentation. Based on the data collected, it appears that the presentation of velocity feedback (1) encouraged trainees to pay more attention to all of their feedback, and (2) created a cognitive framework for that feedback which may have been distinct from the framework the training goals attempted to create. The first point is based on the finding that individuals who received velocity feedback spent more time reviewing the non-velocity screens than did individuals who did not receive velocity feedback. The second is based on the finding that while the trainees spent more time reviewing the critical information, which should have helped them perform better on the generalization trial (from a strategic standpoint), they did not actually demonstrate this improved performance.

Again, this is a mixed blessing. The distraction effect was not hypothesized, but the finding that providing velocity feedback increased trainee attention to the non-velocity feedback is potentially critical. Thus, this finding has implications for training design, since in scenarios where the velocity feedback is not of a nature which tends to oppose the remainder of the feedback (e.g., performance-based velocity feedback distracting trainees from feedback linked to mastery goals), the increased attention to the remainder of the feedback screens should be valuable.

The practice manipulation appears to have suffered from a different problem, that of being overly weak, or conducted in a time frame which did not allow its effects to emerge. Examining the empirical model generated at the end of my data analyses (Figure 5), it is clear that the practice manipulation did almost <u>nothing</u>. It predicted basic performance during generalization, but nothing else aside from the interaction with time in predicting self-regulatory activity. Examining the effects of the practice manipulation on self-regulation over time, however, demonstrates that the individuals receiving variable practice were on the upswing, with respect to self-regulatory activity, at the end of training. It is possible that given a longer experiment effects for the practice manipulation would have emerged. The manipulation may have been too weak to generate noticeable effects in the time allotted. The process discussed in the literature by which variable practice should benefit learners is one of abstraction of critical elements of the task based on repeated exposure. With only ten practice trials, it may be that the task was too complex for all of the elements to be meaningfully abstracted in three and one-half hours.

In terms of implications to be drawn from this finding, the value of variable practice may have been overstated in the literature, particularly with respect to complex tasks. An experiment demonstrating that practice variability interacts with task complexity to determine outcomes would go a long way toward clarifying whether the recommendations of Schmidt and Bjork (1992) are meaningful when we consider the kinds of complex cognitive tasks that increasingly occupy our training programs.

Finally, it is possible that the sequencing of goals in the study may have affected the development of self-efficacy and self-regulation. The goals began relatively simple, then progressed to more complex goals. However, it may be that in this experiment, the requirements for achieving the initial goals were overly simple, and made the later goals appear more difficult by comparison. Previous studies utilizing this paradigm may have avoided this effect through the use of more cues (5 per decision) or ambiguous cues. The current study, with 3 cues and no ambiguity, may have been overly simple, creating larger goal-performance discrepancies than anticipated, and thereby leading to declines in the self-efficacy of trainees, as well as self-regulatory activity. This is not to say that sequencing goals is inappropriate from a training standpoint. The lesson to be taken away from this finding is one which was warned about by Hesketh (1997); if the initial goals of training are too simple to achieve, then we should not be surprised if trainee motivation or efficacy decline when the goals become more complex.

With several limitations of the study (as well as related implications) discussed, I would now like to turn my attention to potential directions for future research that have presented themselves, in addition to those I have noted throughout my discussion.

Directions for Future Research

Several opportunities for future research present themselves, based on the findings of this study. These deal with further exploration of some of the unexpected findings, as well as an expansion of the measurement techniques developed for this research.

One of the most interesting elements of the research was the fact that while performance increased over the course of training, in a manner which approximated a standard learning curve, self-efficacy decreased from the beginning of training to the end of training. The specific causal factors for the decline in efficacy, however, cannot be uniquely determined via the data collected for this study. Several possibilities presented themselves, and were discussed in the previous section. However, they remain speculation, and studies must be conducted to determine the circumstances under which trainee self-efficacy will decrease, in spite of overall gains in learning and skill development. Such motivational declines are an enormous problem, and research is necessary to allow us to predict and prevent their occurrence.

Related to the decline in self-efficacy is the nature of the velocity feedback manipulation utilized in this study. The manipulation included two components. One was simply the presentation of score feedback, along with the components of score, which allowed trainees a single piece of information they could use to track their progress over the course of training. The second component was the estimate each participant was asked to make with respect to how much progress s/he had seen on the game from one trial to the next. The decline in efficacy may have been tied more to one of these components than to the other, and I'm interested in exploring their relative importance to the observed declines in efficacy in a study which is better able to decompose the effects.

Along the same lines, a reasonable question is what effect it has to make velocity feedback explicit, rather than implicit. When trainees are given only score feedback, we must conclude that they are attending to it and noting change over time (implicit velocity feedback), whereas when they are asked to make an estimate of their progress following every trial, the velocity (change over time) is made explicit. We might argue that the effects of implicit vs. explicit velocity feedback may depend on the task and the nature of the feedback itself. That is, in the current study, it might be the case that because of the nature of the feedback and the learning curve involved, participants might have done better had the velocity feedback been implicit, rather than being asked to estimate their progress following every trial. As it stands, participants perceived a great deal of improvement early in training, but less improvement later on, based on the data collected. The complexity of the task seems like a potential moderator variable. A possible study might be a 2 x 2, in which task complexity (simple vs. complex) was crossed with implicit vs. explicit velocity feedback. In both conditions, a questionnaire would be given at the conclusion of the experiment to probe the extent to which trainees believed themselves to be improving over time. Complexity could be manipulated through information processing requirements, with low complexity involving three-cue decisions with no cue ambiguity, and high complexity involving five-cue decisions with ambiguous information. One hypothesis might be that explicit velocity feedback would be harmful in conditions where the task is relatively simple (the three cue, no ambiguity condition), as trainees may plateau relatively quickly and cease to observe improvement, whereas such explicit velocity feedback would be beneficial throughout training to individuals in the more complex condition, where improvement should be continuous and should not plateau over the course of training because their learning would not reach its maximum before training ended. The dual nature of the velocity manipulation must be decomposed for a better understanding of the effects observed in this study to be obtained.

As was noted in the previous section, the practice variability manipulation did not produce results isomorphic with those observed in the psychological literature. However, the existing literature deals with relatively simple motor tasks, and has not dealt to a great extent with complex cognitive tasks like that utilized in this study. Two possibilities must by explored, at the very least, with respect to this finding. First, are the lack of findings in this study the result of insufficient variability in the task? This is relatively unlikely, as the appearance and requirements of the task shifted markedly over the nine training trials, with different numbers of targets initially visible at different stages in training, and different arrangements of targets on the radar screen. Studies may need to be conducted to determine if degree of variability in complex task practice is potentially causal in schema development.

Perhaps more likely is the argument presented earlier in the discussion, that the schema development that seems to underlie the observed effects in the literature takes longer for more complex cognitive tasks, and may not be able to occur sufficiently in relatively short experiments dealing with complex cognitive tasks like TEAMS/TANDEM. To determine if it is a question of task complexity interacting with experimental duration, simpler experiments should be designed within this paradigm, which can be accomplished in a shorter time frame, to determine if results similar to those obtained in the motor learning literature can be obtained for cognitive tasks; if so, it may reasonable to assert that for more complex tasks, longer-term training programs should lead to similar types of outcomes, in terms of schema development and, ultimately, increased adaptability and expertise.

Finally, from a measurement perspective, it is important that further research be conducted to explore the potential utility of situational judgment-type measures of adaptive knowledge as a means to predict adaptability and generalization of skills from training back to the job. The results from this study are encouraging, but in no means final. While the SJT was able to out-predict cognitive ability and declarative knowledge, it was not able to significantly predict strategic generalization performance beyond strategic performance at the end of training. This is a long-term goal, and will require refinement of the measurement system as well as a more thorough understanding of how adaptability at the end of training may differ from adaptability on the job. An understanding of how we may best assess these differences, from a measurement standpoint is also necessary.

Conclusion

While the results of the study were mixed, and the model did not prove to be the best possible representation of the data, several interesting findings emerged. The manipulations – practice variability and velocity feedback – did affect the processes they were hypothesized to affect, if not in precisely the manner predicted. Self-regulation (specifically, self-monitoring multiple aspects of the training environment) was shown to have its primary effects on cognitive/learning outcomes, and both proximal and distal outcomes of training were able to be predicted relatively well with the study variables.

However, a great deal of work remains to be done. I have outlined several directions I believe represent fruitful lines of research. Task complexity and learning issues make laboratory studies an ideal medium for continuing to explore the concerns raised in this study, while not limiting my ability to utilize data from outside sources as well, as it becomes available. The issues central to this dissertation – training design, training evaluation, and a better understanding of the cognitive processes that form the foundation for learning and skill development – are ones which provide a myriad of opportunities for exploration, and can reasonably be expected to be more than sufficient to sustain a stream of research for many years to come.

REFERENCES

REFERENCES

Ackerman, P. L. (1992). Predicting individual differences in complex skill acquisition: Dynamics of ability determinants. Journal of Applied Psychology, 77, 598-614.

Acton, W. H., Johnson, P. J., & Goldsmith, T. E. (1994). Structural knowledge assessment: Comparison of referent structures. Journal of Educational Psychology, 86, 303-311.

Ames, C. & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. Journal of Educational Psychology, 80, 260-267.

Anderson, J. R. (1982). Acquisition of cognitive skill. Psychological Review, 89, 369-406.

Anderson, J. R. (1983). The architecture of cognition. Cambridge, MA: Harvard University Press.

Anderson, J. R. (1987). Skill acquisition: Compilation of weak-method problem solutions. Psychological Review, 94, 192-210.

Baldwin, T. T., & Ford, J. K. (1988). Transfer of training: A review and directions for future research. Personnel Psychology, 41, 63-105.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1991). Social cognitive theory of self-regulation. Organizational Behavior and Human Decision Processes, 50, 248-287.

Bandura, A., & Wood, R. (1989). Effects of perceived controllability and performance standards on self-regulation of complex decision making. Journal of Personality and Social Psychology, 56, 805-814.

Bouffard, T., Boisvert, J., Vezeau, C., & Larouche, C. (1995). The impact of goal orientation on self-regulation and performance among college students. British Journal of Educational Psychology, 65, 317-329.

Brown, K. G., Mullins, M., Weissbein, D., Toney, R., & Kozlowski, S. W. J. (1997, April). Mastery goals and strategic reflection: Preliminary evidence for interference. In S. W. J. Kozlowski (Chair) and M. Quinones and J. Martocchio (Discussants) Symposium "Metacognition and Training," presented at the Twelfth Annual Meeting of the Society of Industrial and Organizational Psychology, St. Louis, MO.

Button, S. B., Mathieu, J. E., & Zajac, D. M. (1996). Goal orientation in organizational research: A conceptual and empirical foundation. Organizational Behavior and Human Decision Processes, 67, 26-48.

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989). Component fluency in a problem-solving context. Human Factors, 31, 489-502.

Carver, C. S., & Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. Psychological Bulletin, 92, 111-135.

Carver, C. S., & Scheier, M. F. (1990). Origins and functions of positive and negative affect: A control-process view. Psychological Bulletin, 97, 19-35.

Carver, C. S., & Scheier, M. F. (1998). On the self-regulation of behavior. New York: Cambridge University Press.

Catalano, J. F., & Kleiner, B. M. (1984). Distant transfer in coincident timing as a function of variability of practice. Perceptual and Motor Skills, 58, 851-856.

Chan, D., & Schmitt, N. (1997). Video-based versus paper-and-pencil method of assessment in situational judgment tests: Subgroup differences in test performance and face validity perceptions. Journal of Applied Psychology, 82, 143-159.

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. Cognitive Science, 13, 145-182.

Clifton, M. A. (1985). Practice variability and children's motor behavior. Perceptual and Motor Skills, 60, 471-476.

Cohen, J. J. (1988). Statistical power analysis for the behavioral sciences. Hillsdale, NJ: LEA.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. Psychological Review, 82, 407-428.

Curtis, K. A. (1992). Altering beliefs about the importance of strategy: An attributional intervention. Journal of Applied Social Psychology, 22, 953-972.

Dalessio, A. T. (1994). Predicting insurance agent turnover using a video-based situational judgment test. Journal of Business and Psychology, 9, 23-32.

Dansereau, D. F., Brooks, L. W., Holley, C. D., & Collins, K. W. (1983). Learning strategies training: Effects of sequencing. Journal of Experimental Education, 51, 102-108.

Duda, J. L., & Nicholls, J. G. (1992). Dimensions of achievement motivation in schoolwork and sport. Journal of Educational Psychology, 84, 290-299.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. Psychological Review, 95, 256-273.

Earley, P. C., Lee, C., & Hanson, A. L. (1990). Joint moderating effects of job experience and task component complexity: Relations among goal setting, task strategies, and performance. Journal of Organizational Behavior, 11, 3-15.

Earley, P. C., Northcraft, G. B., Lee, C., & Lituchy, T. R. (1990). Impact of process and outcome feedback on the relation of goal setting to task performance. Academy of Management Journal, 33, 87-105.

Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. Journal of Personality and Social Psychology, 54, 5–12.

Etelapelto, A. (1993). Metacognition and the expertise of computer program comprehension. Scandinavian Journal of Educational Research, 37, 243-254.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychology, 34, 906-911.

Ford, J. K. (1997). Advances in training research and practice: An historical perspective. In J. K. Ford, S. W. J. Kozlowski, K. Kraiger, E. Salas, & M. Teachout (Eds.), Improving training effectiveness in work organizations (pp. 1-18). Mahwah, NJ: LEA.

Ford, J. K., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, E. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. Journal of Applied Psychology, 83, 218-233.

Forsterling, F. (1985). Attributional retraining: A review. Psychological Bulletin, 98, 495-512.

Frese, M., & Altmann, A. (1989). The treatment of errors in learning and training. In L. Bainbridge & S. A. R. Quintanilla (Eds.), Developing skills with information technology (pp. 658-682). New York: Wiley.

Garcia, T. & Pintrich, P. R. (1994). Regulating motivation and cognition in the classroom: The role of self-schemas and self-regulatory strategies. In D. H. Schunk & B. J. Zimmerman (Eds.), Self-regulation of learning and performance: Issues and educational applications. New Jersey: Erlbaum.

Gay, G. (1986). Interaction of learner control and prior understanding in computer-assisted video instruction. Journal of Educational Psychology, 78, 225-227.

Gist, M. E., & Mitchell, T. R. (1992). Self-Efficacy: A theoretical analysis of its determinants and malleability. Academy of Management Review, 17, 183-211.

Gist, M. E., Schwoerer, C., & Rosen, B. (1989). Effects of alternative training methods on self-efficacy and performance in computer software training. Journal of Applied Psychology, 74, 884-891.

Glaser, R., & Bassok, M. (1989). Learning theory and the study of instruction. Annual Review of Psychology, 40, 631-666.

Goldsmith, T. E., & Kraiger, K. (1997). Application of structural knowledge assessment to training evaluation. In J. K. Ford and associates (Eds.), Improving training effectiveness in work organizations (pp. 73-96). Mahwah, NJ: LEA.

Green, D. P., Whitehead, J., & Sugden, D. A. (1995). Practice variability and transfer of a racket skill. Perceptual and Motor Skills, 81, 1275-1281.

Hastie, R. (1984). Causes and effects of causal attribution. Journal of Personality and Social Psychology, 46, 44-56.

Hatano, G., & Inagaki, K. (1986). Two courses of expertise. In H. Stevenson, H. Azuma, & K. Hakuta (Eds.), Child development and education in Japan. New York: W. H. Freeman and Company.

Hesketh, B. (1997). Dilemmas in training for transfer and retention. Applied Psychology: An International Review, 46, 317-386.

Hollenbeck, J. R., Williams, C. R., & Klein, H. J. (1989). An empirical examination of the antecedents of commitment to difficult goals. Journal of Applied Psychology, 74, 18-23.

Holyoak, K. J. (1991). Symbolic connectionism: Toward third generation theories. In K. A. Ericsson & J. Smith (Eds.), Toward a general theory of expertise: Prospects and limits (pp. 301-336). New York: Cambridge University Press.

Holyoak, K. J., & Spellman, B. A. (1993). Thinking. Annual Review of Psychology, 44, 265-315.

Hsee, C. K., & Abelson, R. P. (1991). Velocity relation: Satisfaction as a function of the first derivative of outcome over time. Journal of Personality and Social Psychology, 60, 341-347.

Huber, J. (1997). Differences in problem representation and procedural knowledge between elite and nonelite springboard divers. The Sport Psychologist, 11, 142-159.

Ivancic, K., & Hesketh, B. (1995). Making the best of errors during training. Training Research Journal, 1, 103-125.

Johnson, R., & McCabe, J. (1982). Schema theory: A test of the hypothesis, variation in practice. Perceptual and Motor Skills, 55, 231-234.

Kanfer, R., & Ackerman, P. L. (1989). Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition [Monograph]. Journal of Applied Psychology, 74, 657-690.

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. Annual Review of Psychology, 44, 23-52.

Kelly, H. B. (1982). A primer on transfer of training. Training and Development Journal, 36, 102-106.

Kerr, R. (1982a). Practice variability: Abstraction or interference. Perceptual and Motor Skills, 54, 219-224.

Kerr, R. (1982b). Practice variability and longer and shorter retention intervals. Perceptual and Motor Skills, 54, 243-250.

Kluger, A. N., & DeNisi, A. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychological Review, 119, 254-284.

Kozar, B., Vaughn, R. E., Lord, R. H., & Whitfield, K. E. (1996). Basketball free-throw performance: Practice implications. Journal of Sport Behavior, 18, 123-129.

Kozlowski, S. W. J. (1998). Training and developing adaptive teams: Theory, principles, and research. In J. A. Cannon-Bowers & E. Salas (Eds.), Decision making under stress: Implications for training and simulation. Washington, D. C.: APA.

Kozlowski, S. W. J., Gully, S. M., Smith, E. M., Brown, K. G., Mullins, M. E., & Williams, A. E. (1996, April). Sequenced mastery goals and advance organizers:

Enhancing the effects of practice. In K. Smith-Jentsch (Chair), When, how, and why does practice make perfect? Symposium conducted at the 11th Annual Conference of the Society for Industrial and Organizational Psychology, San Diego, CA.

Kozlowski, S. W. J., Mullins, M. E., Toney, R. J., & Bell, B. S. (in preparation). Adaptive Performance: Mastery vs. Performance Goals and Feedback Consistency.

Kozlowski, S. W .J., Toney, R. J., Mullins, M. E., Weissbein, D. A., Brown, K. G., & Bell, B. S. (in press). Developing Adaptability: A Theory for the Design of Integrated-Embedded Training Systems. In E. Salas (Ed.), Human/technology interaction in complex systems (Vol. 10). Greenwich, CT: JAI Press.

Kozlowski, S. W. J., Toney, R. J., Weissbein, D. A., Mullins, M. E., Brown, K. G., & Bell, B. (1998, April). Training adaptive performance. In S. W. J. Kozlowski, S. Parker, & M. Frese (Chairs) and S. J. Motowidlo (Discussant) symposium "Beyond task performance: Proactivity and learning," presented at the Thirteenth Annual Meeting of the Society for Industrial and Organizational Psychology, Dallas, TX.

Kozlowski, S. W. J., Weissbein, D. A., Brown, K. G., Toney, R. J., & Mullins, M. E. (1997, May). Guiding the development of deployable shipboard training systems: Enhancing skill acquisition, adaptability, and effectiveness. (Final Report 1.1; Contract No. N61339-96-K-0005). Michigan State University, East Lansing, MI.

Latham, G. P., & Locke, E. A. (1991). Self-regulation through goal setting. Organizational Behavior and Human Decision Processes, 50, 212-247.

Lindsley, D. H., Brass, D. J., & Thomas, J. B. (1995). Efficacy-performance spirals: A multilevel perspective. Academy of Management Review, 20, 645-678.

Locke, E. A., & Latham, G. P. (1990). A theory of goal setting & task performance. Englewood Cliffs, NJ: Prentice-Hall.

Lord, R. G., & Levy, P. E. (1994). Moving from cognition to action: A control theory perspective. Applied Psychology: An International Review, 43, 335-367.

Martocchio, J. J., & Dulebohn, J. (1994). Performance feedback effects in training: The role of perceived controllability. Personnel Psychology, 47, 357-373.

Meece, J. L. (1994). The role of motivation in self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), Self-regulation of learning and performance: Issues and educational applications (pp. 25-44). New Jersey, Erlbaum.

Meece, J. L., Blumenfeld, P. C., & Hoyle, R.H. (1988). Students' goal orientations and cognitive engagement in classroom activities. Journal of Educational Psychology, 80, 514-523.

Miller, R. B., Behrens, J. T., Greene, B. A., & Newman, D. (1993). Goals and perceived ability: Impact on student valuing, self-regulation, and persistence. Contemporary Educational Psychology, 18, 2-14.

Mitchell, T. R., Hopper, H., Daniels, D., George-Falvy, J., & James, L. R. (1994). Predicting self-efficacy and performance during skill acquisition. Journal of Applied Psychology, 79, 506-517.

Motowidlo, S. J., Dunnette, M. D., & Carter, G. W. (1990). An alternative selection procedure: The low-fidelity simulation. Journal of Applied Psychology, 6, 640-647.

Motowidlo, S. J., & Tippins, N. (1993). Further studies of the low-fidelity simulation in the form of a situational inventory. Journal of Occupational and Organizational Psychology, 66, 337-344.

Mullins, M. E., Kozlowski, S. W. J., Schmitt, N., & Howell, A. E. (in preparation). Predicting the use of the Internet in business: An application of innovation theory.

Mullins, M. E., Kozlowski, S. W. J., Toney, R. J., Bell, B. S., Brown, K. G., & Weissbein, D. A. (1999, April). Adaptive performance: Mastery versus performance goals and feedback consistency. Paper presented at the Fourteenth Annual Conference of the Society for Industrial and Organizational Psychology, Atlanta, GA.

Nelson, T.O. (1996). Consciousness and metacognition. American Psychologist, 51, 102-116.

Nelson, T. O., Dunlosky, J., Graf, A., & Narens, L. (1994). Utilization of metacognitive judgments in the allocation of study during multitrial learning. Psychological Science, 5, 207-213.

Ostroff, C. (1991). Training effectiveness measures and scoring schemes: A comparison. Personnel Psychology, 44, 353-374.

Paas, F. G. W. C., & van Merrienboer, J. G. (1994). Variability of worked examples and transfer of problem-solving skills: A cognitive load approach. Journal of Educational Psychology, 86, 122-133.

Pintrich, P.R. & DeGroot, E.V. (1990). Motivational and self-regulated learning components of classroom academic performance. Journal of Educational Psychology, 82, 33-40.

Pintrich, P. R., Smith, D. A., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). Educational and Psychological Measurement, 53, 801-813.

Posner, M. I. (1988). Introduction: What is it to be an expert? In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), The nature of expertise (pp. xxix-xxxvi). Hillsdale, NJ: LEA.

Ren, J., & Sheridan, T. B. (1995). An adaptive decision aid for real environments. IEEE Transactions on Systems, Man, and Cybernetics, 25, 1384-1391.

Ridley, S. D., Schutz, P. A., Glanz, R. S., & Weinstein, C. E. (1992). Self-regulated learning: The interactive influence of metacognitive awareness and goal-setting. Journal of Experimental Education, 60, 293-306.

Saks, A. M. (1997). Transfer of training and self-efficacy: What is the dilemma? Applied Psychology: An International Review, 46, 365-370.

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. Psychological Review, 82, 225-260.

Schmidt, R. A. (1976). The schema as a solution to some persistent problems in motor learning theory. In G. E. Stelmach (Ed.), Motor control: Issues and trends (pp. 41-65). New York: Academic Press.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. Psychological Science, 3, 207-217.

Schunk, D. H. (1994). Self-regulation of self-efficacy and attributions in academic settings. In D. H. Schunk & B. J. Zimmerman (Eds.), Self-regulation of learning and performance: Issues and educational applications (pp. 75-99). New Jersey: Erlbaum.

Smith, E. M. (1996). Unpublished Doctoral Dissertation, Michigan State University, East Lansing, MI.

Smith, E. M., Ford, J. K., & Kozlowski, S. W. J. (1997). Building adaptive expertise: Implications for training design strategies. In M. A. Quinones and A. Ehrenstein (Eds.), Training for a rapidly changing workplace: Applications of psychological research (pp. 89-118). Washington, DC: APA.

Tennyson, R. D. (1980). Instructional control strategies and content structures as design variables in concept acquisition using computer-based instruction. Journal of Educational Psychology, 72, 225-232.

Tennyson, R. D. (1981). Use of adaptive information for advisement in learning concepts and rules using computer assisted instruction. American Educational Research Journal, 18, 425-438.

Tesluk, P. E., Farr, J. L., Mathieu, J. E., & Vance, R. J. (1995). Generalization of employee involvement training to the job setting: Individual and situational effects. Personnel Psychology, 48, 607-632.

Trotter, R. J. (1986, July). The mystery of mastery. Psychology Today, 32-38.

Waldersee, R., & Luthans, F. (1994). The impact of positive and corrective feedback on customer service performance. Journal of Organizational Behavior, 15, 83-95.

Warr, P., & Bunce, D. (1995). Trainee characteristics and the outcomes of open learning. Personnel Psychology, 48, 347-375.

Weaver, J. L., Bowers, C.A., Salas, E., & Cannon-Bowers, J.A. (1995). Networked simulations: New paradigms for team performance research. Behavioral Research Methods, Instruments, & Computers, 27, 12-24.

Weaver, J. L., Morgan, B., B., Hall, J., Compton, D. (1993). Team decision making in the command information center: Development of a low-fidelity team decision making task for assessing the effects of teamwork stressors. Orlando, FL: Naval Training Systems Center, Human Factors Division.

Wenger, E. (1987). Artificial intelligence and tutoring systems: Computational and cognitive approaches to the communication of knowledge. Los Altos, CA: Morgan Kaufman.

Wernimont, P. F., & Campbell, J. P. (1968). Signs, samples, and criteria. Journal of Applied Psychology, 52, 372-376.

Wood, R. E. (1986). Task complexity: Definition of the construct. Organizational Behavior and Human Decision Processes, 37, 60-82.

APPENDICES

Appendix A

Participant # ______

Informed Consent Tactical Action Game (TAG)

The study in which you are about to participate investigates your performance on the Tactical Action Game (TAG). TAG is a computer simulated, radar tracking task in which you will measure the attributes of contacts that appear on your radar screen and decide what action should be taken. You will also be asked to answer questionnaires which will help us understand how you learn to perform the game. It is important that you answer the questions as honestly and accurately as you can.

Your participation in this study requires three and one-half hours of your time. You will receive 7 Psychology subject pool credits for this 3.5 hour time commitment. No possible risks or discomforts are anticipated as a result of this study.

Awards available for this study are explained in detail in a separate handout. Winners will be determined at the conclusion of this study. If you win, you will be contacted at the address and phone number you indicate below within 3 weeks of the study's conclusion. Instructions for claiming the award through the Department of Psychology Business Office will be provided when you are contacted.

Participation is this study is completely voluntary. You are free to discontinue the study at any time for any reason without penalty. Simply inform the investigator if you wish to withdraw. Your responses will be completely confidential. During the study we will ask you to put your name on a computer scoring form. This is only to be used to identify and contact you should you win an award. Your name will not be associated with your responses and will be kept confidential.

You are free to ask any questions you might have about this study at any time. At the end of your involvement, you will be provided with feedback explaining the purpose of this research in more detail. You may ask about the results of the study when it is complete by contacting any of the investigators. Their names and phone numbers are listed on the debriefing form you will receive at the conclusion of your involvement. If you have any questions about your participation in this study, ask the investigator before you indicate your consent to voluntarily participate by signing below.

I have been fully informed about the above-described study and its possible risks. I give permission for my participation in this study. I know that the investigator and his/her associates will be available to answer any questions I may have. I understand that I am free to withdraw this consent and discontinue participation in this study at any time without penalty.

Date______________

Print Name____________________ Signature______________________________

Address______________________ Phone________________________________

Appendix B

Debriefing Form
Tactical Action Game (TAG)

The study in which you just participated was designed how training design elements act to produce the kinds of outcomes valued by organizations conducting training in the real world. During this study, you operated the TAG radar simulation. TAG simulates the complex physical performance, information processing, and decision-making demands of real teams performing fast-paced, critical tasks. To perform the TAG simulation you needed to learn how to operate the task and develop strategies for effective task performance. TAG required you to gather information about objects on the screen, make decisions, and take actions based on the information you gathered. We will use this information gathered during the study to link your performance on the task to your knowledge of the task.

If you have any questions about this study or would like to receive a copy of the results when they are complete, please notify the investigator now. If, in the future, you have any questions about the study or would like to receive the results when they are complete, please call one of the investigators listed below. Finally, thank you for participating in this study. We tried to make it as interesting for you as possible, and we are open to suggestions. So if you think we can improve this study in any way, please feel free to talk to us now or call us in the future.

Investigator: Morrie Mullins 353-9166

Appendix C: Award Instructions

In this experiment you will be operating a complex computer task and answering questions about your experiences. We will award a total of eight cash prizes to the best TAG players. Two categories of proficiency will be recognized, and four awards will be offered in each category:

Two 1st place prizes at $50 each
Two 2nd place prizes at $40 each
Two 3rd place prizes at $30 each
Two 4th place prizes at $20 each

Each set of four awards will be made for different types of game proficiency:

One pair of awards will be made for the players who understand the game the best during the three practice sessions. You will answer several questionnaires about the game during and after the practice sessions. You need to think carefully about your answers to the questions. The top players who answer these questions the best will be awarded 1st, 2nd, 3rd, and 4th Place Prizes.

The second pair of awards will be made for the players who do the best on the final TAG session that will take place at the end of the experiment. The top players who do the best will be awarded 1st, 2nd, 3rd, and 4th Place Prizes. We let you know when the final session is about to begin.

The Prizes are independent of each other. That means its possible to be awarded prizes in both categories of proficiency. Your chances of getting an award are pretty good -- it's all up to you.

Open your folder and take out the Tactical Action Game Description and the Consent Form. Please read both sheets. If you agree to participate in our study, please sign and date the consent form and return it to the folder. I'll be around to collect the folders later in the experiment.

Appendix D: Feedback Screens

FEEDBACK: FIRST AND LAST SCREENS

You will now have an opportunity to review your activity during the practice period you just completed. You should use the information provided on the following screens to guide your study and practice.

Remember that once you leave a screen, you cannot go back to review it again. Spend as much time as you need on each screen.

Now, advance to the next screen to begin reviewing your feedback.

(Press the space bar to advance to the next screen)

You should use the information you have gained from the feedback to guide your study and your practice.

Now, exit the feedback program and wait for instructions from your lab monitor.

(Press the space bar to exit the feedback program)

VELOCITY (SCORE) FEEDBACK

During this past practice period:

Average amount of time spent on a target:	#
Your total score:	#
Points gained for engaging targets correctly:	#
Points lost for engaging targets incorrectly:	#
Points lost for targets entering defensive perimeters:	#
Number of targets engaged:	#
Number of targets engaged correctly:	#
Number of targets engaged incorrectly:	#
Average amount of time spent on a target:	#
Number of times you zoomed in:	#
Number of pop-up targets you engaged:	#

- Pay attention to your score and its constituent information, and use it to track your progress during the training.

(Press the space bar to advance to the next screen)

MASTERY FEEDBACK: FIRST TRIAL BLOCK

During this past practice period:

TYPE subdecisions: __#__ correct out of __#__ total (__%__)
CLSS subdecisions: __#__ correct out of __#__ total (__%__)
ITNT subdecisions: __#__ correct out of __#__ total (__%__)

- If you're getting subdecisions incorrect, you have not learned the cues.
- If you are relying on the manual to get cue information, you may not have fully memorized the cues.
- If you are not making very many decisions, you are not practicing your skills.

(Press the space bar to advance to the next screen)

During this past practice period:

FINAL_ENGAGE decisions: __#__ correct out of __#__ total (__%__)

- If you're getting these decisions incorrect, you have not learned the cues or you have not learned the correct decision rule for peaceful and hostile targets.
- If you are not making very many decisions, you are not practicing your skills.

(Press the space bar to advance to the next screen)

During this past trial you did the following:

Hooked at least one contact: __Y/N__
Decided Type/Class/Intent: __Y/N__
Engaged at least one contact: __Y/N__
Used the zoom feature: __Y/N__

- If you have not done these activities, you are not getting familiar with the task.

(Press the space bar to advance to the next screen)

MASTERY FEEDBACK: SECOND TRIAL BLOCK

During this past practice period:

Times you zoomed out: ___#___
Marker targets hooked: ___#___
Targets hooked outside of outer perimeter: ___#___

- If the numbers above are low, you are not practicing the skills necessary to defend the outer perimeter.

(Press the space bar to advance to the next screen)

During this past practice period:

Inner perimeter intrusions: ___#___
Outer perimeter intrusions: ___#___

- If these numbers are greater than zero, then contacts are crossing your defensive perimeters.

(Press the space bar to advance to the next screen)

During this past practice period:

Targets that popped-up: ___#___

- If you did not notice any of these pop-ups, you were not aware of changes in the situation that were occurring.

(Press the space bar to advance to the next screen)

MASTERY FEEDBACK: THIRD TRIAL BLOCK

During this past practice period:

Speed queries of targets near inner defensive perimeters: __#__
Speed queries of targets near outer defensive perimeters: __#__

- If either of these numbers is low, you are not checking the priority of targets near your perimeters.

(Press the space bar to advance to the next screen)

During this past practice period:

Inner intrusions: __#__
Inner intrusions prevented: __#__

Outer intrusions: __#__
Outer intrusions prevented: __#__

- If you are not preventing intrusions on both perimeters, you are not prioritizing before engaging targets.
- If there are more intrusions than preventions on either perimeter, you are not attending to the perimeters or you are not engaging targets efficiently.

(Press the space bar to advance to the next screen)

During this past practice period:

High priority targets engaged: __#__ out of __#__ total (__%__)
Low priority target engaged: __#__ total

- If you are engaging more low priority than high priority targets, you are not prioritizing effectively.
- If you are not engaging a high percentage of high priority targets, you are not engaging targets efficiently.

(Press the space bar to advance to the next screen)

Appendix E: Measures

INSTRUCTIONS FOR ANSWERING QUESTIONS ON THE SCANTRON

Please write your last name in the area marked YOUR LAST NAME. Please write in your first name and middle initial in the areas marked YOUR FIRST NAME and MI. Do NOT bubble the letters since we will not be using your name for data, and your responses will be kept anonymous.

Please DO fill in your PID and bubble the corresponding numbers. After filling in your name and PID, please answer the following questions by filling in the appropriate bubble, beginning with question number 1.

Demographic Information

After filling in your name and subject number please answer the following questions by filling in the appropriate bubble, beginning with question number 1.

1. What is your sex?

   (1) Male (2) Female

2. What is your age?

   (1) < 18 yrs (2) 18-19 yrs (3) 20-21 yrs (4) 22-23 yrs (5) > 23

3. What is your overall grade point average?

   (1) 0 - 1.0 (2) 1.1 - 2.0 (3) 2.1 - 3.0 (4) 3.1 - 4.0 (5) >4.0

4. Have you been to this particular lab before?

   (1) Yes (2) No

5. Are you left or right handed?

   (1) Left (2) Right

6. Do you play video games?

   (1) Never (2) Rarely (3) Sometimes (4) Frequently (5) Always

Goal Orientation Measures

Button, Mathieu, & Zajac (1996)

This set of questions asks you to describe how you feel about each of the following statements. Please use the scale shown below to make your ratings.

```
   Strongly                                           Strongly
   Disagree   Disagree   Neutral     Agree            Agree
 <---|----------|----------|----------|----------|--->
    (1)        (2)        (3)        (4)        (5)
```

Check to make sure you are beginning on question number [x].

1. The opportunity to do challenging work is important to me.
2. I do my best when I'm working on a fairly difficult task.
3. I try hard to improve on my past performance.
4. When I have difficulty solving a problem, I enjoy trying different approaches to see which one will work.
5. The opportunity to learn new things is important to me.
6. The opportunity to extend the range of my abilities is important to me.
7. I prefer to work on tasks that force me to learn new things.
8. When I fail to complete a difficult task, I plan to try harder the next time I work on it.
9. The things I enjoy the most are the things I do the best.
10. I feel smart when I can do something better than most other people.
11. I like to be fairly confident that I can successfully perform a task before I attempt it.
12. I am happiest at work when I perform tasks on which I know that I won't make any errors.
13. I feel smart when I do something without making any mistakes.
14. I prefer to do things that I can do well rather than things that I do poorly.
15. The opinions others have about how well I can do certain things are important to me.
16. I like to work on tasks that I have done well on in the past.

Goal Commitment Scale

(Hollenbeck, Williams, & Klein, 1989)

```
 Strongly                                         Strongly
 Disagree    Disagree    Neutral     Agree         Agree
<---|-----------|-----------|-----------|-----------|--->
   (1)         (2)         (3)         (4)         (5)
```

1. I take the goal(s) of this task session seriously.
2. I'm willing to put forth effort to work toward the presented goal(s).
3. It is quite likely that the goal(s) of this session may need to be revised, depending on how things go.
4. I care about the goal(s) of this session.
5. I am committed to pursuing the goal(s) of this session.
6. It wouldn't take much to make me abandon the goal(s) of the session.
7. I think the goal(s) presented to me are worth pursuing.

Self-Efficacy

This set of questions asks you to describe how you feel about your capabilities to play TAG. Please use the scale shown below to make your ratings.

```
 Strongly                                             Strongly
 Disagree    Disagree    Neutral     Agree             Agree
<---|-----------|-----------|-----------|-----------|--->
   (1)         (2)         (3)         (4)         (5)
```

Check to make sure you are beginning on question number [x].

1. I can meet the challenges of this simulation.
2. I am confident in my understanding of how information cues are related to decisions.
3. I can deal with decisions under ambiguous conditions.
4. I am certain that I can manage the requirements of this task.
5. I believe I will fare well in this task if the workload is increased.
6. I am confident that I can cope with this simulation if it becomes more complex.
7. I believe I can develop methods to handle changing aspects of this task.
8. I am certain I can cope with task components competing for my time.

Declarative Knowledge Test

The following is a knowledge test about TAG. Please use the Scantron sheet to answer the following questions. Bubble in the correct letter for each question, making sure the question numbers match. Check to make sure you are beginning on question number [x].

1. If a Response is Given, what is the likely Intent of the target?

   a. Military
   b. Hostile
   c. Civilian
   d. Peaceful

2. If a target's Speed is 25 knots, its Communication Time is 85 seconds, and its Altitude/Depth is 0 feet, what does this suggest about the target's Type?

   a. The target is a Surface Vessel
   b. The target is a Submarine
   c. The target is Civilian
   d. The target is Military

3. A Submarine has which of the following characteristics?

   a. Speed 30 knots, Altitude/Depth -20, Communication time 85 seconds.
   b. Speed 30 knots, Altitude/Depth 0, Communication time 30 seconds.
   c. Speed 20 knots, Altitude/Depth 0, Communication time 80 seconds.
   d. Speed 20 knots, Altitude/Depth -20, Communication time 90 seconds.

4. A Maneuvering Pattern of Code Delta indicates which of the following? The target is:

   a. Air
   b. Military
   c. Surface
   d. Civilian

5. A Blue Lagoon Direction of Origin indicates which of the following? The target is:

   a. Unknown
   b. Sub
   c. Civilian
   d. Military

6. A target that gives No Response indicates which Intent?

   a. Peaceful
   b. Hostile
   c. Military
   d. Unknown

7. If a target's Altitude/Depth is 10 feet, what is the Type of the target?

   a. Air
   b. Surface
   c. Submarine
   d. Unknown

8. Your Outer Defensive Perimeter is located at:

   a. 64 nm
   b. 128 nm
   c. 256 nm
   d. 512 nm

9. If a target's Intelligence is Unavailable, what Class does this suggest for the target?

   a. Air
   b. Civilian
   c. Military
   d. Unknown

10. What Threat Level would be assigned to a Hostile target?

   a. 1
   b. 2
   c. 3
   d. 10

11. If a target's characteristics are Communication Time = 20 seconds and Speed = 50 knots, which of the following actions should you take?

   a. Choose Intent is Peaceful
   b. Choose Type is Surface
   c. Get another piece of information
   d. Choose Type is Air

12. A Military target has which of the following sets of characteristics?

   a. Intelligence is Platform, Red Sea Direction of Origin, Maneuvering Pattern is Code Delta.
   b. Intelligence is Unavailable, Red Sea Direction of Origin, Maneuvering Pattern is Code Echo.
   c. Intelligence is Platform, Blue Lagoon Direction of Origin, Maneuvering Pattern is Code Delta.
   d. Intelligence is Unavailable, Blue Lagoon Direction of Origin, Maneuvering Pattern is Code Echo.

13. If a target's characteristics are Intelligence is Private and Maneuvering Pattern is Code Foxtrot, which of the following actions should you take?

    a. Choose Class is Military
    b. Choose Intent is Peaceful
    c. Choose Class is Civilian
    d. Choose Intent is Unknown

14. A Peaceful target will demonstrate what form of countermeasures?

    a. Jamming
    b. None
    c. Unknown
    d. Undetected

15. A Communication Time of 52 seconds indicates that the target is likely:

    a. Air
    b. Surface
    c. Submarine
    d. Unknown

16. If a target's characteristics are Response is Inaudible, Threat Level = 3, and Countermeasures are Jamming, which of the following actions should you take?

    a. Choose Intent is Unknown
    b. Choose Intent is Peaceful
    c. Choose Intent is Hostile
    d. Choose Intent is Military

17. If a target's Maneuvering Pattern is Code Echo, this suggests that the target falls into which category?

    a. Class is Unknown
    b. Class is Military
    c. Class is Hostile
    d. Class is Peaceful

18. A Peaceful target will demonstrate what Threat Level?

    a. 0 c. 2
    b. 1 d. 3

19. Your Inner Defensive Perimeter is located at:

    a. 10 nm c. 64
    b. 32 nm d. 128

Adaptive Knowledge Measure

Response options in **bold face** are keyed as the "best" option, while those in *italics* are keyed as the "worst" option, based on *a priori* coding and expert responses to the questionnaire.

The following scenarios are designed to assess your expertise in applying what you know about the TAG game to different situations. Please read each of the situations presented carefully, and mark the option you would **most** likely choose and the item you would **least** likely choose on the scantron. Be sure to begin with number [x] on your scantron form.

Scenario 1

Four targets are approaching your OUTER DEFENSIVE PERIMETER. Target One is moving at 22 knots, Target Two at 350 knots, Target Three at 305 knots, and Target Four at 35 knots. All targets are equally close to the defensive perimeter.

A. *Prosecute Target One first*
B. **Prosecute Target Two first**
C. Prosecute Target Three first
D. Prosecute Target Four first

1. Which of these options would you **MOST LIKELY** choose?
2. Which of these options would you ***LEAST* LIKELY** choose?

Scenario 2

Five targets are approaching your INNER DEFENSIVE PERIMETER. Target One is moving at 222 knots, Target Two at 355 knots, Target Three at 425 knots, and Target Four at 3 knots, and Target Five is moving at 294 knots. All targets are equally close to the defensive perimeter.

A. *Prosecute Target One first*
B. Prosecute Target Two first
C. **Prosecute Target Three first**
D. Prosecute Target Five first

3. Which of these options would you **MOST LIKELY** choose?
4. Which of these options would you ***LEAST* LIKELY** choose?

[Please continue to the next page]

Scenario 3

Your radar screen indicates that 5 fast targets are approaching your INNER DEFENSIVE PERIMETER, and that 3 fast targets and 5 slow targets are approaching your OUTER DEFENSIVE PERIMETER. All of the targets are about the same distance from their respective perimeters.

A. Deal with the fast targets at the outer perimeter first, then move to the inner

B. Deal with all the targets at the outer perimeter first, then move to the inner

C. Deal with the targets at the inner perimeter first, then move to the outer

D. It doesn't matter which order you deal with the targets because the penalty values are the same at both perimeters

5. Which of these options would you **MOST LIKELY** choose?
6. Which of these options would you ***LEAST* LIKELY** choose?

Scenario 4

In a sudden burst of activity, the enemy has sent its entire force against your fleet, hoping to wipe you out. Your radar screen is filled with targets, and there is no way you can hope to deal with all of them before the fleet is overwhelmed, so you must choose wisely. Because of the massive number of targets, you only have time to look at a minimum amount of information on each target.

A. Look at target Intent, and only prosecute Hostile targets

B. Look at target Class, and only prosecute Military targets

C. Look at target Type, and only prosecute Air targets

D. Look at target speed, and only prosecute fast targets

7. Which of these options would you **MOST LIKELY** choose?
8. Which of these options would you ***LEAST* LIKELY** choose?

Scenario 5

The Admiral decides to expand the fleet because of increasing political tensions, and adds a destroyer group 500 nm from your station. He instructs you that you now have a third defensive perimeter to monitor, located at 512 nm. Because of the distance of the new group from the remainder of the fleet, he instructs you that protecting this perimeter is **much** more important than protecting the perimeter at 256 nm. While monitoring your radar, you notice 6 targets rapidly approaching your MIDDLE DEFENSIVE PERIMETER (256 nm) and 5 targets rapidly approaching the OUTER DEFENSIVE PERIMETER (512 nm).

A. Deal with the military targets first

B. Deal with the middle perimeter targets first

C. Deal with the outer perimeter targets first

D. Deal with the hostile targets first, since peaceful targets don't threaten your destroyer group

9. Which of these options would you **MOST LIKELY** choose?
10. Which of these options would you ***LEAST* LIKELY** choose?

For the next two scenarios, assume the following: In game-play terms, you have three penalty circles. INNER DEFENSIVE PERIMETER intrusions result in a deduction of 50 points. MIDDLE DEFENSIVE PERIMETER intrusions result in a deduction of 100 points. OUTER DEFENSIVE PERIMETER intrusions result in a deduction of 75 points.

Scenario 6

12 targets are approaching your inner perimeter. 8 are fast, 4 are slow, and of the fast targets, six are close to the perimeter. 15 targets are approaching the middle perimeter. 8 of these targets are also fast, but only 3 fast targets are close to the perimeter. 4 targets are approaching your outer perimeter. All are fast, and all are close to the perimeter.

A. *Focus on the INNER DEFENSIVE PERIMETER*
B. Focus on the MIDDLE DEFENSIVE PERIMETER
C. Focus on the OUTER DEFENSIVE PERIMETER
D. **Focus your attention equally across all fast targets, moving back and forth across perimeters until you have dealt with all targets successfully**

11.Which of these options would you **MOST LIKELY** choose?
12.Which of these options would you ***LEAST LIKELY*** choose?

Scenario 7

Now assume instead that you have 22 targets sitting almost on top of your inner perimeter, but hardly moving at all. You still have 15 targets approaching your middle perimeter, with 8 moving fast and being fairly close to the perimeter. At your outer perimeter, you have 12 targets, all of which are moving fast and are as close to the perimeter as the targets approaching the middle perimeter.

A. *Focus on the INNER DEFENSIVE PERIMETER*
B. Focus on the MIDDLE DEFENSIVE PERIMETER
C. **Focus on the OUTER DEFENSIVE PERIMETER**
D. Focus your attention equally across all fast targets, moving back and forth across perimeters until you have dealt with all targets successfully

13.Which of these options would you **MOST LIKELY** choose?
14.Which of these options would you ***LEAST LIKELY*** choose?

[Please continue to the next page]

Scenario 8

Your radar screen is malfunctioning and is incapable of giving you an accurate readout of its range, making it difficult to locate your defensive perimeters. You know that two of your submarines were assigned to guard the perimeters, but without information on the current range of your scope, you aren't sure where to find them. You must determine how to defend your defensive perimeter.

A. Look for submarine targets and prosecute all of the other targets that approach them.

B. Look for submarine targets, zoom out, and prosecute all of the other targets that approach that region.

C. Look for stationary targets and prosecute all of the other targets that approach them.

D. Look for stationary targets, zoom out, and prosecute all of the other targets that approach that region.

15.Which of these options would you **MOST LIKELY** choose?
16.Which of these options would you *LEAST LIKELY* choose?

Scenario 9

Your defensive perimeters are at 10 nautical miles and 256 nautical miles. Your radar screen is clear, and then suddenly your sensors come to life and clusters of targets pop up all around your screen. You need to decide which cluster of pop-up targets to deal with first. All targets are moving at the same speed.

A. The four-target cluster at 81 nm

B. The two-target cluster at 15 nm

C. The ten-target cluster at 250 nm

D. The six-target cluster at 280 nm

17.Which of these options would you **MOST LIKELY** choose?
18.Which of these options would you *LEAST LIKELY* choose?

STOP!

Self-Regulation "Diary" Entry

Training Trials

Please use the space below to describe the goals you focused on during the previous trial. Please be specific with respect to what goals you adopted during the past five minutes. When you finish writing, please wait for further instructions.

Generalization Trial

Please use the space below to describe the most important/critical element of the task that you had to learn or perform during the training session today. Please be specific, because it is important for the purposes of future training design that we accurately understand what you, as a trainee, had the most difficulty grasping based on how we designed the training.

Self-Regulatory Activity Items

The following questions ask you to consider the kinds of things you were thinking about over the course of the previous three trials. Because different people may pay attention to different things in the task, there are no right or wrong answers to these questions, so please answer as honestly as possible with respect to how much you thought about each of the things listed below.

Almost Not At All		Moderate Amount		A Great Deal
(1)	(2)	(3)	(4)	(5)

1. I tried to monitor closely the portions of the task where I needed the most practice.
2. I noticed where I made the most mistakes during practice and focused on improving those areas.
3. I evaluated the feedback at the end of the practice trial to determine how I would approach the next trial.
4. While practicing the scenarios, I monitored how well I was learning their requirements.
5. I monitored how well I was performing on this task.
6. I tried to monitor those portions of the task that would give me information about how well I was reaching my goals.
7. I actively planned how I should approach each trial.
8. I used the feedback from each trial to devise a plan for how to approach the next trial.
9. I developed strategies that allowed me to improve my mastery of TAG.
10. I focused on long-term goals for skill development rather than short-term performance.
11. I set goals for myself in addition to the mastery goals I was provided.

Self-Regulatory Skill Questionnaire

The next set of items asks you to think about how you generally approach learning, in terms of learning strategies and study skills, in the classroom environment. **There are no right or wrong answers to these questions**. Use the scale below to indicate how true each statement is of your approach to learning. If you think the statement is very true of you, circle 5; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 5 that best describes you.

```
Not at all                                        Very
True of Me                                   True of Me
<---|----------|----------|----------|----------|--->
   (1)        (2)        (3)        (4)        (5)
```

1. I pay attention to things I need to practice when I'm learning something new.
2. I notice where I make mistakes and focus on improving those areas.
3. I evaluate feedback I receive to determine how to approach future activities.
4. When I'm practicing a new skill, I monitor how well I'm learning its requirements.
5. I constantly monitor how well I'm performing tasks I'm working on.
6. I try to monitor those aspects of tasks I'm working on that give me information about how well I'm reaching my goals.

Motivation Questionnaire

This set of questions asks you to describe how motivated you were in this experiment overall. Please use the scale shown below to make your ratings.

```
 Strongly                                          Strongly
 Disagree   Disagree   Neutral     Agree           Agree
<---|----------|----------|----------|----------|--->
   (1)        (2)        (3)        (4)        (5)
```

1. I put forth effort to answer questions accurately and honestly.

2. I tried to make good choices in determining the best and worst options on the sample scenarios I was presented.

3. I tried to do well when playing the TAG simulation.

4. Overall, I was motivated to do well on all parts of the experiment.

Feedback Satisfaction Questionnaire

```
Strongly                                               Strongly
Disagree    Disagree    Neutral     Agree      Agree
<---|-----------|-----------|-----------|-----------|--->
   (1)         (2)         (3)         (4)         (5)
```

1. The feedback helped me to know if I was reaching my goal(s).
2. In general, the feedback I received was useless to me.
3. In general, the feedback I received was helpful to me.
4. There was feedback I received that I didn't use.
5. There was just the right amount of feedback.
6. I wished I could have received more feedback.
7. The way the feedback was provided frustrated me.
8. I was satisfied with the manner in which I received feedback.
9. I was frustrated because I didn't get the feedback I needed.
10. I was frustrated with the amount of feedback I received.

Appendix F: Figures

The following pages contain the figures referenced in the text of this dissertation.

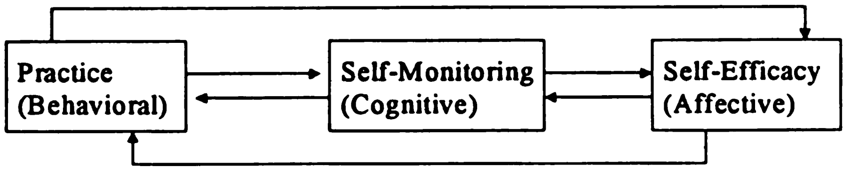
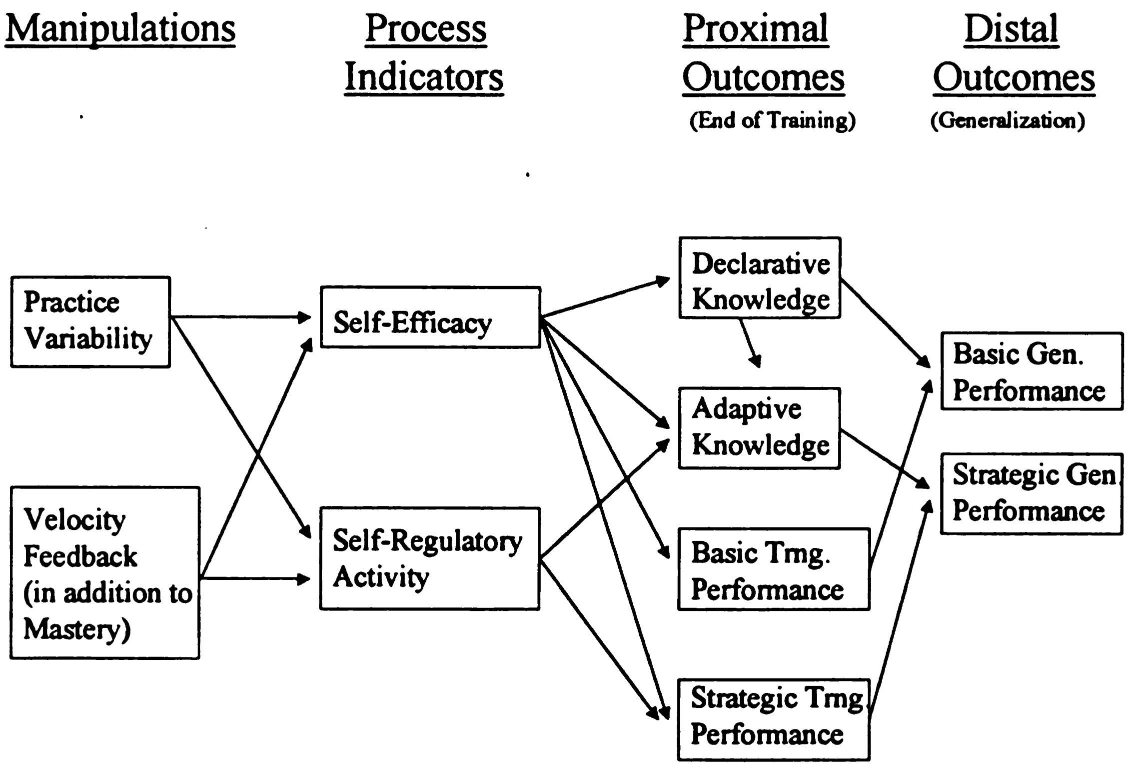


Figure 1: The Self-Regulatory System (Kozlowski et al., 1997)



Note: Basic Trng. Performance = Basic Performance in the final training trial; Strategic Trng. Performance = Strategic Performance in the final training trial; Basic Gen. Performance = Basic Performance in the generalization trial; Strategic Gen. Performance = Strategic Performance in the generalization trial

Note: Cognitive Ability, Mastery Orientation, Performance Orientation, Gender, and Video Game Experience were used as covariates in all regression analyses.

Figure 2: Experimental Model (Theoretical)

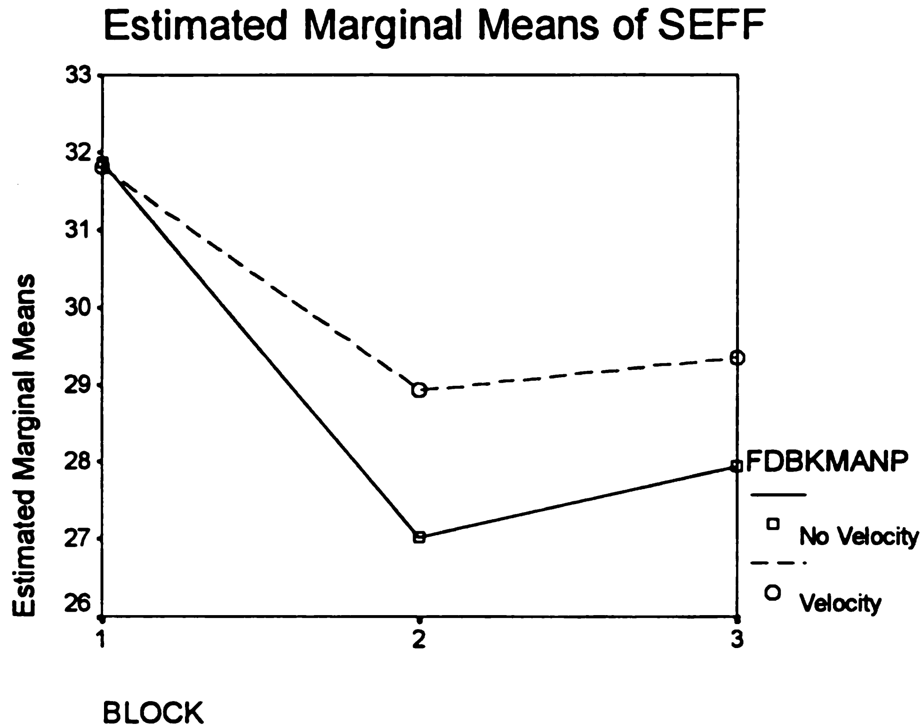


Figure 3: Profile Plot of Means for Self-Efficacy Following Trials 3, 6, and 9

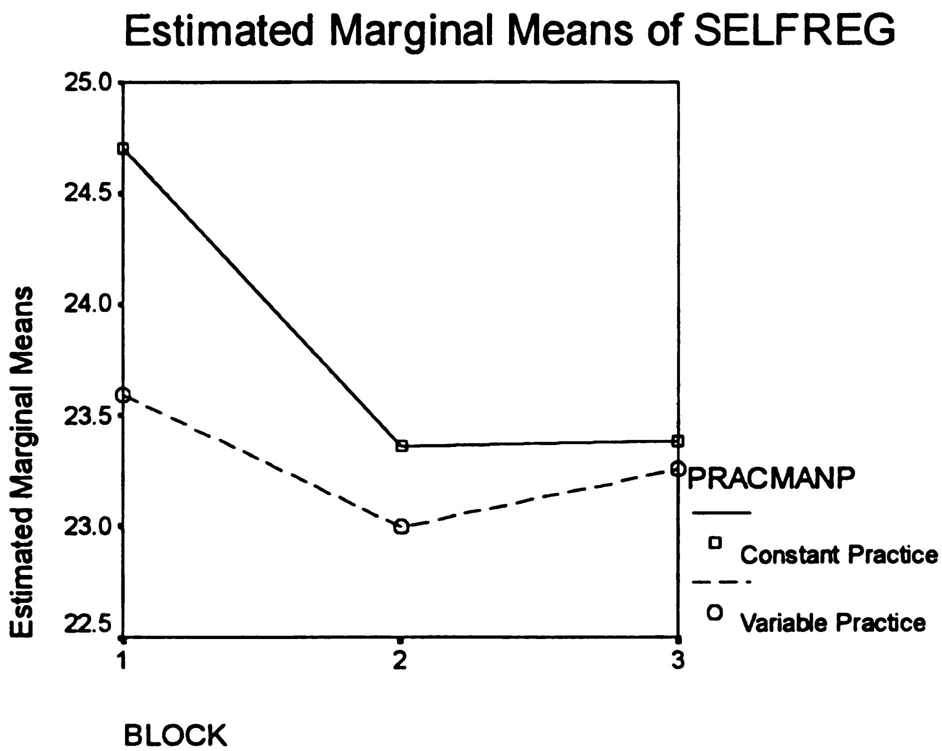
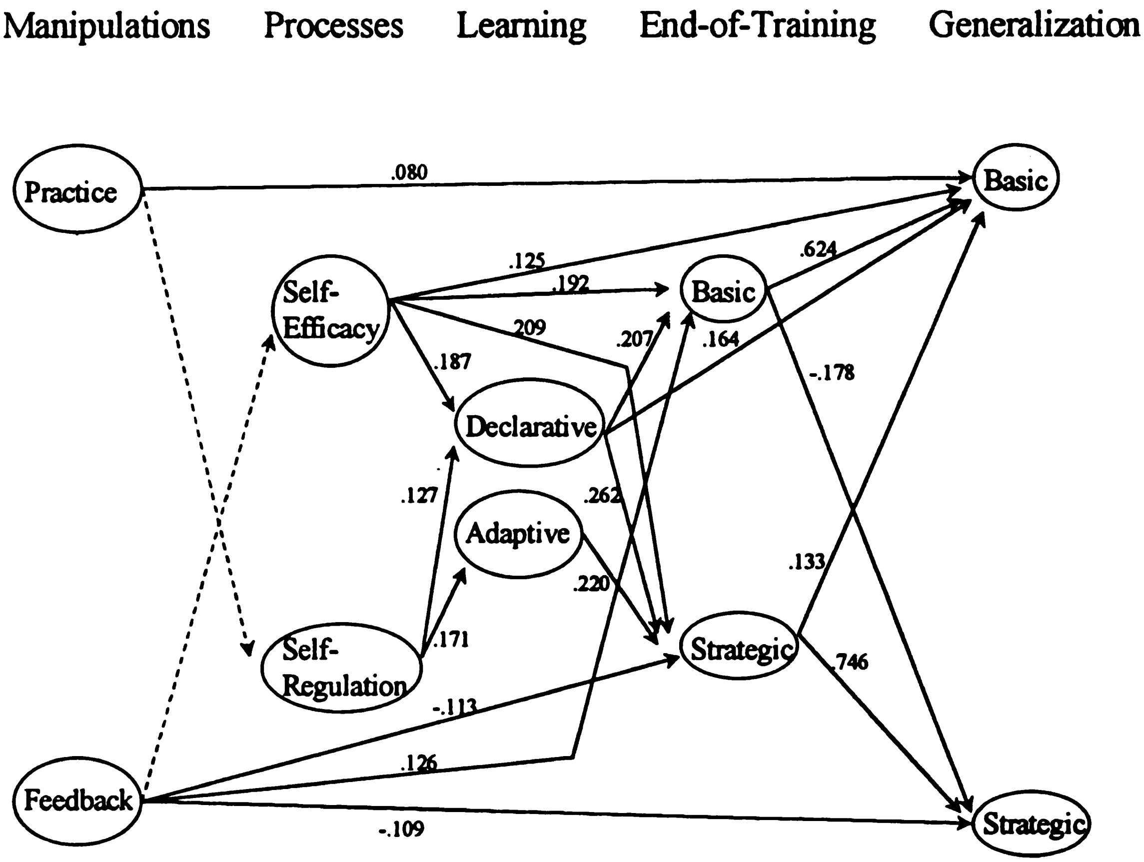


Figure 4: Profile Plot of Means for Self-Regulation Following Trials 3, 6, and 9



Note: All beta weights reported are from the final step in the appropriate regression analysis, and all are significant ($p < .05$). Dotted lines indicate interaction effects of manipulations with time.

Figure 5: Revised Model, Post-Analytic

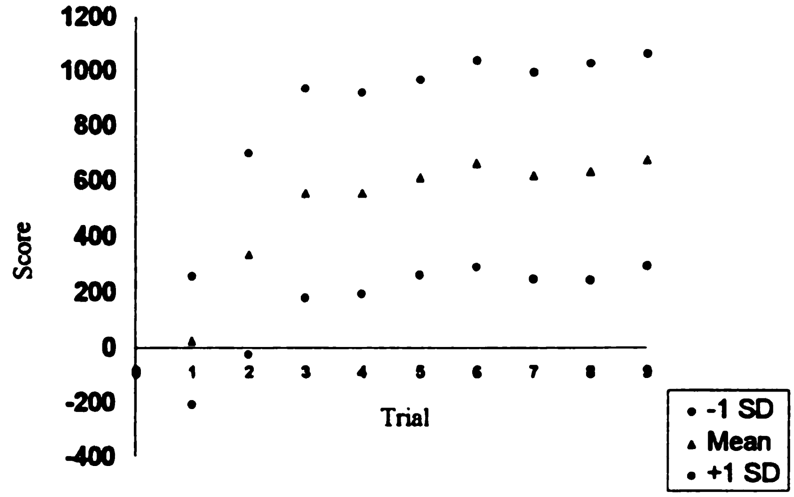


Figure 6: Trainee Score Over Nine Training Trials