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SELF-REGULATION AND ADAPTATION: A PROCESS APPROACH

By

Brady M. Firth

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ABSTRACT

SELF-REGULATION AND ADAPTATION: A PROCESS APPROACH

By

Brady M. Firth

Research on adaptation has only recently begun to rely on a self-regulatory, process-oriented framework. This paper extends this framework by studying how individuals engage in self-regulatory processes when overcoming changes in the environment. Metacognitive and feedback manipulations are introduced during training in order to investigate how training can enable individuals to better engage in self-regulatory processes that enable adaptation to environmental changes. Results indicate that studying adaptive processes over time is essential, as the effects of metacognitive training were only manifest over time. Although many hypotheses were not supported, this study indicates that multiple regulatory pathways and processes are involved in adaptation. An alternate, dynamic model of adaptation is offered and future research directions suggested.

This work is dedicated to Danielle, Liam, and Elsie.

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Chapter 1

Introduction

Adapting to changing environments is a central human endeavor. In the workplace, technological developments, team-centered work, changes in organizational structures, and an increasingly global economy require employees to be responsive to change. When environmental pressures shift, individuals must adapt their behavior in order to maintain or improve performance. The recent turmoil of the world economy has placed a new premium on adaptability, as companies seek leaders and workers who cannot just survive hard times, but profit from them. From factory floor to executive suite, adaptation seems to matter for both the bottom-line and the well-being of employees.

While researchers and managers have both become more interested in understanding what enables adaptation, the nature of adaptability is still in question. Three primary reasons explain why researchers have been unable to reach a consensus on how to best define and conceptualize individual adaptation. First, adaptation is a multi-dimensional phenomenon that involves multiple constructs. These multiple dimensions and components will be described in detail below. However, this complexity precludes any quick and easy solutions on how best to conceptualize adaptation. Second, there are multiple methodological difficulties inherent in studying adaptation. For example, the need to incorporate the element of time, a reliance on self-reported measurements of key variables, how best to measure variables related to adaptation (e.g., knowledge structures and metacognition) and the difficulties of generalizing findings beyond a local context all complicate the study of adaptation (Kraiger, Ford, & Salas, 1993; LePine et al., 2000; Smith et al., 1997). Third, researchers approaching any problem utilize alternative perspectives and come to the table with differing assumptions. The study of adaptation has been no different. These three difficulties have resulted in multiple definitions of what adaptation is. Adaptation has been defined as a latent variable (Verbruggen & Sels, 2008), behavior (Ashford, 1986; Pulakos et al., 2001), an outcome (Burke et al. 2006; Kozlowski et al., 2001) and a process (Bell & Kozlowski, 2008; Chen, et al. 2005). Furthermore, adaptation is closely related to other concepts such as innovation, learning, creativity (Burke et al., 2006), and far transfer. Given such varied definitions, operationalizations, and conceptualizations, researchers are yet to agree on what adaptation "really" is.

These basic differences have resulted in recent adaptive performance research progressing along three general frameworks. First, Pulakos and colleagues identified eight task work dimensions of adaptation and found that individual differences predicted performance on these dimensions (Pulakos et al., 2002). This research refined our understanding of adaptive performance dimensions and identified useful predictors of such performance. However, it did little to inform what can be done to enable adaptation. Second, many researchers have treated adaptation as a result of training. This research typically identifies individual differences and training elements which predict performance on a transfer task (e.g., Ford et al., 1998; Kozlowski et al. 2001). This research does more to identify ways of improving adaptive performance for certain task types, but falls short of explaining how individuals self- regulate learning and performance while adapting. Other researchers suggest more directly that adaptation occurs through self-regulatory processes that can be enacted during learning and task performance. For example, learners who are able to regulate cognitive, motivational, and/or affective processes during learning are better able to transfer knowledge, skills, and abilities to novel or more complex tasks (Bell & Kozlowski, 2008; Chen et al., 2005). This work begins to illuminate what the process of adaptation entails, but has not taken full advantage of longitudinal data collection in order to measure the underlying processes involved over time.

Delineating the roles that such regulatory processes play during transfer and future performance is the primary aim of this study. I meet this aim and extend research on individual adaptation to environmental change in three ways. First, I hope to extend and develop process-oriented adaptation theory. Adaptation has only recently been construed in the organizational literature as a process and, as noted previously, this conceptualization is neither dominant nor pervasive. Previous process-oriented research has used relatively simple and static methods of measurement, typically capturing relevant processes by measuring training transfer at one or two time points. This design is useful to answer whether individuals do adapt, but lacks the ability to answer how individuals adapt (i.e., how regulatory pathways are enacted over time to enable adaptation). In this paper I argue for a process-oriented theory of adaptation and use a methodology suitable to such an argument. I measure self-regulatory processes over time while subjects learn, practice, and perform a computerized radar task, and show that individuals that enact such processes are better able to adapt to changing environmental pressures.

Second, I seek to extend theory that entails multiple regulatory pathways. Bell & Kozlowski (2008) hypothesized that three pathways (cognitive, motivational, and affective) are involved in adaptive self-regulation. They found that the cognitive and motivational pathways are closely intertwined, and that the affective pathway did not have as dominant a role. In this study, I seek to disentangle the first two pathways by investigating the relationship of several cognitive and motivational variables over time. By measuring and describing the relationships between these variables across time in more detail, I hope to come closer to identifying causal relationships within and across these pathways.

Third, although adaptation is a result of learning, practice, and self-regulation, how best to prepare individuals to adapt remains an unanswered question. Moving beyond knowledge structures and individual differences, it is unclear what processes separate high-adapters from low-adapters. I implement metacognitive- and feedback-based training approaches to investigate how self-regulatory processes are engaged during training and what the effects of these processes during adaptation are. By introducing metacognitive and feedback manipulations during training and then measuring their effects during both learning and adaptive phases, it will be possible to gain a better understanding of how adaptive processes are responsive to intervention. This first step in identifying meaningful interventions for leveraging adaptive processes will help identify boundary conditions and practical utility of adaptation theory.

Adaptation Research

Recent research on adaptation can be described by two general frameworks. First, adaptation has been conceptualized as the effect of individual differences on performance. From this perspective, individuals possess particular characteristics that enable them to perform well in particular contexts. Second, adaptation has been considered from a process perspective. In this case, individuals with varying characteristics engage in particular processes during learning or training which lead to desirable performance outcomes in adaptive contexts. Within each of these general frameworks, various definitions and approaches have been taken.

Adapation has been explained in terms of stable individual characteristics for a number of years (Jackson, 1967; Morrison, 1977; Mumford, Baughman, Threlfall, Uhlman, & Costanza, 1993; Murphy, 1989; Sternberg, 1997). Scholars have built from this individual difference approach to offer more specific definitions of what adaptive performance is, complete with differential predictors and specific job requirements. LePine, Colquitt, and Erez (2000); Pulakos, Arat, Donovan, and Plamandon (2000); and Pulakos et al. (2002) have done the brunt of this work.

LePine et al. (2000) investigated the effects of ability, conscientiousness, and openness to experience on performance in a changing environment. These authors' theoretical approach was based in a desire to identify personal characteristics that are advantageous for selection efforts in adaptive environments. Identifying selectable traits that permit adaptation, they argued, has the advantage over continually hiring new employees that fit the demands of the current environment or of offering continual training to update employees' capacities for changing demands because it is more practical and less expensive.

LePine et al. (2000) defined adaptive performance as the capability and willingness to work in a changing environment. They operationalized adaptive performance as decision-making performance within a computer simulation after rule changes occurred within the task. Measuring adaptive performance in this way enabled the authors to offer empirical support for conceptualizing adaptive performance as distinct from generic performance by demonstrating that the two types of performance are predicted by different variables.

Participants engaged in a 75-trial computerized task in which they were required to make decisions about how to process sets of enemy units that appeared on the game grid and had different characteristics and processing requirements and priorities. After trials 25 and 50, the processing and decision rules were, unknown to the participants, changed such that participants were forced to adapt their behavior in a way that enabled them to track these changes and learn and use the new rules. Prior to the 1st change, ability was the only predictor of performance, with an absolute correlation of $r = 0.23$. Following the 1st change, ability was correlated more strongly with adaptive performance at an absolute $r = 0.43$, and conscientiousness and openness predicted adaptive performance at $r = 0.29$ and $r = -0.35$, respectively. The negative relationship between conscientiousness and performance was driven by dependability facets rather than achievement facets. These correlations were the same after the second change as they were after the first change.

This study indicates that there are empirical differences in pre- and post-change performance, at least in regards to valid predictors of each. The authors demonstrated that adaptive performance is a useful idea, since it requires something more than generic performance does from the individuals doing the performing. Furthermore, they identified popular and widely used individual difference variables as predictors of adaptive performance.

The primary limitations of the study in regards to the current paper is that the authors overlooked any sort of processes involved in adaptive performance by focusing only on the predictors of distinct performance periods. We are left with little idea about what's going on during or following the changes in the task that permits successful individuals to bring their advantageous characteristics to bear. Some light was shed on this by the supplemental analyses that indicated that individuals scoring higher on dependability, order-seeking, and deliberation did worse in adapting than others. Contrary to conventional wisdom in the field, conscientiousness may not always be a good thing. This suggests potential mechanisms that enable adaptive performance. For example, it is possible that individuals focused on keeping things under control and seeking the status quo are poor at adapting. However, the methodology precluded any investigation of distinctions between those with characteristics predictive of adaptive performance. Are these characteristic necessary or just sufficient for adaptive performance? Can individuals enact particular processes that enable them to successfully perform regardless of their personal characteristics? This study leaves these questions unanswered.

Contributing to the identification of individual differences that enable adaptive performance, Pulakos et al. (2000) developed a taxonomy of adaptive performance with the intent that this taxonomy would in turn permit better understanding and prediction of adaptive behavior. Their aim was to add adaptive performance to the eight dimensions of performance put forward by Campbell et al. (1993). In pursuing this end, adaptation was defined in terms of observable and measurable behaviors across different contexts. By defining adaptive performance in terms of a set of specific behaviors, the authors hoped to identify particular criteria that could then be used to produce a better index of relevant predictors.

Pulakos et al. (2000) used a total of 9,462 critical incidents from 21 jobs across 11 organizations to assess the extent to which hypothesized adaptive performance dimensions were involved across jobs. These critical incidents were coded and sorted into eight dimensions of adaptive performance. The eight dimensions of adaptive performance are handling emergencies or crisis situations; handling work stress; solving problems creatively; dealing with uncertain and unpredictable work situations; learning work tasks, technologies, and procedures; demonstrating interpersonal adaptability; demonstrating cultural adaptability; and demonstrating physically oriented adaptability.

The critical incidents were used to create a 68-item Job Adaptability Instrument (JAI) that assesses the extent to which adaptive performance dimensions are a) of importance and b) require time on a given job. In a test of nine different jobs, the JAI demonstrated high reliability (alpha $M = .94$, alpha $SD = .20$). The agreement of individuals within these nine jobs was also high, with ICCs ranging from .72 to .98. Although EFAs and CFAs indicate that eight-dimensional model is the best fit, the dimensions correlate anywhere from .30 to .69 with one another.

Pulakos et al. (2002) further tested this eight-dimensional model of adaptive performance by investigating the degree to which certain individual differences predict each of the eight dimensions. The authors developed and administered a biodata instrument meant to sample adaptive behaviors, an interest instrument that measured interest in working in situations that demand dimensions of adaptive performance, and a task-specific self-efficacy measure that captured how effective individuals feel they are at adapting in ways consistent with the eight dimensional taxonomy of performance. These three measures were aligned such that they measured their respective constructs in ways that were as similar as possible across each of the eight dimensions of adaptive performance. Openness to experience, emotional stability, achievement motivation, and ability were also used to predict adaptive performance. Two adaptive performance measures (i.e., a behaviorally based rating scale and supervisory ratings) were used to provide criterion validity for the dimensions of adaptive performance. Overall, past experience, interest, self-efficacy, ability, and achievement motivation all predicted adaptive performance. Only a single scale of the experience measure provided incremental prediction of adaptive performance above and beyond ability and achievement motivation.

Pulakos and colleagues demonstrated that adaptive performance can be described in terms of multiple dimensions. As far as efforts to predict performance behaviors from individual differences are concerned, this work is indispensable as it establishes relatively concrete criteria that likely generalize across most jobs. Previous work regarding individual differences and their impact on adaptive performance was largely fractured, as performance was operationalized uniquely by each set of authors. While work by Pulakos and colleagues did not completely obviate this problem, it did lay the groundwork for systematizing any findings related to individual-difference predictors of adaptive performance. With such a foundation in place, future efforts to identify additional predictors of adaptive performance behaviors can simultaneously be more precise and generalizable.

Despite these advances, the taxonomy of adaptive performance set forward by Pulakos and colleagues and the other work on predicting adaptive performance reviewed to this point rest on particular assumptions about the nature of adaptation that may not be completely founded. The primary assumptions are that adaptation is an outcome predictable by particular characteristics of the individual and contingent on the work environment.

Adaptation can also be conceived in terms of processes and learning behaviors that impact the way in which individuals process information and behave in adaptive contexts. Similar to LePine et al. (2000), Kozlowski et al. (2001) investigated individual differences as predictors of adaptive performance. However, in this case the focus was on the influence that the process of training and learning had on adaptive performance. Individual differences were used to predict numerous outcomes of training, and adaptation was defined as the generalization of what had been learned during training to a more difficult and complex computer simulation task. It was found that goal orientation, training goals, and ability predict training outcomes, which were operationalized as knowledge structure development, training performance, self-efficacy, and performance in an adaptive transfer task. Regression results support the argument that the manner in which people approach adaptive tasks impacts performance outcomes. Being learning-goal oriented, pursuing mastery goals, developing coherent knowledge structures, and building self-efficacy all predict final adaptive performance.

Ford, Smith, Weissbein, Gully, and Salas (1998) demonstrated that training outcomes and ultimately transfer performance are influenced by the types of learning strategies individuals engage in. Ford et al. (1998) measured learning strategies by assessing levels of metacognitive activity during training, the extent to which tasks similar to the transfer task were practiced, and the frequency of strategic target classification and prioritization during the computer simulation task. These learning strategy measures predicted the learning outcomes of declarative knowledge, final training performance, and self-efficacy. Of most relevance to the current study, metacognitive activity predicted the learning outcomes of knowledge, final training performance, and self-efficacy, with standardized regression coefficients of 0.22, 0.29, and 0.32, respectively. These learning outcomes in turn each predicted transfer performance, which was operationalized as the performance of a more complex version of the trained task. Results indicated that the effect of at least one individual difference variable (i.e., goal orientation) on transfer performance is influenced by the metacognitive strategies engaged during learning.

The work of Kozlowski and Ford and their respective colleagues emphasized the importance of individual difference variables on adaptive performance, but contributed more to the literature by demonstrating that adaptive performance is enabled by more than just the brute effect of individual characteristics. Training can act on these characteristics and enable individuals to successfully navigate adaptive contexts. Knowledge, training performance, and self-efficacy each can be developed through manipulating the manner in which individuals pursue their goals and engage in learning processes. Generally, these studies indicate that the activity of the individual during learning and/or training can impact the likelihood that individuals successfully adapt.

Whereas the model tested by Ford et al. (1998) focused on learning strategies that impacted learning outcomes; Chen, Thomas, and Wallace (2005) focused on post-training self-regulatory processes that impacted adaptive performance. Adaptive performance was operationalized as a novel and complex task on a computerized helicopter simulation following training. The predictive training outcomes that were measured were declarative knowledge, self-efficacy, and task skill. It should be noted that these training outcomes are similar to those measured by Ford et al. (1998) and Kozlowski et al. (2001). The former measured efficacy, training performance, and knowledge; the latter measured declarative knowledge, self-efficacy, training performance, and knowledge structure coherence. Following Kanfer (1990), Chen et al. (2005) bisected self-regulation into goal choice and goal striving processes. Goal choice processes involve "deciding where and how to allocate task-related effort", and goal striving involves the allocation of resources and expenditure of effort in the pursuit of specific goals (Chen et al., 2005, p 830). Although the effects of knowledge and skill on adaptive performance were unmediated by self-regulatory processes, self-efficacy only impacted adaptive performance through its influence on self-regulatory processes. Self-efficacy predicted goal striving processes more strongly than it did goal choice processes.

Chen and colleagues' (2005) findings on the relationships between individual self-regulatory processes, training outcomes, and adaptive performance are relevant to the current study for two reasons. First, post- training self-regulation processes are predicted by training outcomes. Although the reasons for this were not directly tested, it is reasonable to suppose that whatever happened during training to improve skill and knowledge also influences the way in which individuals engage in goal choice and goal striving activities. Ford et al. (1996) and Kozlowski et al. (2001) also did not measure any process changes that occurred during training. Even if it is not the case that training influences goal processes, the specific outcomes of training directly impact goal choice and goal striving activities. This suggests that the relationship between training and self-regulatory processes is an important one. Second, self-regulatory processes predict adaptive performance above and beyond training outcomes. The outcomes of training are not of sole importance; the manner in which individuals select, prioritize, allocate resources towards, and pursue strategic and task goals after training can impact the degree to which they successfully adapt.

It is regretful that this study does not provide more insight in regards to what it was about the training that improved training outcomes and enabled successful regulatory processes. The study included no measurement of self-regulation during training. Rather, goal choice and striving were respectively measured after a transfer planning and transfer execution stage following training and prior to an adaptive stage. Potential predictors of training outcomes were not within the scope of this study, perhaps largely in part because such predictors had been successfully identified by previous work. However, the fact that self-regulation was related to training outcomes and played an important role in post-training performance raises the question of whether or not self-regulatory processes are also important during training. Thus far we have seen that self-regulatory processes play a role in adaptation, but it is yet unknown how these processes operate over time both during and after training to influence training outcomes and adaptive performance. The purpose of this study is to fill this gap in the literature by investigating the role of self-regulation during training, and how these processes consequently impact adaptive performance.

Bell and Kozlowski (2008) offered a more expansive process-oriented perspective of adaptation by suggesting that three general self-regulatory pathways are involved in adaptive performance. This study examined three core training design elements central to active learning interventions and measured their effects across cognitive, motivational, and affective pathways. The final outcomes of interest were analogical and adaptive transfer; analogical transfer was performance on a post-manipulation, novel scenario of equivalent difficulty, and adaptive performance was operationalized as performance on a version of a computerized radar simulation task more complex than was faced during training or previous trials. Bell and Kozlowski (2008) showed support for the implication of cognitive, motivational, and affective pathways on adaptive performance, and found that self-regulatory processes can be influenced by training design.

Using moderated structural equation modeling, the authors found general support for their model. The three training designs involving exploratory learning and error framing each brought about performance gains. The emotion control pathway impacted performance through self-efficacy (i.e., the motivatonal pathway). The primary regulatory processes that played a role in this model were metacognition, self-efficacy, state goal orientations, intrinsic motivation, and state anxiety. Without going into the details of a rather complex model, all effects of self-regulatory processes on adaptive transfer were mediated by either self-efficacy or knowledge. Anxiety as well as state prove and avoid goal orientations significantly related to self-efficacy, and supplemental analyses indicated that metacognitive activity also significantly related to self-efficacy. Metacognitive activity also predicted participation in self-evaluation activities and intrinsic motivation.

In relation to the present study, Bell and Kozlowski (2008) offer three primary contributions. First, they demonstrated that active learning interventions are effective. Self-regulatory processes which in turn affect adaptive performance can be influenced by interventions. Second, accounting for the interrelationships of regulatory processes when predicting adaptive transfer is important. Of most interest are the links between pathways, particularly the links connecting metacognition with intrinsic motivation and self-efficacy which had standardized coefficients of .37 and .41, respectively. These two relationships were not originally hypothesized and were the result of supplemental analyses. However, the relatively large coefficients associated with these relationships indicate that future work ought to more closely investigate how metacognition relates to intrinsic motivation and self-efficacy. Third, although training approaches and regulatory processes are important predictors of adaptive performance, some individual differences predispose individuals to be better at adaptive transfer than others. This is in line with previous research (e.g., Ford et al., 1996; Kozlowski et al., 2001; LePine, 2000). This suggests that in research focusing on processes of adaptation, individual differences must be controlled or accounted for.

Conceptualizing Adaptation

Adaptation is the engagement over time of self-regulatory processes which enable loss reduction, maintenance, or improvement of performance effectiveness in a changing environment. This conceptualization builds most directly from Jundt (2008). He defined adaptation as "the ability to appropriately and functionally align behavior with task and/or environment changes in a way that improves, maintains, or limits decrements in performance effectiveness" (Jundt, 2008, p 15). In building from this conceptualization, I highlight that the processes involved in adaptation necessarily unfold over time.

The mechanisms of adaptation are self-regulatory processes. Self-regulatory processes are those that "enable an individual to guide goal-directed activities over time and across contexts" and involve feedback loops and dynamic readjustments that are contingent on environmental cues (Karoly, 1993, p 25). These processes and related constructs will be discussed in detail in the following section, but consist of metacognition, self-efficacy, goal processes, and effort. In the context of adaptation, these processes will enable individuals to discover and employ new strategies. The maintenance or improvement of performance serves as criteria for whether or not adaptation has occurred. Because adaptation is a context dependent phenomenon, this conceptualization allows for the preservation, maintenance, or improvement of performance effectiveness; the decision of which to utilize as the ultimate criterion must be made locally depending on the task. The loss reduction of performance effectiveness means that decrements in performance are minimized. This may be a suitable criterion if circumstances are such that decrements are unpreventable or unrealistic. The degree and speed of environmental changes must also ultimately be decided at a local level. I suggest that such environmental changes must significantly degrade routine or automatized performance levels and will likely be unanticipated (Eisenhardt & Tabrizi, 1995; Scott, 1987).

One type of adaptation is training transfer. Transfer is usually defined as the ability to perform a task in a more complex environment than was trained for. It is the generalization of training to real-world problems. Transfer may also require adaptive expertise (Kozlowski et al., 2001; Smith, Ford, & Kozlowski, 1997). Adaptive expertise is the capability to meet novel, difficult, and complex situations by modifying knowledge, skills, and abilities gained through training (Schmidt and Bjork, 1992). The development of knowledge structures and metacognitive skills during learning enable individuals to both recognize opportunities to adapt and know what to do in order to adapt during transfer. In other words, transfer is inseparable from the process of learning

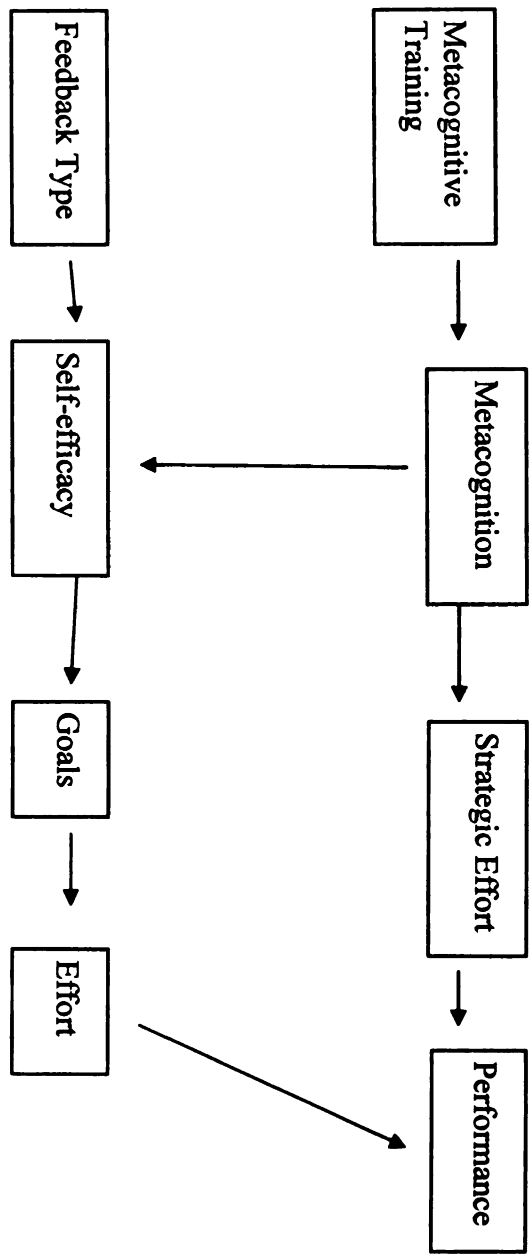
(Gick and Holyoak, 1987). Unfortunately, transfer is not often studied in terms of processes that are enacted over time (Burke & Hutchins, 2007). My conceptualization of adaptation incorporates these relationships between learning, self-regulation via metacognition, and performance in novel environments. This study investigates the role of self-regulation during an adaptive phase of performance after training; this adaptive phase is a form of training transfer.

Adaptive Processes

Adaptation requires individuals to alter behavior in strategic ways that require self-regulation. When individuals are able to self-regulate in novel or changing environments, they detect change, diagnose its cause, and then demonstrate adaptive performance (Ivancic & Hesketh, 2000; Jundt, 2008). Once individuals detect and diagnose a change, they must rebalance their efforts between exploitative versus exploratory behavior as they adapt. Exploitative behavior is that which seeks to maximize behavior based on what is known (e.g., engaging in proven strategies), while exploratory behavior is that which seeks to maximize behavior that reduces uncertainty (e.g., discovering new strategies). In a stable environment over time, individuals tend to balance exploration and exploitation in such a way as to optimize performance, which often means that exploration occurs at a relatively low rate (March, 1991). When environmental changes are introduced, this equilibrium must be rebalanced, which often involves an initial increase in exploration. Individuals will likely be better at restoring equilibrium between exploitative versus exploratory behavior when they effectively self-regulate their efforts to navigate change. When individuals are unable to self-regulate in such environments, they will likely maintain maladaptive behaviors or disengage from the task (Bell & Kozlowski, 2008; Tsui & Ashford, 1994).

The current model which describes the variables and pathways expected to be involved in adaptive performance over time is illustrated in Figure 1. Given the responsiveness of self-regulatory processes to training interventions, two training manipulations are introduced that are expected to create variation in the post-training levels of self-regulatory processes across conditions. Beyond these initial post-training differences, it is expected that individuals across conditions will demonstrate different patterns of self-regulation over time as a result of these training interventions. I introduce metacognitive and feedback interventions which are expected to influence metacognition and self-efficacy, respectively, during training. The effects of these interventions on metacognition and self-efficacy will then impact self-regulation during an adaptive phase. Below, I describe the rationale behind these interventions and their expected effects before turning to a description of how these variables affect patterns of self-regulation over time.

Figure 1. Adaptive self-regulation heuristic



Training Interventions

Metacognition is the knowledge of and control over one's own cognitions (Ford, Smith, Weissbein, Gully, & Salas, 1998; Flavell, 1979). Metacognition is also the awareness of how information is acquired, and how information influences learning and performance (Schmidt & Ford, 2003). However, metacognition extends beyond the Socratic injunction to "know thyself" and the mere possession of knowledge. It consists of processes that are engaged on-line during task performance (Kluwe, 1987). Metacognition is often conceptualized as consisting of monitoring and control functions, and also incorporates planning efforts (Brown, Bransford, Ferrara, & Campione, 1983; Schraw & Moshman, 1995). Monitoring processes consist of the identification of tasks to receive effort and resources, awareness of progress of the task, and anticipation of future outcomes of the current performance trajectory (Schmidt & Ford, 2003). Control processes deal with actual engagement in the task. Resource allocation decisions, task strategy and tactic selection, the selection of task pacing and level of effort to be exerted, and prioritization of performance actions are all control processes (Schmidt & Ford, 2003). These processes aid planning efforts and assist individuals in learning how best to allocate resources.

Metacognition permits the detection, diagnosis, and resolution of errors that occur during learning (Ivancic & Hesketh, 2000). It enables deeper processing and enables more complex and sophisticated strategies to be developed during training and transfer of problem-solving tasks (Berardi-Coletta, Buyer, Dominowski, & Rellinger, 1995). Metacognitive interventions have been successful at bringing about learning and performance gains. Teaching students about cognition and providing strategic learning plans have lead to successful strategy use and performance (Manning, 1992; Meloth, 1990; Short & Ryan, 1984). By providing knowledge of the importance and effects of metacognition, knowledge of how to engage in metacognitive processes, self-questioning strategies, and self-reflection prompts, Schmidt and Ford (2003) successfully induced metacognitive activity that in turn impacted self-efficacy, declarative knowledge, and task performance. These findings suggest that metacognition can be effectively influenced during training. Individuals that develop metacognitive processes during training are likely to perform well during initial transfer tasks (Ford et al., 1998; Schmidt & Ford, 2003). Therefore, it is hypothesized that:

H1: *Metacognitive training will lead to higher initial levels of metacognition at the beginning of the adaptive phase than no metacognitive intervention.*

Feedback, or information regarding progress towards a goal, has long been recognized as an important element of learning, self-regulation, and performance (Ammons, 1956; Bogart, 1980; Carver & Scheier, 1982; Guzzo, Jette, & Katzell, 1985; Ilgen, Fisher, & Taylor, 1979; Locke & Latham, 1990). Feedback enables self-regulatory efforts to be directional and sustainable over time. While feedback is implicitly incorporated into most adaptive performance research, explicit consideration of general feedback has been limited. Among the studies focusing on learning strategies, regulatory processes, and their effects on adaptation, a small number of studies have incorporated feedback directly in their models (e.g., DeShon et al. 2004, Tolli & Schmidt, 2008). As this prior work was not focused on individual adaptive performance, this paper fills a gap in the literature by directly investigating the role of different types of feedback on individual self-regulation and adaptive performance. More specifically, I investigate the effect of self-referenced versus normative feedback during training on post-training self-efficacy during an adaptive performance episode.

Feedback interventions affect self-efficacy beliefs (Tolli & Schmidt, 2008). When positive feedback is given indicating that individuals have performed well, self-efficacy is likely to increase. Likewise, when negative feedback indicates that individuals have performed poorly, self-efficacy is likely to decrease. Aside from the direction of the feedback, the referent of the feedback is also an important determinant of self-efficacy.

Feedback Intervention Theory (FIT) suggests a general explanation as to how feedback reference may impact self-efficacy (Kluger & DeNisi; 1996). The basic argument of FIT is that goals or standards are organized hierarchically. Since attention is a limited resource, only feedback-standard gaps that receive attention actively affect behavioral regulation. There are three general levels of attention: meta-task processes involving the self, task-motivation processes involving the focal task, and task-learning processes involving the details of the focal task. Attention is normally directed at moderate levels of the goal hierarchy on task-motivation processes. Although attention is probabilistically distributed across several feedback loops within a hierarchy, a feedback intervention (FI) will shift attention across these loops up and down the hierarchy.

By conducting a meta-analysis, Kluger and DeNisi (1996) found partial support for their propositions that FI-induced attention to self can attenuate performance and that FI-induced attention to task-motivation or task-learning processes can augment performance. Normative feedback is one mechanism that shifts attention away from task-motivation processes towards meta-task processes. When individuals receive normative feedback, they are likely to focus on the self-concept, which debilitates performance. FIT also suggests that attention to the self is accentuated on non-dominant or cognitively demanding tasks (Baumeister, Hutton, & Cairns, 1990; Mikulincer, Glaubman, Ben-Artzi, & Grossman, 1991; Wicklund, 1975). When individuals must adapt while performing a novel or changing task, the task is more likely to be non-dominant and cognitively demanding.

Vancouver and Tischner (2004) investigated the role of normative feedback on performance and framed their study in terms of FIT. Vancouver Tischner (2004) argued that resource-sensitive tasks require more cognitive processing than tasks without stringent resource limitations. These resources can be stolen by efforts to reduce self-concept discrepancies. Efforts to reduce self-concept discrepancies, thus diverting attention away from the task, were hypothesized to be driven by normative feedback (Kluger & DeNisi, 1996). It was found that a downward spiral of decreasing performance on a novel task can eventuate after individuals receive negative normative feedback if they are not given the opportunity to self-affirm. These findings support FIT's claim that normative feedback can draw attention to the meta-task level of the goal hierarchy and impinge on task-motivation and task-learning processes.

Although meta-task processes, the self-concept, and self-efficacy all share commonalities, these three constructs are not isomorphic. Shih and Alexander (2000) tested a more direct link between normative feedback and self-efficacy. They demonstrated that normative feedback led to lower student self-efficacy, goal-setting, and performance on a computer-based logic game than self-referenced feedback. This is likely because normative feedback shifts attention away from task-motivation processes and can lead to self-doubt and anxiety that hampers self-efficacy. Self-referenced feedback refers to an individual's prior performance without comparison to others, and can help maintain focus on task-motivational processes (Shih & Alexander, 2000). Self-referenced feedback provides individuals with a more useful comparison in regards to mastering the task, and can lead to a greater mastery orientation which enhances self-efficacy and performance (Chen & Mathieu, 2008; Fisher & Ford, 1998; Kluger & DeNisi, 1996; Kozlowski et al., 2001). This can lead toboth an increased motivation to learn and actual improvements in learning (Shih & Alexander, 2000). In line with Kluger and DeNisi's (1996) arguments, feedback that helps individuals maintain attention on task-motivation processes ought to help maintain self-efficacy. In accordance with these findings, it is hypothesized that:

H2: *Self-referenced feedback during training will lead to higher initial levels of self-efficacy at the beginning of the adaptive phase than normative feedback during training.*

It is expected that both interventions will be complimentary. The model predicts a positive relationship over time between metacognition and self-efficacy. Those receiving both interventions will receive both the indirect benefit to self-efficacy through increased metacognition (via metacognitive training) and the direct benefit to self-efficacy (via self-referenced feedback). Task-focused, strategic approaches should be better than self-focused and/or non-strategic approaches. Given the expected positive effects of each of these interventions on metacognition and self-efficacy and the eventual effects these have on other self-regulatory processes and adaptive performance, it is expected that those receiving both interventions will out perform all other conditions. Thus, it is hypothesized that:

H3: *Those receiving both metacognitive training and self-referenced feedback will demonstrate the highest levels of self-efficacy and metacognition at the beginning of the adaptive phase.*

It is also expected that both the metacognitive and feedback interventions will have an effect on self-regulation after the initial increases in post-training levels of metacognition and self-efficacy. It takes time for individuals to learn to implement training in a novel environment (Baldwin, Ford & Blume, 2009). Individuals with higher initial levels of metacognition and/or self-efficacy are expected to engage more fully in the task over time; they will be better at monitoring and controlling their efforts and at persisting in the face of difficulty. The positive effects of the manipulations on metacognition will improve over time as individuals learn to engage metacognitive processes in more complex situations. The self-referenced feedback is expected to condition individuals to focus on their own prior personal performance; this framing will lead individuals to become more self-efficacious as they gain mastery over the changing environment and task. Individuals with lower initial levels of metacognition and/or self-efficacy are expected to become overwhelmed or frustrated with the adaptive phase, and rather than remaining engaged and receiving the practice gains that would otherwise be experienced, they will sustain relatively low and flat levels of self-regulation over time. Beyond the effect of time, individuals with higher initial levels of metacognition and self-efficacy will be better able to respond to changes in the environment that occur during adaptive episodes Therefore, it is hypothesized that:

H4: *Metacognitive training will lead to a higher rate of increase in metacognition during adaptation than no metacognitive training.*

H5: *Self-referenced feedback during training will lead to a higher rate of increase in self-efficacy during adaptation than normative feedback during training.*

Self-regulation Processes Over Time

The general logic of the model (see Figure 1) is that the manipulations impact metacognition and self-efficacy, and the effects of these two processes on adaptive performance are mediated by goals and effort. As hypothesized, training manipulations are expected to ultimately result in greater increases in metacognition and self-efficacy over time. This mediated model of self-regulation and adaptive performance suggests that initial values of metacognition and self-efficacy positively predict the initial values of goals and effort. Furthermore, if the positive linkages between variables in the model hold, and if metacognition and self-efficacy increase over time, then it is expected that goals, effort, and adaptive performance should also demonstrate change over time. These relationships are all expected to be positive, such that an increase in one process leads to increases in the consequent processes. Thus, those receiving no metacognitive training and/or normative feedback during training will demonstrate lower levels of self-regulation that increase slowly over time; those receiving metacognitive training and/or self-referenced feedback during training will demonstrate higher levels of self regulation that increase more rapidly over time. The remainder of this section provides further rationale for these relationships as well as specific hypotheses.

Metacognition, self-efficacy, goals, and effort are all closely related self-regulatory processes, and the literature suggests that the linkage relationships posited in the model will hold over time during adaptation. A positive relationship between metacognition and self-efficacy has been consistently replicated in a number of studies

(Bell & Kozlowski, 2008; Ford et al., 1998; Keith & Frese, 2005). The degree to which individuals monitor and control the environment, their resources, and strategies will likely impact the degree to which they recognize changes in the environment and enable the formulation of viable alternative strategies. This, in turn, will lead to improved self-efficacy, as individuals will feel more confident in their ability to successfully engage in the task and implement new strategies.

Self-efficacy is the belief that "one can mobilize the motivation, cognitive resources, and courses of action needed to exercise control over environmental events" in order to accomplish a task (Bandura & Jourden, 1991, p 942). One's efficacy largely determines the level of effort one will expend on a task, and how long they will persevere when faced with obstacles (Bandura, 1986). Self-efficacy can lead to higher learning and performance, at least when between-person comparisons are made (Bandura, 1986, 1991; Locke & Latham, 1990; Vancouver, 2006). Self-efficacy is also an important learning outcome (Ford et al., 1998; Kozlowski et al., 2001). Although self-efficacy may lose its predictive power of future performance when prior performance is controlled for, it plays an important role when the task or environment becomes more complex and/or difficult by enabling resilience and persistence (Gist & Mitchell, 1992; Kozlowski et al., 2001). Through its influence both during and after learning, self-efficacy positively relates to adaptive transfer and performance, at least partially through its effects on goal processes (Bell & Kozlowski, 2008; Chen et al., 2005).

The relationship between self-efficacy and goal processes has been well-documented. A number of studies indicate that individuals higher in self-efficacy set higher goals (e.g., Bandura, 1991; Latham & Locke, 1991; Vancouver, Thompson, and

Williams, 2001). When efficacy is high, individuals are willing to attempt to accomplish more. When efficacy is low, individuals will lower their goals, expecting to accomplish less. Tolli and Schmidt (2008) demonstrated that over time, self-efficacy positively relates to goal levels. In this case, self-efficacy and goal levels were assessed at two time points; a decrease in self-efficacy from Time 1 to Time 2 (M = 1.61, 1.52, respectively) was accompanied by a decrease in goal level from Time 1 to Time 2 (M = 65.41, 56.87, respectively). During adaptive episodes, this relationship is believed to hold. When individuals are faced with change, a belief that they can succeed despite these changes will enable them to continue to set relatively high goals that will direct their efforts. When self-efficacy decreases, individuals are likely to set lower goals.

Goal level is the level of performance desired to be obtained (Locke, Chah, Harrison, & Lustgarten, 1989). Goal level is consistently linked to performance increases (Locke & Latham, 1990; DeShon et al., 1996). When individuals set higher goals, they are better able to focus their efforts on tasks that will contribute to the realization of those goals. However, research indicates that when individuals are performing complex tasks or performing in novel environments, difficult goals can interfere with initial performance (Earley, Connolly, & Ekegren, 1989; Locke et al., 1989). Despite these findings, it is still unclear how goal level affects adaptive performance over time. Higher goal levels inhibit initial adaptive performance as individuals struggle to explore and develop new rules and responses. However, higher goal levels can act as an incentive to strive even when the goal seems impossible (Locke, 1986), and may help individuals persist in the face of challenges and push through initial performance decrements during adaptive episodes. Furthermore, individuals may be more willing to set and pursue difficult goals if they are self-set rather than assigned (Locke, 2001). In the present study, individuals set their own goal levels. It is expected that as individuals set higher goals, they will exert more effort on the task despite the changing environment.

Effort is the intensity and duration of work expended on a task (Weissbein, 1992). Intensity is the rate of work done, and duration is the time spent doing the work. Effort is a limited resource that can be applied differentially across multiple tasks at once. Virtually all motivational theories incorporate effort; when individuals pursue goals, they are exerting effort at particular tasks that enable the accomplishment of those goals (Kanfer, 1990; Locke & Latham, 1991; Yeo & Neal, 2004). Effort has consistently been shown to relate to performance on a wide number of settings (Brown & Leigh, 1996; Rasch & Tosi, 1992; Terborg & Miller, 1978; Yeo & Neal, 2008). Even if individuals are not discerning in how they expend effort, exerting more effort is more likely to lead to adaptive performance gains than simply doing less (or nothing at all).

In order to capture the manner in which effort is exerted, I make a distinction between effort and strategic effort. Strategic effort captures the idea of working smarter rather than harder. When individuals exert strategic effort, they allocate their time and resources towards those portions of the task that will bring the largest gains over time. As discussed previously, metacognition enables the development of and use of strategy (Berardi-Coletta, Buyer, Dominowski, & Rellinger, 1995; Manning, 1992; Meloth, 1990; Short & Ryan, 1984). It is expected that as individuals engage in metacognitive processes, they will develop viable alternative strategies. These strategies will be enacted not simply by working harder, but by exerting effort in a specific, intelligent manner. This strategic effort is expected to contribute directly to adaptive performance.

In line with the arguments above, it is expected that as individuals train and adapt over time:

H6a: *Metacognition will predict self-efficacy.*

H6b: *Self-efficacy will predict goal levels.*

H6c: *Goal levels will predict effort.*

H6d: *Effort will predict adaptive performance.*

H6e: *Metacognition will predict strategic effort.*

H6f: *Strategic effort will predict adaptive performance.*

Due to the relationships between the self-regulatory processes and adaptive performance described above, the change in one variable over time will likely impact the way its consequent changes over time. It is predicted that the rates of change for each self-regulation variables impact the rates of change of their respective consequents.

H7a: *The rate of change in metacognition will predict the rate of change in self-efficacy; that is, if metacognition increases more rapidly, self-efficacy will increase more rapidly.*

H7b: *The rate of change in self-efficacy will predict the rate of change in goal level.*

H7c: *The rate of change in goal level will predict the rate of change in effort.*

H7d: *The rate of change in effort will predict the rate of change in adaptive performance.*

H7e: *The rate of change in metacognition will predict the rate of change in strategic effort.*

H7f: *The rate of change in strategic effort will predict the rate of change in adaptive performance.*

Tying these hypotheses back to those made about the effect of the training manipulations on metacognition and self-efficacy, those in the metacognitive training and/or self-referenced feedback during training conditions will demonstrate higher levels of self-regulation that improve over time. If such training increases metacognition and self-efficacy, and if the relationships between self-regulatory variables are as hypothesized, then it follows that for any self-regulatory variable, increased levels will positively relate to higher rates of change over time.

H8: *For all self-regulation variables, the initial levels of a self-regulatory variable at the beginning of adaptation will positively relate to the rate of change of that variable over time.*

Chapter 2

Method

Study 1: Pilot Study

The purpose of the pilot study was to gather normative performance data for use in the normative feedback during training condition in the primary study. The same task, measures, and procedure were implemented in the pilot study as in the primary study, with the exception that no feedback manipulations were implemented. Furthermore, the strength of the metacognitive training manipulation was piloted in order to ascertain if it was of appropriate design and strength for the primary study.

Data was collected from 106 students at a large midwestern university. Participants received credit in the psychology research pool for their participation. Participants were removed from any analyses if they had large amounts of incomplete data. This resulted in a final sample size of 98.

Task

I used the computer-based radar-tracking simulation TANDEM for the experimental task (Dwyer et al. 1992). TANDEM is a complex decision-making task that requires participants to track and engage enemy contacts. To engage contacts, participants "hook" them, gather information regarding 3 classes of characteristics, and then use this information to decide if and how the contact should be processed (i.e., take action or clear). Participants must also prevent contacts from crossing two perimeters on the radar screen. To do this, participants must locate the perimeters, monitor the perimeters, prioritize contacts, and process prioritized contacts. Points are gained for correctly processing contacts, and are lost for permitting contacts to cross the perimeters.

Procedure

Before arriving at the lab, participants took an online survey which contains demographic and individual difference items. This occurred when students signed up for the study from one week to one day before arriving at the lab.

Initial training consisted of a 12-minute power point presentation that taught basic operating procedures and rules of the game. Participants were then given 2.5 minutes to review the game manual, and then played an initial 1 minute familiarization trial.

Next, participants completed four training trials while receiving their respective experimental manipulation. Each trial consisted of five parts. Participants first had the opportunity to review the game manual, which contains all the information required to perform well on the task. Next they set goals, performed a four-minute trial, received feedback that details performance across a number of dimensions, and responded to a small set of items. After the four training trials, participants took a five minute break.

Following the five-minute break, participants engaged in an eight-trial adaptive phase. Each of these six trials consisted of the same five-step sequence as the training trials. However, these six trials are more complex than the training trials (i.e., more contacts, different point values for low- and high-priority contacts, and harsher penalties for perimeter-crossings by contacts). This increased complexity required participants to change their strategy in order to be successful. Upon completion of the task, participants took a series of brief exit measures.

Manipulations:

Metacognitive Training: Participants were given brief instruction on the importance of metacognition to learning and performance, and were taught about the basic elements of metacognition. Next, participants were taught how to engage in self-questioning, which has been shown to increase comprehension and the elaboration of strategy (Berthold, Nückles, & Renkl, 2007; Schmidt & Ford, 2003). Participants were prompted to respond to a number of questions following each round in an effort to engage in metacognition. Finally, participants received a handout that summarized the material taught about metacognition and lists the prompting questions. This sheet was collected at the conclusion of training.

No-metacognitive Condition: Participants received inert information about radar tracking in the military to fill the time taken by the metacognitive instruction in the experimental condition.

Measures

The measures were administered at three general time points. Most individual difference variables were administered during participation sign-up prior to arriving at the lab. Process variables were assessed after each performance trial, for a total of 11 times. Finally, once finished with the task participants completed a brief exit survey.

Individual Differences:

<u>Goal Orientation (trait):</u> A modified version of VandeWalle's (1997) 13-item measure was used, such that items were phrased to be domain-general rather than work specific. Responses were made on a 6-point scale, ranging from 1 (strongly disagree) to 6 (strongly agree). The measure contains three scales. The Mastery Orientation scale contains 5 items, the Performance-Avoid Orientation scale contains 4 items, and the Performance-Prove Orientation scale contains 4 items. All items are in Appendix B. This measure has demonstrated high internal consistency (α = .85 for learning, α =.83 for

performance-avoid, and α =.84for performance-prove) and reasonably good test-retest reliability (α = .66 for learning, α =.60 for performance-avoid, and α =.57 for performance-prove). It has also demonstrated validity through correlations with related measures (VandeWalle, 1997).

Personality: The IPIP was used to assess personality on the dimensions of neuroticism, extroversion, conscientiousness, openness, and agreeableness. This measure consists of 50 items total, with 10 items for each dimension. Reliability coefficients for the neuroticism, extroversion, conscientiousness, openness, and agreeableness scales are .86, .86, .81, .82, and .77, respectively (Goldberg, 1999).

Ability: Participants self-reported their highest ACT or SAT scores. Both the SAT and ACT have demonstrated large general cognitive ability components (Frey & Detterman, 2004) and reported internal consistency reliabilities have been high for both (e.g., KR-20 = .96 for the ACT composite score; American College Testing Program, 1989). Self-report scores were utilized out of convenience, and should be acceptable given that self-report scores have been shown to correlate strongly with actual scores (i.e., between .88 and .92; Cassady, 2001; Gully et al., 2002).

Process Variables:

Metacognition: Metacognition was assessed by a 4-item measure. This measure is designed to assess how well participants plan, monitor, and control their goal-oriented behavior. All items were measured on a 5-point scale, from 1 (never) to 5 (constantly).

Self-efficacy (state): A 2-item measure was used to assess participants' self-efficacy. All items were measured on a 5-point scale, from 1 (strongly disagree) to 5 (strongly agree).

Goal Level: Goal level is the level of performance an individual seeks to obtain. Participants were asked to record a specific performance goal, in terms of total points expected to be gained in the upcoming round.

Effort: The total number of targets engaged during a trial was calculated and used as the measure of effort.

Strategic Effort: Strategic effort was assessed behaviorally by summing the number of times participants "zoom" in or out on the radar screen, engage high priority contacts, and the time spent examining the manual before each trial. The nature of the task makes it is difficult if not impossible to successfully adapt without a proportional increase in strategic effort.

Dependent Variable:

Performance: Performance was operationalized as the total trial score, and was thus assessed at the end of each trial. The total final score of the adaptive performance trials was used as a measure of adaptive performance. The adaptive performance trials differed substantially from the training trials along the three dimensions of task complexity identified by Wood (1986). In the adaptive performance trials, there were 22 contacts, which is about 38% more than the 16 contacts in the training trials (component complexity). For the adaptive trials, 16 contacts were present immediately at the start of the trials, with an additional six 'pop-up' contacts appearing at 30 second increments (coordinative complexity). There were also penalties imposed for perimeter-crossings by contacts during the adaptive trials, such that 75 points was deducted for each crossing (dynamic complexity). The nature of these changes was such that individuals must alter their search patterns and prioritize how they process contacts.

Results

The primary purpose of this pilot study was to obtain baseline performance data to use to calibrate the normative feedback for the primary study. Normative performance scores were obtained from this pilot study and utilized as input to the normative feedback section of the primary study. The mean score across the training trials for the pilot study was 765, with a SD of 244. The mean score for trial 1 was 581, for trial 2 it was 784, for trial 3 it was 815, and for trial 4 it was 882.

A secondary purpose of this study was to test the metacognitive training manipulation and its effect on post-training metacognition levels. There was no main effect of training on trial 5 metacognitive levels ($F=.302$, $p = 0.75$). It was expected that there would be significant results. In order to strengthen the metacognitive training manipulation, changes were made to the training protocol and handouts received by the subjects such that they were more clear, succinct, and straightforward. The training in the primary study reflected these changes to training materials and content.

Study 2: Primary Study

Sample

Data was collected from 396 undergraduate students (approximately 100 for each condition) at a large midwestern university. Participants received credit in the psychology research pool for their participation. Participants were removed from any analyses if the majority of their process measure data was missing or unusable. This removal resulted in an approximate sample size of 378, with some analyses resulting in slightly different sample sizes based on how minor missing data was treated and what specific variables were included.

Task

The Tandem task used in this study was identical to that used in the pilot study, with the exception that the placement of 6 contacts were varied from what was reported above. These contacts were positions such that they crossed perimeters at different times.

Design and Procedure

The design of this study was a 2X2 between-subjects with repeated measures on processes and outcomes. The first between-subjects experimental manipulation was such that one group received metacognitive training while the other received none. The second between-subjects experimental manipulation was such that one group received self-referenced feedback during training, while the other received normative feedback.

Before arriving at the lab, participants took an online survey which contained demographic and individual difference items. This occurred when students signed up for the study from one week to one day before arriving at the lab. Upon arriving at the lab, individuals were randomly assigned to one of the four experimental conditions. Next, participants received training.

Initial training consisted of a 12-minute power point presentation that taught basic operating procedures and rules of the game. Participants were then given 2.5 minutes to review the game manual, and then played an initial 1 minute familiarization trial.

Next, participants completed four training trials while receiving their respective experimental manipulation. Each trial consisted of five parts. Participants first had the opportunity to review the game manual, which contains all the information required to perform well on the task. Next they set goals, performed a four-minute trial, received feedback that details performance across a number of dimensions, and responded to a small set of items. After the four training trials, participants took a five minute break.

Following the five-minute break, participants engaged in an eight-trial adaptive phase. Each of these six trials consisted of the same five-step sequence as the training trials. However, these six trials are more complex than the training trials The adaptive performance trials differed substantially from the training trials along the three dimensions of task complexity identified by Wood (1986). In the adaptive performance trials, there were 22 contacts, which is about 38% more than the 16 contacts in the training trials (component complexity). For the adaptive trials, 16 contacts were present immediately at the start of the trials, with an additional six 'pop-up' contacts appearing at 30 second increments (coordinative complexity). There were also penalties imposed for perimeter-crossings by contacts during the adaptive trials, such that 75 points was deducted for each crossing (dynamic complexity). The nature of these changes was such that individuals must alter their search patterns and prioritize how they process contacts. Upon completion of the task, participants took a series of brief exit measures.

Manipulations

Self-referenced Feedback: Participants in this condition were told how their overall trial performance compared to their performance on the previous trial. This comparison was expressed as a simple statement of both scores. In general terms, feedback read, "Your overall score this round was X. Last round, you scored Y".

Normative Feedback: Participants in this condition were told how their overall trial performance compared to the performance of a normative sample on the previous trial. This comparison was expressed as a value-free percentile ranking. Normative scores were obtained from the pilot study, with scores for each training trial reported above. Normative scores were obtained for each specific training trial and utilized in feedback respectively. The mean score across all four training trials for the pilot study for those not receiving metacognitive training was 765, with a SD of 244. The 40th% and 60% scores were 676 and 828, respectively. Reported rankings were rounded up or down to the nearest five percent, such that someone scoring at the 52% were told they scored at the 50th percentile. Thus, in the primary study, participants in the normative feedback condition who scored 800 received feedback that read, "Your overall score this round was in the 60% percentile compared to other participants' scores this round". A simple definition of the concept of percentiles was provided to ensure subjects understood this feedback. Normative performance scores used for feedback can be found in Appendix A.

Metacognitive Training: Participants were given brief instructions on the importance of metacognition to learning and performance, and were taught about the basic elements of metacognition. Next, participants were taught how to engage in self-questioning, which has been shown to increase comprehension and the elaboration of strategy (Berthold, Nückles, & Renkl, 2007; Schmidt & Ford, 2003). Subjects received a handout that summarized the material taught about metacognition and listed specific prompting questions (see Appendix A). After each training trial, participants responded to these same specific questions, which were geared towards helping them engage in self-questioning for this specific simulation. For this, they were given two minutes to answer as many of the questions as they could in any order, with the understanding that they would not be graded, but that they were to use them to their advantage. Furthermore, they were instructed to spend part of those two minutes to memorize the questions so they could be utilized during the adaption trials. All training materials were collected at the conclusion of training trials (i.e., after trial 4).

No-metacognitive Condition: Participants received inert information about radar tracking in the military to fill the time taken by the metacognitive instruction in the experimental condition.

Measures

Goal orientation and ability items were administered during participation sign-up prior to arriving at the lab. All other variables were assessed either during or after each performance trial, for a total of 12 times each. Finally, once finished with the task participants completed a brief exit survey.

Individual Differences:

Goal Orientation (trait): A modified version of VandeWalle's (1997) 13-item measure was used, such that items were phrased to be domain-general rather than work specific. Responses were made on a 6-point scale, ranging from 1 (strongly disagree) to 6 (strongly agree). The measure contains three scales. The Mastery Orientation scale contains 5 items, the Performance-Avoid Orientation scale contains 4 items, and the Performance-Prove Orientation scale contains 4 items. All items are in Appendix B. This measure has demonstrated high internal consistency (α = .85 for learning, α =.83 for performance-avoid, and α =.84for performance-prove) and reasonably good test-retest reliability (α = .66 for learning, α =.60 for performance-avoid, and α =.57 for performance-prove). It has also demonstrated validity through correlations with related measures (VandeWalle, 1997).

Ability: Participants self-reported their highest ACT or SAT scores. Both the SAT and ACT have demonstrated large general cognitive ability components (Frey & Detterman, 2004) and reported internal consistency reliabilities have been high for both (e.g., KR-20 = .96 for the ACT composite score; American College Testing Program, 1989). Self-report scores were utilized out of convenience, and should be acceptable given that self-report scores have been shown to correlate strongly with actual scores (i.e., between .88 and .92; Cassady, 2001; Gully et al., 2002).

Process Variables:

Intrinsic Motivation: Intrinsic motivation was assessed by a 7-item questionnaire after each trial. All items were measured on a 5-point scale, from strongly disagree to strongly agree.

Metacognition: Metacognition was assessed by a 4-item measure. This measure is designed to assess how well participants plan, monitor, and control their goal-oriented behavior. All items were measured on a 5-point scale, from 1 (never) to 5 (constantly).

Self-efficacy (state): A 2-item measure was used to assess participants' self-efficacy. All items were measured on a 5-point scale, from 1 (strongly disagree) to 5 (strongly agree).

Goal Level: Goal level is the level of performance an individual seeks to obtain. Participants were asked to record a specific performance goal, in terms of total points expected to be gained in the upcoming round.

Effort: The total number of targets engaged during a trial was calculated and used as the measure of effort.

Strategic Effort: Strategic effort was assessed behaviorally by summing the number of times participants "zoom" in or out on the radar screen, engage high priority contacts, and the time spent examining the manual before each trial. The nature of the task makes it is difficult if not impossible to successfully adapt without a proportional increase in strategic effort.

Dependent Variable:

Performance: Performance was operationalized as the total trial score, and was thus assessed at the end of each trial. The total final score of the adaptive performance trials was used as a measure of adaptive performance. The adaptive performance trials differed significantly from the training trials, as detailed above. The nature of these changes was such that individuals must alter their search patterns and prioritize how they process contacts.

The averaged performance across the four training trials was used as a control variable, while the performance scores during the adaptation trials (i.e., trials 5-12) were utilized to examine the relationships among the regulatory process variables of interest

Analytic Strategy

To test H1-H3, which address the main effects and interactions of the metacognitive and feedback manipulations, I will use analysis of covariance (ANCOVA). By using ANCOVA, individual difference variables will be treated as covariates and partialled out from comparisons between conditions. H1-H3 will be supported if the corresponding F-tests are significant once covariates are accounted for.

To test H4 and H5, which address the changes over time of metacognition and self-efficacy between conditions, I will use Hierarchical Linear Modeling (HLM). By utilizing HLM, I will be able to test whether or not the coefficients of change for metacognition and self-efficacy are significantly different between groups. It is expected that in the case of metacognition, the group receiving the metacognitive training will have a significantly larger slope parameter than the control group. Similarly, it is expected that the self-referenced feedback group will have a significantly larger slope parameter than the normative feedback group.

To test H6, which addresses average relations between key variable pairings, I will use hierarchical regression. This will enable control variables to be partialled out before investigating the true relationships of interest.

To test H7, which addresses the degree to which the change in an antecedent over time predicts the change in a consequent over time, I will use HLM. This analysis will enable the relationships between each key variable pairing to be investigated over time. H8 will be supported if the appropriate slope parameters for each analysis is significant.

Finally, to test H8 I will latent growth modeling (LGM) using AMOS 18.0. By utilizing HLM to investigate this hypothesis, it is possible to obtain the desired covariance parameter, which would also describes the desired relationship. However, obtaining the statistical significance of this parameter is difficult by such means. By examining the relationship between intercept and slope through LGM, one can ascertain the magnitude of the relationship between the initial level of each process variable and their corresponding rates of change. If the intercept is significantly and positively related to the slope parameter for each process variable, H8 will be supported.

Covariates were included in all analyses. The covariates included were all control variables described above; that is, intrinsic motivation, goal orientation, ability, and training performance. Intrinsic motivation was included as a Level-1 covariate in HLM, while the others were included as Level-2 Covariates.

Chapter 3

Results

Table 1 reports descriptive statistics and between-person correlations among all variables. Table 2 reports on its lower diagonal the between-person correlations of the key variables of interest, and on its upper diagonal the averaged within-person correlations of the key variables. Analyses proceeded by examining only trials 5-12, which were the adaptive trials. Training trials were not directly included in the analyses except as a control variable, and training performance was averaged across the four training trials.

To test H1 and H2, ANCOVAs were run. H1, which predicted that metacognitive training will lead to higher initial levels of metacognition at the beginning of the adaptive phase than no metacognitive intervention, was not supported ($F=.659$, $p = 0.73$; see Table 3). Similarly, H2, which predicted that self-referenced feedback during training will lead to higher initial levels of self-efficacy at the beginning of the adaptive phase than normative feedback during training, was not supported ($F= 0.437$, $p=.901$, see Table 4). Regarding H1, these results indicate that at the end of training, there was no significant difference in self-reported metacognition scores between metacognitive training conditions. Likewise for H2, these results indicate that at the end of training, there was no significant difference in self-reported self-efficacy scores between feedback conditions.

In line with these results, H3, which predicted that those receiving both metacognitive training and self-referenced feedback will demonstrate the highest levels of self-efficacy and metacognition at the beginning of the adaptive phase, was tested via MANCOVA and was also not supported ($F=.276$, $p=.843$). Recall that participants in condition 1 received metacognitive training with self-referenced feedback, condition 2 received metacognitive training with normative feedback, condition 3 received no metacognitive training with self-referenced feedback, and condition 4 received no metacognitive training with normative feedback. It was expected that participants in condition 1 would demonstrate higher levels of both metacognition and self-efficacy. This was not the case. There were no differences in initial levels of metacognition or self-efficacy between any of these groups.

Both H4 and H5 predicted differences in slopes between groups for metacognition and self-efficacy during adaptation trials. Furthermore, these slopes were anticipated to be positive. In reality, both process variables decreased over time (see Figures 3 and 4). Thus, by default H4 and H5 were not supported. However, the thrust of these hypotheses was to predict differences in slopes between groups for both process variables. HLM was used to test whether or not there were differences despite the decreasing slopes. Reframed in terms of metacognitive training leading to a slower rate of decrease in metacognition than experienced by those without metacognitive training, H4 was supported ($B=.16$, $SE=.05$, $df=374$, $p < .001$, see Table 5). The resultant ICC value from running the unconditional means model is ICC= 0.663. The results reported result from a model that incorporates all covariates, includes metacognitive training as a level-2 predictor, with random slopes and intercepts. Time is incorporated into this final model as a level-1 predictor variable.

However, even when reframed in terms of decreasing slopes, H5 was not supported ($B=.03$, $SE=.02$, $df=374$, $p=.158$, see Table 6). No significant differences in the slopes of self-efficacy were found, indicating that feedback condition had no impact on the rates of decrease in self-efficacy during adaptation. Results are non-significant regardless of whether the random effect of intercept is included or not. Obtained from the unconditional means model, the ICC=.597.

H6 predicted individual relationships between process variables in the general model presented in Figure 1 averaging across time and conditions. Because the average relationship, regardless of changes over time, was of interest, hierarchical linear regression was used to test this block of hypotheses. For each process variable, the values for trials 5-12 were averaged, creating an aggregate value of each variable for each participant. Furthermore, all control variables were entered in first, followed by the relevant independent variable in a hierarchical fashion. Results for all H6 analyses are reported in Table 7. H6a, which stated that metacognition would predict self-efficacy, was supported ($B= .32$, $t=3.5$, $p<.001$). The ICC for H6a is 0.586. H6b, which stated that self-efficacy would predict goal-level, was not supported ($B=.09$, $t=2.057$, $p=.11$); the ICC for H6b is 0.623. H6c, which stated that goal level would predict effort, was supported ($B= .24$, $t=7.78$, $p<.001$); the ICC for H6c is 0.568. H6d, which stated that effort would predict performance, was supported ($B=.75$, $t=26.9$, $p<.001$); the ICC for H6d is .526. H6e, which stated that metacognition would predict strategic effort, was not supported ($B=.084$, $t=1.26$, $p=.209$), indicating that across conditions metacognition does not predict strategic effort; the ICC for H6e is .285. To further investigate these null effects, a supplementary analysis was run. An alternate model was tested in which control variables were entered first in block one, then metacognitive training was entered as a predictor of strategic effort in block 2. Receiving metacognitive does predict strategic effort ($B=.131$, $t=2.50$, $p<.05$), indicating that receiving metacognitive training positively predicts strategic effort across trials. This finding indicates that self-reported metacognitive levels may not adequately capture the benefits received by metacognitive training. H6f, which stated that strategic effort would predict adaptive performance, was supported, but in the opposite direction anticipated. Results indicate that the average level of strategic effort across all adaptive trials negatively predicts performance averaged across all trials ($B=-.23$, $t=-2.69$, $p<.05$). This may be due to the specific features of the simulation. The point values of targets were such that the penalty for not processing contacts strategically were offset by the point values obtained by processing non-strategic, easily processed targets. Thus, those individuals not demonstrating strategic effort were able to process more targets and have higher scores as a result, even despite penalties for not being strategic.

Having tested the average effects of each process variable averaged across time, I sought to uncover the relationships between each variable pairing of interest over time and across conditions. To do so, HLM was used because it enables one to obtain the desired growth parameters by incorporating multiple measurements of key process variables within individuals. Results for all H7 analyses are reported in Table 8. H7a, which predicted that changes in metacognition would predict changes in self-efficacy, was supported ($B=.039$, $SE=.01$, $t=3.18$, $df=375$, $p<.05$). H7b was supported, such that changes in self-efficacy predict changes in goal-level ($B=13.64$, $SE=6.38$, $t=2.04$, $df=375$, $p<.05$). H7c was supported, such that changes in goal-level predict changes in effort ($B=.002$, $SE=.00035$, $t=4.67$, $df=375$, $p<.000$). H7d was also supported, indicating that changes in effort predict changes in adaptive performance ($B=73.7$, $SE=2.28$, $t=31.6$, $df=375$, $p<.001$). H7e was not supported ($B=-0.13$, $SE=0.08$, $t=-1.34$, $df=375$, $p=.18$).

However, when adding metacognitive training as a level-2 predictor, H7e was supported such that for those receiving metacognitive training, metacognition predicted adaptive performance (B=-0.11, SE=.004, t=-2.18, df=375, p<.05). The relationship is negative because metacognition decreases over time. Further analyses (MANCOVA) indicate that the levels of strategic effort are relatively stable over time, while metacognition decreases over time, and that the effect of metacognitive training on strategic effort is significant (F=6.492 df=1 p<.05). H7f was supported (B= 6.39 SE= 1.24, t= 5.18, df=374, p=.000), indicating that changes in strategic effort positively relate to changes in performance. The general equation from which all H7 analyses were obtained is found in Equation 1.3.

To test H8, which stated that initial levels of a variable would predict the rate of change of that variable, latent growth modeling was performed using Amos 18.0. For each key variable, the general model used was as follows. For each variable of interest, the intercept value was drawn so as to predict the slope value, and all covariates included in prior analyses were included into the model. The desired covariance parameter relating the intercept and slope was obtained. Running this model for each respective variable, the desired parameters were only statistically significant for self-efficacy, effort, and adaptive performance (-.047; -.034; and -.07, respectively; p<.05). Results for all H8 analyses are reported in Table 9. Because each of these significant results were both small and negative, H8 was not supported.

Chapter 4

Discussion

As a whole, the results of this study were not as expected. The specific reasons for why this may be so will be discussed in detail below. Generally, the failure of the feedback intervention was the greatest disappointment, and likely contributed to the inability to find many of the expected relationships and trajectories. Also disappointing was the lack of a major and immediate impact of metacognitive training. Despite the setbacks experienced, the results of this study indicate that metacognitive training can lead to changes in adaptive processes over time. Furthermore, the rates of change of many important process variables predict the rates of change of their intended consequents. Also demonstrated was that the general hypothesized relationships between key process variables tend to hold when averaged over time.

It was found that receiving metacognitive training does lead to a slower rate of decay of metacognitive processes enacted over time during adaptive periods. The rate of change of strategic effort is predicted by the rate of change of metacognition for those receiving metacognitive training, such that those with higher metacognitive scores over time exert more strategic effort. Thus, higher levels of strategic effort are exerted during adaptation trials by those receiving metacognitive training compared to those without. Furthermore, the rates of change of self-efficacy, goal level, and effort were all predictive of the rates of change of their hypothesized consequents. In the cases of metacognition and self-efficacy, negative slope changes were found.

The metacognitive manipulation did drive the differences in slopes in metacognition during the adaptation trials, but the fact that there were no differences in intercepts for metacognition immediately following training indicates two points. First, and least interesting, is that there are likely improvements that could be made to the metacognitive training utilized, such that immediate differences following training could be obtained. That is, if manipulation strength had been greater, it is possible that differences in metacognition immediately following training could be created. However, the metacognitive training utilized was far more intensive, lengthier, and 'stronger' than other attempts to manipulate metacognition that the author is aware of. This leads to the second point, which is that it appears very likely that the benefits of metacognitive training become more distinct over time. Because the metacognitive training manipulation resulted in differences in slopes of metacognition but no differences in intercepts at trial five, time was essential to uncovering the effects. The implications of this will be discussed further below.

The feedback manipulation did not work at all as expected. Overall trends suggest that there were slight differences in the slope of self-efficacy by condition towards the end of the adaptation trials, indicating that perhaps the effects of the feedback manipulation may become apparent over time. If this were the case, it is possible that adding additional trials to the experiment would have resulted in significant effects. Regardless, the desired differences in self-efficacy at the end of training were not obtained. An additional pilot experiment not reported above was run with n= 27 to test general effects of the feedback manipulation. Although no significant results were found, there was a clear trend in the desired direction for both the intercepts and slopes of self-efficacy after training. The non-significant results were attributed to a small sample size, and work progressed under the assumption that with a larger sample the desired effects would precipitate. This was unfortunately not the case. As a result, because differences in intercepts or slopes of self-efficacy were not driven by the manipulation, no differences in goal level, effort, strategic effort, and adaptive performance by condition were obtained. Although these differences by condition in goal level, effort, strategic effort, and adaptive performance were not formally hypothesized, it was expected that they would exist and in turn enable other formal predictions to be confirmed.

Additional analysis (an ANCOVA) revealed that training performance is predicted by receiving self-referenced feedback during training when controlling for other process variables and individual differences ($F=3.49$, $p=.06$). Training performance, in turn, was a significant predictor of several process variables (see Tables 1, 7, and 8). Training performance was correlated significantly with metacognition, self-efficacy, goal level, effort, strategic effort, and adaptive performance; each of these were positive correlations, except for a negative correlation with metacognition. It was also a significant predictor of self-efficacy, goal level, effort, strategic effort, and adaptive performance when averaged over time. Furthermore, training performance significantly predicted the rates of change of all key variables except metacognition and self-efficacy. Thus, although the specific results expected for the effect of the feedback manipulation were not significant, self-referenced feedback during training may affect adaptive processes through its effect on training performance. I did not formally test for mediation, as the crucial requirements outlined by Baron and Kenny (1986) that the predictor be correlated with both the mediator and outcome were not satisfied. Although I do not posit reasons or mechanisms for these potential relationships, future research may be fruitful in this area. A feedback manipulation more directly intended to improve training performance may result in the effects desired in this study (i.e., improved self-regulation through the theorized linkages described in this study).

Although the declining slopes of metacognition and self-efficacy were counter to what was hypothesized, several explanations may describe why such findings occurred. The most likely explanation for the decreasing scores for both self-efficacy and metacognition is survey response fatigue. Supporting this supposition is the fact that off-task thoughts, an additional process measure not included in the analyses, increased over time ($F = 17.3$, $p < 0.001$). Similarly, intrinsic motivation also decreased over time ($F = 40.3$, $p < 0.001$). One deterrent to performing longitudinal experiments is that they are often difficult to obtain enough measurement points. Even when care was taken to obtain numerous measurement points in the present study, it appears that doing so worked against finding desired results as participants tired of the task and surveys.

An additional, but unlikely, explanation for the decline in slopes for metacognition is that engaging in metacognition required perceived effort, which declines over time as a result of practice (Yeo & Neal, 2008). In the present study, metacognition did require cognitive effort, and it is possible that engaging in metacognition became easier over time as a function of practice. The slower rate of decline for those receiving metacognitive training then would have resulted as individuals strove to sustain their efforts more than others. Difficulties with this explanation are that the metacognitive measure was not intended as a measure of subjective effort, actual measures of effort rose over time, and an unreported measure of perceived task effort did not correlate well over time with metacognition.

There was effectively no relationship found between self-efficacy and performance. Vancouver's work anticipates a negative relationship (e.g., Vancouver & Kendall, 2006), while Bandura would predict a positive relationship (Bandura, 1991). My findings are out of line with the literature, as both between- and within-person correlations were effectively zero. Self-efficacy was generally flat in trajectory with a slightly negative slope, while performance slowly improved. I argued earlier that self-efficacy may have declined over time as a result of measurement being influenced by participant fatigue. The difficulty in such an explanation is that performance did not decline, as would be expected if subjects were genuinely fatigued, but continued steadily upwards with a plateauing trend during the last few trials. Goal-level was essentially flat. It is possible that fatigue only influenced the repetitive process questionnaires, and that participants found the simulation itself more engaging so as not to evidence a similar drop.

Averaged across trials, metacognition positively predicts self-efficacy, goal level positively predicts effort, effort positively predicts adaptive performance, metacognition positively predicts strategic effort, and strategic effort negatively predicts performance. The last finding regarding the negative relationship between strategic effort and performance was counter to prediction, and on one hand is disheartening given that one would hope investing effort in being strategic and careful about behavior would lead to performance gains and a general advantage. A potentially positive upside of this finding will be discussed below.

Generally, it was not found that initial levels of key process variables predicted the rates of change of those variables, as was hypothesized. Although self-efficacy, effort, and adaptive performance had significant parameters, the small coefficients and negative signs are not in line with what was predicted. It is possible that these null results would be obtained in other future studies. If this were the case, implications for self-regulation and adaptation theories would be that the rates of change for self-regulatory processes are independent of initial levels. This would be noteworthy, indicating that gains, or losses, in these processes over time could happen for people with very different initial levels; this would have large implications for training Unfortunately, such implications are unlikely, given that the results obtained were likely due to the fact that there were no initial differences to begin with (and furthermore, there were few if any differences in slopes between conditions). Regarding the cases for which there were negative correlations, the slope for self-efficacy was opposite that of effort and adaptive performance. These differences prevent any meaningful implications to be made regarding a general relationship between intercepts and slopes across variables.

One interesting note is that some relationships did not work as expected when measured over time, while simultaneously the cross-sectional analyses indicated that significant results were present. Additional analyses demonstrated that HLM results for the effect of metacognitive training on self-efficacy and strategic effort were not significant, although ANCOVA results show that averaged over trials, metacognitive training predicts self-efficacy and strategic effort ($F=4.02$; $F=6.22$, respectively; $p < .05$). So although the trajectories of these process variables are not different across conditions, general relationships do differ. This underscores points made by Ployhart and colleagues that longitudinal data is critical for understanding processes, given that different answers are obtained from cross-sectional approaches to the same general questions (Pitariu &

Ployhart, 2009; Ployhart & Vandenberg, 2010). Furthermore, these findings point out that within-person findings may be different from between-person findings. The differences between measuring at the between-person versus within-person level has been discussed by others, and has recently been made apparent by the debate between Vancouver and Bandura. The findings in the present study add emphasis to the point that theories of self-regulation and adaptation ought to directly specify which level they are intended to apply. For cases in which it is useful to examine average tendencies over time, it appears reasonable that one must also examine the within-person tendencies over time to gain a better understanding of how the processes are truly behaving.

Contributions

The main purpose of this study was to delineate the roles that regulatory processes play during transfer and future performance. I intended to meet this aim and extend research on individual adaptation to environmental change in three ways. First, this study was intended to extend and develop process-oriented adaptation theory. Second, it was meant to extend theory that entails multiple regulatory pathways. Third, it was meant to shed light on how best to prepare individuals to adapt. Although not all these purposes were fulfilled, this study still provides meaningful contributions along all three of these lines.

This study supports adaptive process theory by demonstrating that if one treats adaptation as an event captured via cross-sectional measurement, it is not likely that the underlying phenomena will be accurately described. Also, it gives credence to the approach of studying cognitive and motivational processes over time, particularly as they are involved in adaptive processes. Although the design of the scenario unfortunately precluded much necessity to adapt, the changes that occurred to metacognition and strategic effort as a result of training indicate that the results of efforts to aid adaptation must be captured over time. The results for H1 indicates that the effect of metacognitive training was not evident immediately following training, but that its benefit becomes apparent over time. The results for H2 and H3 indicate that there was no training effect of feedback type, even over time. So although the trajectories of these process variables are not different across conditions, general relationships over time do differ. One important contribution is that this study demonstrated that regulatory processes do change and relate to one another over time in significant ways. Future research ought to continue to investigate how regulatory processes change over time. However, care must be taken in order to ensure that participants are not fatigued by the number of items or measurement points.

This study also extended theory that relies on multiple regulatory pathways over time. It was demonstrated that both cognitive and motivational pathways are important for performance. Furthermore, a relationship between metacognition and self-efficacy indicates that both pathways are inter-related. Most of the failures in this study were along the self-efficacy/goals/effort pathway, but meaningful contributions can still be gleaned. These processes did relate to one another, and the pathway served as an important antecedent to performance. The results indicate that the trajectories of and relationships between self-efficacy, goal level, and effort are important to understanding performance. Future work ought to continue to investigate both cognitive and motivational pathways of adaptation, even given the limited support obtained here. Basic relationships were present enough to merit inclusion of the key process variables included in this study in future work. However, as evidenced by the significance of some control variables in the analyses such as intrinsic motivation and goal orientation, other variables may require further inclusion into formal theories of adaptation.

Despite the failure of the feedback manipulation, meaningful insights can be gained regarding how to best prepare individuals to adapt. The delayed effect of metacognitive training on metacognition levels indicates that training does impact how individuals engage in processes during transfer. Efforts to train individuals on metacognition may not lead to immediate differences in that specific process, but that the benefits may accrue post-training. This is important for both those developing training regimens and those measuring training effectiveness to remember. The relative weak and either delayed or ineffective results of both training manipulations indicates that training interventions for improving self-regulation ought to be pointed, deliberate, and very strong. My original intent on manipulating self-efficacy in the manner in which I did was based on theoretical concern between self-referenced and normative feedback types. Given that there was no effect discovered, it would have been more valuable to have used another manipulation that would have just created mean differences in end-of-training self-efficacy. Future research could investigate how best to improve self-efficacy during training in a way that leads to improvements in efficacy over time during transfer and performance. Furthermore, future research could fruitfully investigate how to lead to larger gains in metacognition over time, given the significant results metacognition demonstrated.

Limitations

Aside from the failure of the feedback manipulation discussed above, the next largest limitation of this study is that the scenario design was such that potentially meaningful results were made impossible. There was a relatively low number of 'strategic' contacts that attacked the outer perimeter of the radar screen and consequently hurt the participants' score. The scenario was designed such that metacognitive training would cause participants to focus on processing these contacts. Although training resulted in just such behavior, because these strategic contacts were more time intensive to process, because the penalty for not processing them was relatively low, and because there were relatively few of them, it turned out that overall performance was best maximized by *not* processing the strategic contacts and just processing others. This design flaw was not a complete oversight, as care was taken to test a number of scenarios, and performance data was obtained from a number of alternate scenarios through pilot testing. However, because of time constraints, general trends were taken as workable guidelines and the design was not refined enough to ensure that performance scores would align appropriately with the desired behaviors. If more contacts had attacked the outer perimeter, each carrying a stiffer penalty for breaching the perimeter, it is likely that the expected relationships between strategic effort and performance would have resulted.

However, the negative relationship between strategic effort and adaptive performance is instructive in that it points to the cost that strategic effort implicitly carries. Although scenario design alterations would likely have resulted in a positive relationship between strategic effort and performance, these findings demonstrate that strategic effort includes an opportunity cost. When individuals invested time into finding and destroying high priority contacts, they gave up their options to process other contacts that in this case would have been more valuable. The trade-off between exploration and exploitation is well-known (March, 1991), and the present findings indicate that such trade-offs ought to be accounted for in future theory development and measurement efforts in work on self-regulation and adaptation.

Furthermore, the increased difficulty of a better designed scenario would have likely introduced greater variance between conditions in self-efficacy, goal level, and effort. Although not hypothesized formally, it was anticipated that performance would decrease markedly during the beginning of the adaptation phase. In reality, performance only ever improved. This indicates that the adaptation trials were not as difficult as was expected, and that participants were not being forced to adapt.

Future Directions and an Alternate Model

Given that the proposed heuristic of adaptation via cognitive and motivational pathways was not supported as was expected, in this section I revisit the conceptualization of adaptation and posit an alternate model. Although the task did not require participants to alter their strategy or reallocate their efforts in order to maintain performance increases, there were differences in behavior between conditions. I rely on these findings and a dynamic process-oriented view of adaptation in order to suggest an alternate model (Figure 2).

Adaptation consists of the engagement of self-regulatory processes that enable an individual to detect change, diagnose what ought to be done as a result of that change, and then to engage in new behavior that aligns with the diagnosis. Although ideally these processes will enable performance benefits, external forces may prevent such effects.

Thus, adaptation should not measured only through performance outcomes. For example, random error or environmental events may act in such a manner as to prevent performance gains for those that are engaging in adaptive processes. Alternatively, random error or environmental events may enable individuals who do not engage in adaptive processes to experience performance gains that are not, in fact, a direct result of any adaptive processes engaged in by those individuals. Thus, focusing on performance outcomes while overlooking actual adaptive behaviors may likely lead to erroneous conclusions as to whether or not an individual is being 'adaptive', and will most likely result in overlooking the processes that describe what individuals are actually doing.

In the event that there are no immediate performance benefits resulting from adaptive processes, there still remain suitable explanations for why adaptive processes ought to be the focus of interest and study. First, it is possible that the underlying adaptive processes prepare individuals to successfully cope with future changes in the same context, or enable them to generalize the same processes to new contexts which would be accompanied with performance benefits. Neither of these avenues have been investigated, and may be fruitful targets for future research. Second, social scientists are interested in self-regulation in its own right; behavior is behavior whether or not there are performance benefits to it. Thus, even without any performance benefits the regulatory processes underlying individuals' behavior are of direct interest.

Recent emphasis has been placed on two distinct adaptability types, that of transition adaptation and reacquisition adaptation (Lang & Bliese, 2009). These authors describe transition adaptation as the reactions that take place that minimize performance decrements resulting from changes in the task environment that cause previous routines and procedures to become ineffective. Reacquisition adaptation is the process of recovery that occurs once performance decrements are stopped. This subsequent increase in performance is a result of "a systematic and analytical learning behavior needed in order to understand and learn the new challenges of the task" (Lang & Bliese, 2009, p 415).

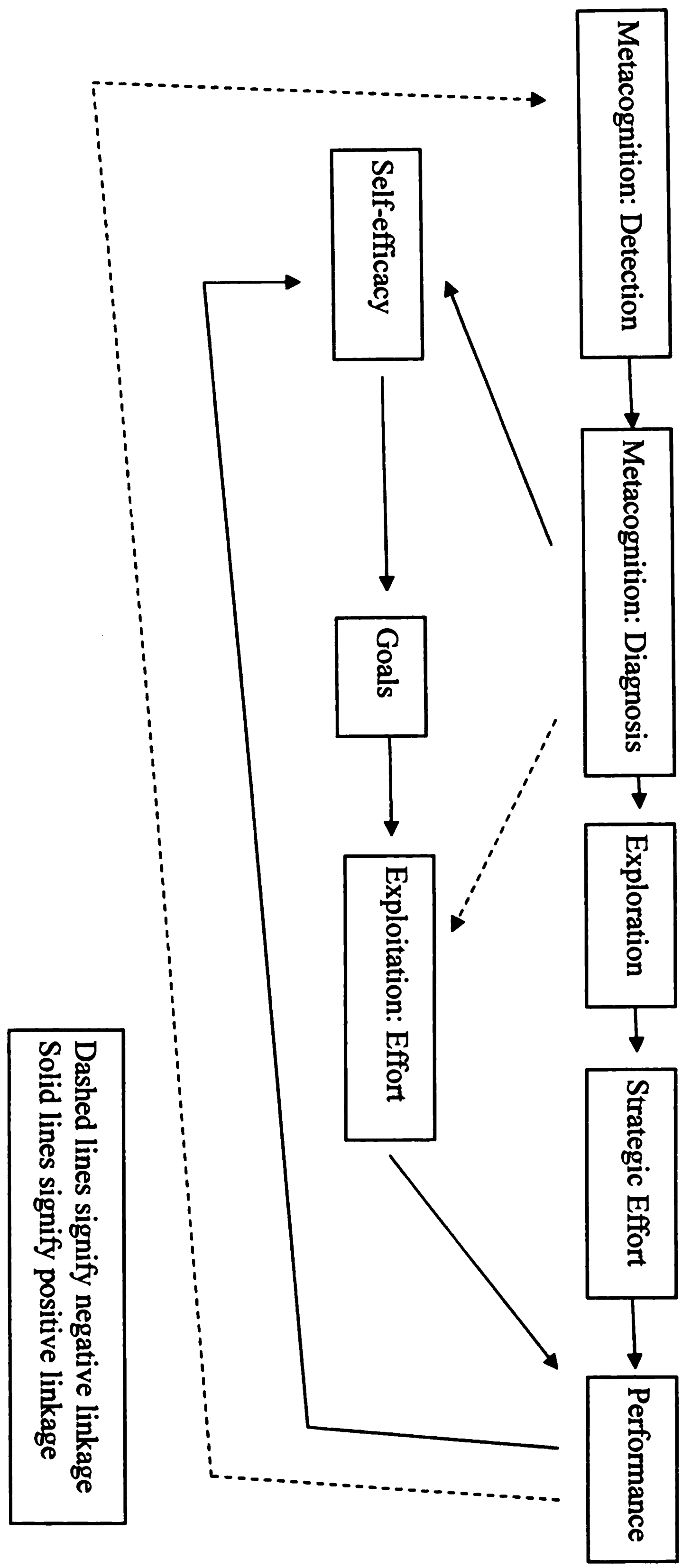
These authors provided valuable contributions by focusing on how to distinguish adaptive performance from other aspects of performance, and on providing clearer methodological and conceptual tools for differentiating between different modes of adaptation. However, their singular focus on performance outcomes overlooks the underlying processes that are actually involved in adaptation. They allude to the role such underlying processes in their description of both transition and reacquisition adaptation; namely, they indicate that detection and diagnostic processes are at play which include recognizing that prior strategies are no longer effective, uncovering new strategies through learning processes, and implementing alternate strategies. Furthermore, they note that after controlling for cognitive ability, a considerable amount of variance in adaptive performance remains. It is my contention that the regulatory processes described in this paper, and detailed further below in my proposed alternate model, likely describe this variance and ought to be used to define adaptation. The performance changes described by Lang and Bliese (2009) may often result from the engagement of adaptive processes, but such performance changes may not be necessary or sufficient indicators of the underlying processes.

Central to the rationale of the model proposed previously in this paper were the issues of exploration and exploitation. The model was intended to capture, to some degree, the efforts of individuals to explore their task space once changes were detected in order to diagnose the nature of those changes and implement suitable strategies that exploit resources in a way different from the status quo or pre-adaptive method. In the current study, metacognition was conceptualized so as to capture both detection and diagnostic processes. Although metacognitive training focused on asking questions to both detect and diagnose change, the metacognitive process questions that were utilized in the task did not explicitly measure the degree to which individuals detect changes. Strategic effort was measured in such a way as to capture both explorative behaviors (i.e., zooms) and the exploitation of resources found and identified as a result of exploration (i.e., high-priority contacts). Thus, the measure of strategic effort utilized in the study confounded those two processes.

In order to more accurately represent and measure the processes of exploration and exploitation, the alternative model distinguishes explicitly between metacognitive processes directed towards detection and those directed towards diagnostics. Similarly, it distinguishes between the exploration of the task domain space as well as the strategic effort exerted towards utilizing resources in novel ways. These processes will be described in detail below.

Breaking up exploration (i.e., search behaviors) and strategic effort in the model emphasizes the point that individuals must both search (e.g., move to new locations, inspect different options, learn new information, consider alternate solutions) and experiment with alternative strategies. Exploration refers to the extent to which individuals engage in search behavior, and strategic effort refers to the extent to which effort is exerted towards exploiting resources that are discovered as a result of the search behavior, and is likely either categorically different from the resources previously exploited, or in a different pattern than before. In some cases, it may be difficult to operationally distinguish between exploration and strategic effort and, depending on the task, measurement of the two may need to be collapsed. In the current study, exploration would have been measured by zooming behaviors, while strategic effort would have been measured by the number of high-priority contacts processed.

Figure 2. Dynamic adaptation heuristic



In this revised model, strategic effort and exploitative effort are distinct. Exploitative effort is intended to capture a 'work harder' strategy, while strategic effort is intended to capture a 'work smarter' strategy. The dynamics of the model suggest a system in which individuals exert effort towards exploiting resources in a somewhat mundane way until performance decrements begin to accrue[1]. At this point, the performance decrements would lead to the engagement of detection and diagnostic processes which, if successful, would lead to the exertion of strategic effort.

A static distinction between strategic effort and exploitative effort is difficult to make, given that after a time the behaviors used to define strategic effort may become the new norm and thus the subject of exploitative effort. If the right environmental dynamics are in place, it is likely that adaptive processes lead to the adoption of a new strategy, exemplified initially by strategic effort, which becomes routinized over time. Exploration may, at different times, require learning or searching one's repertoire of behaviors (Kozlowski et al., 1999). Regardless, strategic effort during adaptation can always be compared to the baseline levels of strategic effort prior to any changes, as well as to levels of exploitative effort. In the case that strategic effort becomes the new norm, those particular behaviors would be redefined as exploitative effort, and strategic effort would be redefined in terms of potential alternate strategies that could be adopted as a result of further exploration.

This fluid conceptualization of strategic effort and exploitative effort has the advantage of being able to contribute to a framework that explains the constant rebalancing and refocusing of effort over time as individuals engage in adaptive

[1] In the case of adaptive tasks, this performance decrement would be externally driven by changes in the task and would not be directly attributable to decreases in self-efficacy or goals.

processes. Its disadvantage is that making specific recommendations on criteria for redefining strategic effort and exploitative effort over time is difficult. One potential option is that once the behaviors selected to represent strategic effort become the predominant focus of effort they ought to be redefined in terms of exploitative effort. This would entail creating a ratio of strategic effort to total effort (i.e., strategic effort plus exploitative effort) and using a ratio of 0.51 as a cutoff. A simple majority rule may be too stringent, and a suitable ratio cutoff criterion ought to be made on a case by case study as a result of both rational analysis and empirical frameworks, also likely informed by subject matter experts. Alternatively, a simple description of the ratio between strategic effort and total effort can be used to describe the switching that occurs between the two pathways, without relying on a cutoff value. On the practical side, it is likely that most studies of adaptive process in the near future will not need to redefine strategic effort as a result of time, given that the current paradigms in the literature have yet to adequately address how adaptive processes are involved in simple changes over a few time points. In the current study, the task was such that a redefinition would have been unnecessary.

The switching mechanism that controls the relative balance between exploitative and explorative behavior is actually two-fold. First, the degree to which changes are diagnosed and potential solutions identified is posited to negatively influence the rate of exploitative effort and positively influence the rate of exploration. If changes are diagnosed and potential solutions identified, individuals will be more likely to exert effort exploring their task domain space in search of suitable alternate strategies. If changes are not diagnosed and no potential solutions present themselves (which would both likely be the result of low detection rates), individuals will be more likely to exert effort towards the status quo behaviors. It is important to note that both the positive and negative linkages designated are not intended to be on/off switches. Rather, the relationship between diagnosis and both exploration and exploitation is one of degree. That is, when diagnostic metacognitive process levels are relatively high, it is still likely that a low base rate of exploitative effort is maintained even when more effort is exerted towards exploration. In other words, while alternate strategies are searched for, some effort may still be exerted towards the current status quo so as not to experience complete performance loss.

The second aspect of this switching mechanism relates to the effect of performance on detection levels. As performance improves, efforts to detect changes will decrease, and relatively higher levels of exploitative effort will result. Since detection is a distal predictor of explorative effort, as mentioned above it is expected that if detection is low, diagnostic processes and explorative effort will subsequently be lower. It follows that when performance is relatively stable, both exploration and exploitation will occur, but at a rate that heavily favors exploitation. Also important to note is that although performance acts as feedback to the system, performance is not required for the enactment of the adaptive processes, nor is performance necessarily a direct reflection of the extent to which adaptive processes are enacted. For example, low performance is expected to drive detection, diagnostic, and exploration processes, and these processes are more likely to continue the lower performance is. Similarly, as performance improves, self-efficacy is expected to remain high and predict exploitative effort. Although no specific exit mechanism is formally included in this model, it is to be understood that persistent and extremely low levels of performance may cause individuals to quit and exit the system.

Conclusion

This study attempted to demonstrate that training can lead individuals to engage more in self-regulatory processes that enable adaptation. Unfortunately, the manipulations did not work as intended, and not all hypotheses were confirmed. Thus, it is unclear whether training can lead to all the desired impacts on self-regulatory processes. Furthermore, simulation design flaws made it difficult to ascertain the extent to which self-regulation enables adaptation. Despite these shortcomings, some results indicate that self-regulatory variables do relate to performance, and that metacognitive training impacts metacognition and strategic effort. These findings, although meager in terms of what was hoped for, do provide support for future research into self-regulation and its role in adaptation. Overall, the findings demonstrate the important of engaging in such investigations using appropriate longitudinal methods.

Appendix A

Table 1. Correlation table, between-individuals

				Correlations				
		M	SD	1	2	3	4	5
1	MC Training	0.49	0.5	1				
2	Feedback Training	0.49	0.5	0.02	1			
3	Metacognition	3.32	0.82	.12*	0.03	1		
4	Strategic Effort	11	7.09	.15*	0.01	0.08	1	
5	Self-efficacy	3.85	0.63	-0.04	0.02	.41**	0.03	1
6	Goal difficulty	688	290	0.03	-0.04	-0.02	0.01	.15**
7	Effort	12.9	2.95	-0.01	0.01	-0.09	0	0.05
8	Adaptive Perf.	1100	293	-0.01	0.01	-0.03	-0.06	0.06
9	Training Perf.	764	251	-0.01	0.06	-0.11*	.22**	.11*
10	Learning GO	4.69	0.63	.19**	0.01	.20**	0.09	.20**
11	Prove GO	4.22	0.76	0.03	-0.01	-0.01	-0.08	0.05
12	Avoidance GO	3.44	0.88	-0.03	0	-0.05	-.12*	-0.04
13	Ability	19.9	5	0.04	-0.03	0.02	0.02	0.06
14	Intrinsic Mot.	155	33	0.08	0.08	.455**	-0.02	.35**

** p<.01; * p<.05

Table 1 (cont'd).

6	7	8	9	10	11	12	13	14
1								
.46**	1							
.476**	.85**	1						
.351**	.53**	.53**	1					
0.06	0.03	0.05	.14**	1				
0.02	-0.01	-0.03	-0.06	.26**	1			
-0.04	0.07	0.06	-0.07	-.27**	.136**	1		
0.02	0.07	0.06	0.08	0.07	-0.01	-0.03	1	
.16**	0.09	.144**	0.07	0.1	-0.02	-0.03	0.01	1

Table 2. Correlation table, between- and within-individuals

		M	SD	1	2	3	4	5	6
1	Metacognition	3.32	0.82	1	*-0.07*	*0.12*	*-0.06*	*-0.16*	*-0.03*
2	Strategic Effort	11	7.09	0.08	1	*0.02*	*0*	*0.19*	*0.14*
3	Self-efficacy	3.85	0.63	0.41**	0.03	1	*0.13*	*0.01*	*0.06*
4	Goal difficulty	688	290	-0.02	0.01	.15**	1	*0.114*	*0.04*
5	Effort	12.9	2.95	-0.09	0	0.05	.46**	1	*0.63*
6	Adaptive Perf.	1100	293	-0.03	-0.06	0.06	.48**	.85**	1

** p<.01

Note- Italic values are averaged within-person correlations

Table 3. HLM results for H1

DV: Trial 5
Metacognition

Source	df	F
Corrected model	7	1.03
Intercept	1	1.93**
Training Performance	1	6.16**
Learning goal orientation	1	13.73**
Prove goal orientation	1	1.92
Avoidance goal orientation	1	0.047
Ability	1	0.001
Intrinsic Motivation (Train)	1	50.23**
Metacognitive Training	1	0.659
Error	355	
Total	362	

* p< .05

Table 4. HLM results for H2

DV: Trial 5 Self-Efficacy

Source	df	F
Corrected model	7	4.7**
Intercept	1	34.96**
Training Performance	1	4.34**
Learning goal orientation	1	6.23**
Prove goal orientation	1	0.002
Avoidance goal orientation	1	0.02
Ability	1	1.81
Intrinsic Motivation (Train)	1	12.68**
Training Feedback Type	1	0.437
Error	355	
Total	362	

* p< .05

Table 5. Results for H4

DV: Rate of change for Metacognition

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	.22**	0.06	369
Level-2 Predictors				
Metacognitive Training	β_{01}	-0.18	0.38	369
Learning goal orientation	β_{02}	1.62**	0.32	369
Prove goal orientation	β_{03}	-0.36	0.27	369
Avoidance goal orientation	β_{04}	0.13	0.2	369
Ability	β_{05}	-0.03	0.25	369
Training Performance	β_{06}	0	0	369
Metacognitive Training	β_{11}	0.16**	0.05	374

Table 6. Results for H5

DV: Rate of change for Self-Efficacy

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	0.01	0.01	369
Level-2 Predictors				
Training Feedback Type	β_{01}	-0.18	0.09	369
Learning goal orientation	β_{02}	0.36**	0.1	369
Prove goal orientation	β_{03}	0.01	0.08	369
Avoidance goal orientation	β_{04}	0	0.08	369
Ability	β_{05}	0.02	0.01	369
Training Performance	β_{06}	0	0	369
Training Feedback Type	β_{11}	0.03	0.02	374

**$p<.01$

Table 7. Results for H6

Predictor/Step			β At Step	β Final	R^2	ΔR^2
DV:		**Self-Efficacy**				
	1	Training Performance	0.06	0.12		
		Learning goal orientation	.16**	0.09		
		Prove goal orientation	0.02	0.04		
		Avoidance goal orientation	0.02	0.01		
		Ability	0.04	0.04		
		Intrinsic Motivation	.33**	0.19**	0.16**	
	2	Metacognition		.32**	0.23**	0.07**
DV:		**Goal Level**				
	1	Training Performance	.32**	.32**		
		Learning goal orientation	-0.05	-0.07		
		Prove goal orientation	0.07	0.07		
		Avoidance goal orientation	-0.04	-0.04		
		Ability	0	0		
		Intrinsic Motivation	.13**	0.1	.125**	
	2	Self-Efficacy		0.09	0.132	0.01
DV:		**Effort**				
	1	Training Performance	0.55**	.47**		
		Learning goal orientation	-0.08	-0.07		
		Prove goal orientation	0.07	0.05		
		Avoidance goal orientation	0.09	.1**		
		Ability	0.04	0.04		
		Intrinsic Motivation	0.05	0.02	0.3**	
	2	Goal Level		.24**	0.36**	0.06**
DV:		**Adaptive Performance**				
	1	Training Performance	.52**	.12**		
		Learning goal orientation	-0.04	0.01		
		Prove goal orientation	-0.02	-0.02		
		Avoidance goal orientation	0.09	0.03		
		Ability	0.02	0		
		Intrinsic Motivation	0.11	0.07	0.29**	
	2	Effort		0.75**	0.7**	.41**

Table 7 (cont'd).

Predictor/Step		β At Step	β Final	R^2	ΔR^2
DV:	**Strategic Effort**				
	Training Performance	.17**	.2**		
	Learning goal orientation	0.04	0.02		
	Prove goal orientation	-0.07	-0.06		
	Avoidance goal orientation	-0.1	-0.1		
	Ability	0	-0.01		
	Intrinsic Motivation	-0.04	-0.1	.05**	
2	Metacognition		.14**	0.07**	.02**
DV:	**Adaptive Performance**				
1	Training Performance	0.52**	.56**		
	Learning goal orientation	-0.04	-0.03		
	Prove goal orientation	0.02	0.01		
	Avoidance goal orientation	0.09	0.07		
	Ability	0.02	0.02		
	Intrinsic Motivation	.11**	.1*	.29**	
2	Strategic Effort		-.225**	.34**	.05**

** p<.01; * p<.05

Supplementary

DV:	**Strategic Effort**				
1	Training Performance	.17**	.18**		
	Learning goal orientation	0.04	0.02		
	Prove goal orientation	-0.07	-0.06		
	Avoidance goal orientation	-0.1	-0.1		
	Ability	-0.02	-0.01		
	Intrinsic Motivation	-0.04	-0.1	.05**	
2	Metacognitive Training		.13**	0.07**	.02**

Table 8. Results for H6

DV: Rate of change for Self-Efficacy

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	0.02	0.01	369
Rate of Change for Metacognition	β_{10}	0.04**	0	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	0.39**	0.1	369
Prove goal orientation	β_{02}	0.01	0.09	369
Avoidance goal orientation	β_{03}	0.005	0.07	369
Ability	β_{04}	0.02	0.01	369
Training Performance	β_{05}	0	0	369

DV: Rate of change for Goal Level

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	-3.04	1.96	369
Rate of Change for Self-Efficacy	β_{10}	13.6**	6.38	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	-5.6	23.9	369
Prove goal orientation	β_{02}	21.38	18.6	369
Avoidance goal orientation	β_{03}	-10.5	15.8	369
Ability	β_{04}	0.64	0.01	369
Training Performance	β_{05}	0.11**	0.02	369

Table 8 (cont'd).

DV: Rate of change for Effort

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_{2}	-0.08**	0.02	369
Rate of Change for Goal Level	β_{10}	0.002**	0	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	-0.15	0.19	369
Prove goal orientation	β_{02}	0.12	0.15	369
Avoidance goal orientation	β_{03}	0.24	0.14	369
Ability	β_{04}	-0.02	0.03	369
Training Performance	β_{05}	0.002**	0	369

DV: Rate of change for Adaptive Performance

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_{2}	5.01**	2.2	369
Rate of Change for Effort	β_{10}	73.7**	2.3	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	-5.03	19.8	369
Prove goal orientation	β_{02}	0.02	15.3	369
Avoidance goal orientation	β_{03}	23.3	13.97	369
Ability	β_{04}	-3.63	2.45	369
Training Performance	β_{05}	0.17**	0.01	369

Table 8 (cont'd).

DV: Rate of change for Strategic Effort

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	-0.13**	0.06	369
Rate of Change for Metacognition	β_{10}	-0.13	0.08	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	0.66	0.52	369
Prove goal orientation	β_{02}	-0.57	0.53	369
Avoidance goal orientation	β_{03}	-0.49	0.32	369
Ability	β_{04}	-0.05	0.07	369
Training Performance	β_{05}	0.001**	0	369

DV: Rate of change for Adaptive Performance

Level-1 Predictors	Parameter	Coefficient	S.E.	df
Intrinsic Motivation	Π_2	0.23	2.1	369
Rate of Change for Strategic Effort	β_{10}	7.4**	1.24	375
Level-2 Predictors				369
Learning goal orientation	β_{01}	1.97	19.9	369
Prove goal orientation	β_{02}	-2.45	15.3	369
Avoidance goal orientation	β_{03}	22.7	13.8	369
Ability	β_{04}	-4.22	2.3	369
Training Performance	β_{05}	0.16**	0.01	369

Table 9

DV	Coefficient	S.E.
Metacognition	-0.005	0.01
Strategic Effort	-0.013	0.02
Self-efficacy	-.047**	0.01
Goal difficulty	0.003	0.002
Effort	-0.034**	0.01
Adaptive Performance	-.07**	0.01

Figure 10. Normative score values

Normative Score Values

10%	574
20%	591
30%	648
40%	676
50%	765
60%	828
70%	887
80%	982
90%	1112

Table 11. Equations

Equation 1.1 for H4:

$$Y = \Pi_0 + \Pi_1(\text{Trial}) + \Pi_2(\text{Intrinsic Motivation}) + \varepsilon_{ij}$$

$$\Pi_0 = \beta_{00} + \beta_{01}(\text{Metacognitive Training}) + \beta_{02}(\text{Learning GO}) + \beta_{03}(\text{Prove GO}) +$$

$$\beta_{04}(\text{Avoidance GO}) + \beta_{05}(\text{Ability}) + \beta_{06}(\text{Training Performance}) + \zeta_{0i}$$

$$\Pi_1 = \beta_{10} + \beta_{11}(\text{Metacognitive Training}) + \zeta_{1i}$$

$$\Pi_2 = \beta_{20}$$

Equation 1.2 for H5:

$$Y_{ij} = \Pi_0 + \Pi_1(\text{Trial}) + \Pi_2(\text{Intrinsic Motivation}) + \varepsilon_{ij}$$

$$\Pi_{0i} = \beta_{00} + \beta_{01}(\text{Training Feedback Type}) + \beta_{02}(\text{Learning GO}) + \beta_{03}(\text{Prove GO}) +$$

$$\beta_{04}(\text{Avoidance GO}) + \beta_{05}(\text{Ability}) + \beta_{06}(\text{Training Performance}) + \zeta_{0i}$$

$$\Pi_{1i} = \beta_{10} + \beta_{11}(\text{Training Feedback Type}) + \zeta_{1i}$$

$$\Pi_{2i} = \beta_{20}$$

Table 11 (cont'd).

Equation 1.3 for a generic H7:

$Y_{ij} = \Pi_0 + \Pi_1$([Process Predictor]) + Π_2(Intrinsic Motivation) + ε_{ij}

$\Pi_{0i} = \beta_{00} + \beta_{01}$(Learning GO) + β_{02}(Prove GO) + β_{03}(Avoidance GO) +

β_{04}(Ability) + β_{05}(Training Performance) + ζ_{0i}

$\Pi_{1i} = \beta_{10} + \zeta_{1i}$

$\Pi_{2i} = \beta_{20}$

Figure 3. Metacognition

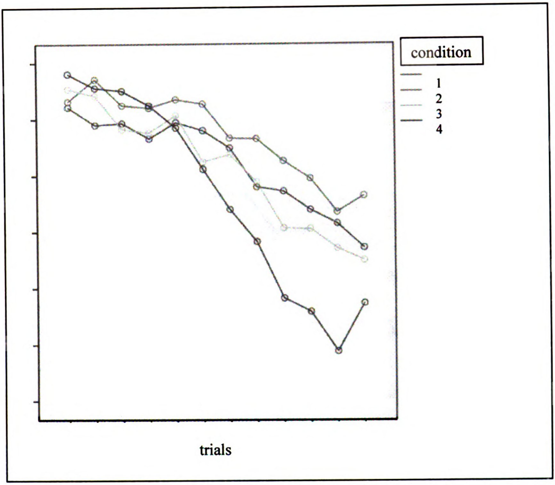


Figure 4. Self-efficacy

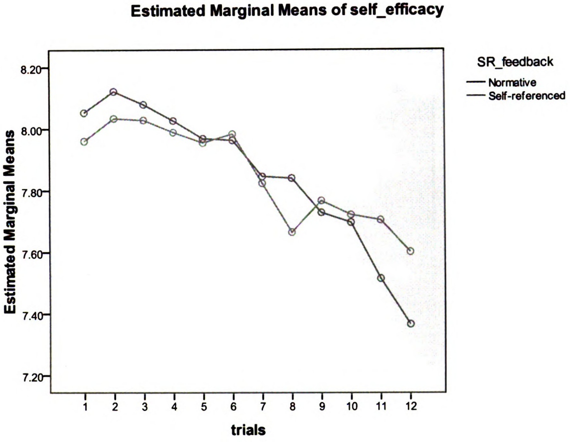


Figure 5. Goal level

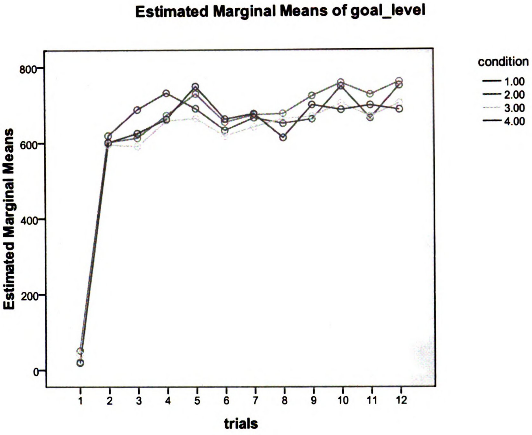


Figure 6. Effort

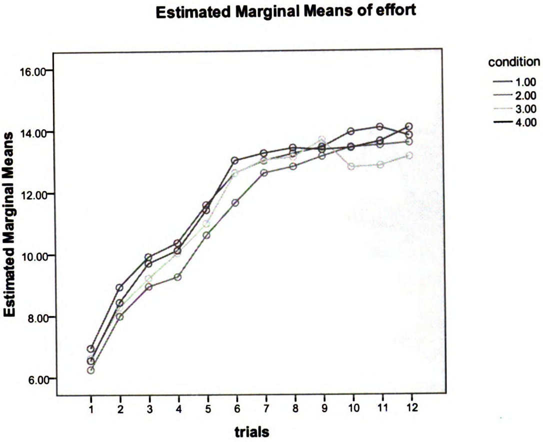


Figure 7. Strategic effort

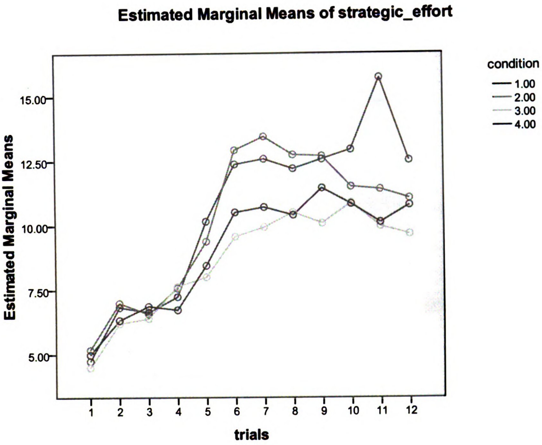
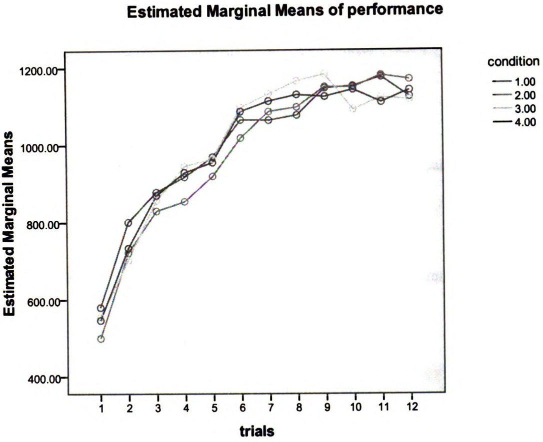


Figure 8. Performance



Metacognitive Training Questions (answered after each training trial)
Please briefly respond to the following questions.

What do I need to learn about how to engage contacts?

Are target speeds related to scoring? If so, how?

What is hurting my score the most? How can I overcome that?

How can I find out which contacts are most important to process?

How could I better use more of the game's functions (e.g., zoom, manual, queries)?

What should I study in the manual to improve my skill and/or strategy?

How can I effectively use the feedback I receive to improve my performance?

How could I be more systematic about improving my performance?

Metacognition Cheat Sheet

Metacognition is the knowledge and control you have over your own thoughts. It includes the awareness you have of how you learn and what you know. When you are using metacognition, you are thinking about the processes of your thoughts, what you know, and what you need to do be a better learner.

Metacognition has been shown to increase awareness, comprehension, self confidence, and the use of effective strategies in tasks like the one you are currently participating in. ***Science has shown that is in your best interest to utilize the metacognitive techniques you have been taught not just during this task (which is important) but really for anything else you do in life.***

Ask yourself questions about what you know

What can I do to more effectively engage contacts?

Are contact speeds related to scoring?

What is hurting my score the most? How can I overcome that?

Ask yourself questions about how you could better strategize and do things better

How can I find out which contacts are most important to process?

How could I better use more of the game's functions (e.g., zoom, manual, queries)?

Think about your planning efforts and how you could improve them

What should I study in the manual to improve my skill and/or strategy?

How can I effectively use the feedback I receive to improve my performance?

How could I be more systematic about improving my performance?

REMEMBER: Learning to ask these questions will help your performance in the game after training is complete and you are faced with new challenges.

Appendix B

Goal Orientation Learning:

For each of the following statements, please indicate how true it is for you.

1) I am willing to take on challenged that I can learn a lot from.
2) I often look for opportunities to develop new skills and knowledge.
3) I enjoy challenging and difficult activities where I'll learn new skills.
4) For me, development of my abilities is important enough to take risks.

Goal Orientation Prove:

For each of the following statements, please indicate how true it is for you.

1) I prefer to do things that require a high level of ability and talent.
2) I'm concerned with showing that I can perform better than my peers.
3) I try to figure out what it takes to prove my ability to others.
4) I enjoy it when others are aware of how well I am doing.
5) I prefer to participate in things where I can prove my ability to others.

Goal Orientation Avoidance:

For each of the following statements, please indicate how true it is for you.

1) I would avoid taking on a new task if there was a chance that I would appear rather incompetent to others.
2) Avoiding a show of low ability is more important to me than learning a new skill.
3) I'm concerned about taking on a task if my performance would reveal that I had low ability.
4) I prefer to avoid situations where I might perform poorly.

Ability:

1) What is your college GPA?
2) What was your ACT/SAT score?

Intrinsic Motivation:

For each of the following statements, please indicate how true it is for you.

1) I enjoyed doing this activity very much
2) This activity was fun to do.
3) I thought this was a boring activity.
4) This activity did not hold my attention at all.
5) I would describe this activity as very interesting.
6) I thought this activity was quite enjoyable.
7) While I was doing this activity, I was thinking about how much I enjoyed it.

Metacognition:

Please indicate the extent to which you agree with each of the following statements regarding your thoughts and behaviors DURING THE LAST TRIAL ONLY.

1) I engaged in self-questioning techniques.
2) I asked myself questions about what I know.
3) I asked myself questions about how I can better strategize.
4) I asked myself questions about how I can improve my planning.
5) I tried to implement new strategies.

Self-efficacy:

This set of questions asks you to describe how you feel about your capabilities for performing on the next trial of this simulation.

1) I am confident in my ability to meet the challenges of this simulation.

2) I am certain that I can manage the requirements of this task.

Goal Level:

1) How many points do you plan to score during the next trial?

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