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dissertation entitled

ADAPTABILITY FROM A PROCESS PERSPECTIVE: EXAMINING THE EFFECTS OF TASK CHANGE TYPE AND A METACOGNITIVE INTERVENTION ON ADAPTIVE PERFORMANCE

presented by

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has been accepted towards fulfillment
of the requirements for the

Ph. D. degree in Psychology

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24 June 2009

Date

# ADAPTABILITY FROM A PROCESS PERSPECTIVE: EXAMINING THE EFFECTS OF TASK CHANGE TYPE AND A METACOGNITIVE INTERVENTION ON ADAPTIVE PERFORMANCE

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Psychology

2009

ABSTRACT

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EXAMINING THE EFFECTS OF TASK CHANGE TYPE AND A METACOGNITIVE INTERVENTION ON ADAPTIVE PERFORMANCE

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While past work on adaptability and adaptive performance has developed and matured primarily over the last two decades, a number of gaps exist in the literature. Namely, existing work generally takes a static approach to examining adaptability and fails to consider potentially important cognitive and behavioral processes that can influence adaptation over time. Furthermore, this work pays little attention to the different ways in which a task can change, which may have implications for how and how well people are able to adapt. Finally, little work has focused on in situ self-regulatory processes that may influence how well people are able to adapt to various types of task change. To address these gaps, the current study introduces and builds from a process model of adaptation by which it is hypothesized that in order to exhibit high levels of adaptive performance effectiveness, people must detect changes in the task they are facing, diagnose the nature of those changes, and finally develop and enact appropriate task strategies. Furthermore, and based on Wood's (1986) taxonomy of task complexity types, this study suggests three different ways in which tasks can change and examines the processes by which people are able to adapt to each of them. In addition, a metacognitive intervention was designed that encouraged participants to devise plans, monitor their performance effectiveness, and evaluate the effectiveness of their strategies in order to investigate the impact of these in situ self-regulatory processes on adaptive

performance. Finally, a number of hypotheses were investigated regarding the potential impact of individual differences factors related to cognitive ability, goal orientation, and personality on adaptive performance effectiveness in relation to the different types of task change. Using a laboratory-based radar simulation task, the findings provide support for the efficacy of thinking about adaptability as a process rather than simply as performance at a given point in time. Specifically, evidence suggests that change detection, relevant knowledge acquisition (e.g. diagnosis), and appropriate strategy change were related to higher levels of adaptive performance effectiveness, although these results were not entirely consistent across the three types of task change that were investigated.

## ACKNOWLEDGMENTS

I would like to thank Dr. Steve Kozlowski for all of the time, effort, and guidance that he offered as my dissertation advisor. Thank you Steve for your ideas and suggestions, for helping to provide clarity on many of the issues I faced while working on this project, and for the resources and opportunities that you provided. I am especially thankful for your patience. Also, I would like to thank Dr. Dan Ilgen, Dr. Kevin Ford, and Dr. Remus Ilies for serving on my committee and for providing me with helpful suggestions and future considerations regarding this work.

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## Introduction

Jobs in current organizations are no longer characterized by static task requirements and assembly line-like work. Rather, workers in many organizations today possess jobs that are characterized by dynamic, ever-changing work environments (Ilgen & Pulakos, 1999; Smith, Ford, & Kozlowski, 1997). In fact, change is considered to be omnipresent in organizations (e.g. Cascio, 2003), and it can come from a number of sources. Changes in technology are rapid and pervasive in modern work environments. Computers are everywhere, and the plethora of new software programs, versions, and systems as well as the availability of the internet for constant and immediate access to data requires continuous adaptation on the part of employees (Hesketh & Neal, 1999; Ployhart & Bliese, 2006). Mergers and restructuring are also common in organizations, and along with them comes the requirement that employees learn new skills for their changed job or adopt new procedures to fit in with new ways of doing things (Pulakos, Arad, Donovan, & Plamondon, 2000). Furthermore, the shift in the U.S. to a primarily information or knowledge based economy brings with it the demand for employees who can continuously update their skills and expertise, as well people who can work with other experts on project-based teams (Hesketh & Neal, 1999).

These changes have lead to a shift in what is considered to be important for job performance. Organizational scholars and practitioners are increasingly coming to the conclusion that employees with the ability to adapt to changes in their jobs are valuable assets and may even be necessities. Indeed, adaptive performance has been suggested to be a component of many different types of current jobs (Pulakos et al, 2000) in addition to traditional aspects of job performance (Campbell, 1990; Campbell, McCloy, Oppler, &

Sager, 1993) and citizenship or contextual performance (Borman & Motowidlo, 1993; 1997).

This increased focus on the importance of adaptability for employees is reflected by a number of relatively recent studies in Industrial/Organizational psychology that focus on examining or predicting adaptive performance. Recognizing the demand for flexible and adaptive employees, one set of studies has taken a selection perspective and focused on individual differences that are directly tied to, or in some cases proposed to be the root of, adaptability (e.g. Cronshaw & Jethmalani, 2005; LePine, Colquitt, & Erez, 2000; Ployhart & Bliese, 2006). Another set of studies and theoretical contributions have come from a training perspective, and they have primarily focused on identifying and/or testing training techniques and methods that build critical task knowledge and skills as well as adaptive skill or expertise (e.g. Bell & Kozlowski, 2002; 2008; Ford et al., 1998; Ivancic & Hesketh, 2000; Keith & Frese, 2005; Kozlowski et al., 2001; Smith, Ford, & Kozlowski, 1997).

While work on adaptive performance in the past 15 to 20 years has come a long way and is certainly impressive, the current state of the literature leaves a number of avenues unexplored. First of all, the current work has focused primarily on selecting and training for adaptive performance, but it has primarily treated the construct as a static operationalization of performance after a task change occurs. Little attention has been given to what people have to go through to adapt to a change in the nature of a learned task. This lack of in situ consideration poses a problem when trying to understand the nature of adaptive performance. Without knowing or thinking about what people are doing to adapt, it is difficult to understand how or why individual differences, training techniques, or the like should influence adaptive performance.

A second area that remains fairly unexplored pertains to different types of tasks that people may have to adapt to. Primarily, current operationalizations of adaptive performance have focused on performance on tasks that are novel, ill-defined, more difficult, and/or more complex than previous tasks. While these tasks certainly require adaptability, there is no existing framework for understanding or thinking about how tasks can change. While Pulakos et al. (2000; 2002) offer an empirically derived taxonomy of different types of adaptive performance, they do not provide a discussion of different components of these tasks that can change.

A third area of research on adaptive performance that has been given little consideration deals with understanding the importance of self-regulatory processes occurring during the process of adaptation. While recent research by Chen, Thomas, and Wallace (2005) takes a step in this direction by examining self-regulatory processes that are thought to translate existing task knowledge, skill, and efficacy into adaptive performance, there is room for further exploration, especially when considering the potential effects of regulatory interventions.

With these open areas of inquiry in mind, the first focus of this paper is to build a conceptual model of adaptation as a process. This model is based on thinking about adaptability to a changing task from a process perspective as a series of steps or activities that one needs to go through. It is grounded in control theory models of self-regulated behavior (e.g. Carver & Scheier, 2001; Klein, 1989) and attempts to highlight the importance of detecting task changes, diagnosing the nature of those changes, and devising and selecting strategies to adapt to those changes.

This model then serves as the foundation for a discussion and explication of different types of task change and how people can adapt to adapt to them. Using Wood's (1986) taxonomy of task components, three distinct types of task change are proposed that are suggested to cut across different types of adaptive performance. Using the conceptual process model of adaptation as a guide, a series of hypotheses are developed regarding the importance of different motivational and cognitive factors in predicting adaptive performance effectiveness in response to these different types of task change.

The third part of this paper focuses on the potential importance of in situ self-regulatory activities, primarily in the form of metacognition, for influencing adaptability to different types of task change. Metacognition can be thought of as the regulation of how well one is making plans, monitoring performance effectiveness, and evaluating the success of one's plans or strategies during task performance (Schraw & Moshman, 1995), or in this case adaptive performance. While previous work has shown the importance of metacognition as a predictor of learning, problem solving, and even adaptive performance, potentially viable metacognitive interventions, especially those aimed at increasing metacognition during actual adaptation, have received little attention. The third section of this paper discusses and presents hypotheses regarding the potential effects of a metacognitive intervention on adaptive performance effectiveness in response to different types of task change.

Finally, a number of individual difference predictors of adaptive performance are discussed in relation to their effects on predicting adaptive performance. This section focuses on individual differences factors related to cognitive ability, personality, and goal orientation. While these factors have been shown to be related to adaptive performance in prior studies, this section uses the conceptual process model of adaptation as a guide for developing hypotheses aimed at assessing potential differential influences of these individual differences on adaptive performance in response to different types of task change.

## A Review of Adaptive Performance

While the I/O Psychology literature on adaptability and adaptive performance is relatively young and certainly still emerging, it is characterized by different perspectives and definitions of adaptability. Appendix A lists numerous definitions of individual adaptability or adaptive performance that have been used in the I/O literature to discuss the same general phenomenon. Reflective of this, Ployhart and Bliese (2006) identified four streams of research that they saw as broadly related to current definitions of adaptability: (1) adaptability as task performance, (2) adaptability as changes to cognitive processing, (3) adaptability as coping, and (4) adaptability as responding to organizational change. For the purpose of this study, I will primarily frame things in terms of the most traditional I/O perspective of adaptability as task performance. While the research in each of these streams certainly has some relevance and conceptual overlap, for the purpose of this study I believe that they are best thought of as supplements and, in fact, some of this research will serve quite prominently in that manner.

Within the I/O literature the research can be further broken down into two approaches: (1) adaptability from an individual difference and selection perspective and (2) adaptability from a training and outcome perspective. Relevant conceptual and empirical work from these two perspectives will now be presented.

The individual difference or selection approach to adaptability primarily views adaptability as a set of personal characteristics or skills that people posses which allow them to perform successfully when a learned task changes. In this approach, adaptability essentially resides within the person and, thus, people can be differentiated because of their varying levels of inherent adaptability.

For example, Cronshaw and colleagues (Fine & Cronshaw, 1999; Cronshaw & Jethmalani, 2005) discuss adaptability as "competencies that enable people to manage themselves in relation to the demands of conformity and/or change in particular situations" (Fine & Cronshaw, 1999, pg 40). Cronshaw and Jethmalani (2005) categorize these skills as being (1) agentic or accommodative in directionality, (2) internally or externally focused, and (3) activated in relation to things, data, or people. These skills are thought to develop throughout one's life and career and are integrated and manifested as values, attitudes, and ways of reacting to physical, social, and/or environmental changes. Cronshaw and colleagues suggest that people with more developed competencies manage these changes better, and thus they exhibit more successful adaptation.

Coming from a similar perspective, Ployhart & Bliese (2006, pg 13) define adaptability as "an individuals' ability, skill, disposition, willingness, and/or motivation, to change or fit different task, social, and environmental features". Based on this definition, they argue that adaptability resides completely within a given individual and is driven solely by individual differences. Thus, similar to Cronshaw & Jethmalini's (2005) idea of agentic vs. accommodative skills, Ployhart & Bliese (2006) suggest that adaptability does not occur only in response to a change in the given environment or task; it can be both reactive and proactive.

Ployhart & Bliese (2006) also make a distinction between adaptability and adaptive performance, suggesting that work from the training/outcome perspective (e.g.

Ford et al, 1998; Kozlowski et al, 2001) tends to focus on adaptive performance, but individual adaptability is better conceptualized a multidimensional composite set of knowledge, skills, and other abilities that form a higher-order adaptability factor. This composite factor is thought to be influenced by sub-facet personality, cognitive ability, physical ability, and value or interest factors, which are proposed to be invariant across different situations, contexts, and environments (Ployhart & Bliese, 2006).

LePine, Colquitt, and Erez (2000) investigated the influence of ability and personality factors on adaptive performance from a more general selection perspective in which they operationalized adaptive performance as decision-making accuracy after changes in proper decision making rules occurred. Using a decision-making simulation, LePine et al. examined the impact of general cognitive ability, conscientiousness, and openness to experience on decision-making accuracy during an initial block of trials and during two subsequent blocks of trials where decision-making rules changed. They found that cognitive ability and openness to experience both became better positive predictors of decision-making accuracy when people had to adapt to changes in the simulation. Contrary to their hypotheses, however, they found conscientiousness was increasingly negatively related to decision-making accuracy when people had to adapt to changes in the simulation.

The training and outcome perspective primarily views adaptability as performance effectiveness on a novel task. Adaptive performance here is often considered to be a function or outcome of various types of training conditions and factors. The outcomes of these training conditions generally focus on cognitive (e.g. declarative and procedural knowledge, knowledge structure), behavioral (e.g. training performance or skill), and/or affective (e.g. self-efficacy) factors, which stem from the Kraiger, Ford, & Salas (1993) taxonomy of training outcomes. These factors, in turn, are thought to influence one's ability to adapt to changes in the nature of the trained task. It is important to note that individual differences such as cognitive ability, personality, and goal orientation are often examined as predictors in these types of studies. Adaptability, however, is viewed as the individual's effectiveness or rated/measured performance, not the combination of these individual difference factors that people posses.

Smith et al. (1997) provided an initial spur in thinking about adaptability from a training perspective by suggesting that prior work in training in I/O psychology had focused primarily on training for "routine" rather than "adaptive" expertise. Smith et al. suggested that simply being able to execute work-related tasks (routine expertise) is not enough in turbulent work environments, rather, people need a more complete understanding of the requirements and structure of work tasks in order to be able to successfully adapt to changing task demands. As seen in Appendix A, Smith et al. (pp. 93) suggest "Adaptability or adaptive expertise is evidenced when the individual responds successfully to changes in the nature of the trained task."

In order to develop this type of adaptive expertise, Smith et al. (1997) proposed that individuals must first develop detailed knowledge of the task domain. This involves gaining well-developed procedural knowledge structures containing a wide range of potential problems and related solutions that are tightly linked together. This knowledge, however, may not be enough, as individuals must also have metacognitive skills related to planning, monitoring, and evaluating their behavior. These skills are suggested to allow individuals to recognize change and successfully transfer relevant previous knowledge to acquire new knowledge about novel tasks.

In concordance with some of the propositions made by Smith et al. (1997), Kozlowski et al. (2001) examined the impact of mastery vs. performance training goals and trait goal orientations (e.g. Dweck, 1986; Nicholls, 1984) on adaptive performance. Utilizing a radar-tracking decision making simulation, adaptive performance was operationalized as performance on a transfer trial that was more dynamic, difficult, and complex than previous training trials. Kozlowski et al.'s results suggested that mastery training goals were related to more complex knowledge structures and higher levels of self-efficacy, which were both related to higher levels of adaptive task performance. In addition, they found that both initial training performance and task declarative knowledge levels were positively related to adaptive performance. Finally, they found that trait learning orientation had a positive influence on adaptive performance through self-efficacy.

Similarly, and based in part on a review of the training outcomes literature conducted by Kraiger et al. (1993), Ford et al. (1998) examined the impact of knowledge, skills, and affect on training performance and adaptive performance/training transfer in a learner-controlled environment. Similar to Kozlowski et al. (2001), Ford et al.'s transfer/adaptability measure was operationalized as performance on a decision-making task that was more difficult and complex than previous trials. Their results suggested that declarative task knowledge levels, training performance, and self-efficacy were all related to adaptive performance. Furthermore, these learning outcomes mediated various effects of metacognition, task strategy practice levels, identical elements learning strategy use, and goal orientations on transfer performance.

Bell & Kozlowski (2002) examined the influence of adaptive guidance training techniques on adaptive performance, which they also operationalized as performance on a radar-tracking simulation scenario that was longer, more difficult, and more complex than their given training scenarios. Unlike many feedback interventions or training interventions, adaptive guidance training provides participants with progressively tailored information about what areas trainees should focus and improve on as they engage in future task iterations, first focusing on basic task knowledge and skills and later moving toward more complex and strategic knowledge and skills. Bell & Kozlowski found that adaptive guidance was related to more appropriate study and practice strategies, more on task cognition, and higher self-efficacy. In turn, these factors influenced task knowledge and skill, which ultimately positively predicted adaptive performance.

A number of studies focused on error-based training (cf. Frese & Altmann, 1989) have also shown effects on adaptive performance. Error training encourages learners to actively acquire information and skill by exploring the task, testing hypotheses, and using trial-and-error methods. In a pair of studies utilizing a driving simulation, Ivancic & Hesketh (2000) showed that those who received error training, as opposed to those receiving training that discouraged making errors, were better able to adapt their skills and perform on an adaptive transfer test that required a different strategy than was used in training to avoid a collision. Keith & Frese (2005) found similar results using an overhead slide creation training task, in which participants had to perform a more difficult and complex slide creation task. Furthermore, Keith & Frese found that self-regulatory activities related to emotion control (e.g. Kanfer & Ackerman, 1989; Kanfer, Ackerman, & Heggestad, 1996) and metacognition (e.g. Flavell, 1979; Nelson, 1996) mediated the effects of error training on adaptive transfer.

A series of works by Kozlowski and colleagues further discussed the importance and development of adaptive performance with the primary focus being on developing adaptive teams. Kozlowski, Gully, Salas, and Cannon-Bowers (1996a); Kozlowski, Gully, McHugh, Salas, and Cannon-Bowers (1996b); Kozlowski (1998); and Kozlowski, Gully, Nason, and Smith (1999) offer the perspective that team adaptability and coordination are functions of team coherence (i.e. shared affect, cognition, and behaviors in the team). While these works focus on the team level and, thus, are beyond the scope of this review, it is important to note that Kozlowski and colleagues (1996a, 1996b) explicitly discuss the importance of individual task and skill training and development within dynamic, repeating cycles of task intensity over time and how this development is an important step in the development of adaptive teams (Kozlowski et al, 1999).

While the studies described above focus primarily on predicting adaptive performance as an event, other work has focused more on defining different types of adaptive performance that may be required on the job. Coming from something of a performance rating perspective, Pulakos et al. (2000) focused on building a taxonomy of different types of adaptive performance at the individual level. Pulakos et al. worked from a definition that adaptive performance constituted "situations in which individuals modified their behavior to meet the demands of a new situation or event or a changed environment"(p. 615). This view of adaptation is clearly situation-driven, and based on an initial review of relevant literature and a subsequent analysis of a number of critical incidents that described occasions of actual adaptive performance on a job, Pulakos et al. put forth eight dimensions of adaptive performance: (1) solving problems creatively, (2) Dealing with uncertain or unpredictable work situations, (3) learning new tasks, technologies, and procedures, (4) demonstrating interpersonal adaptability, (5) demonstrating cultural adaptability , (6) demonstrating physically oriented adaptability , (7) handling work stress, and (8) handling emergency situations.

In a second study, Pulakos et al. (2000) empirically evaluated their eight-dimension taxonomy of adaptive performance by constructing a performance-rating instrument, the Job Adaptability Inventory (JAI), and administering it to more than 3,000 employees in a number of different occupations. Both an exploratory factor analysis and a subsequent confirmatory factor analysis provided evidence supporting the eight-dimension model. Pulakos et al. (2000) also provided evidence that different occupations had varying levels of adaptive performance requirements and suggested that not all dimensions of adaptive performance should be relevant for all jobs.

In a follow up, Pulakos et al. (2002) further explored the structure of adaptive performance behaviors. Confirmatory factor analyses in this study also supported the eight-dimension taxonomy of adaptive performance using predictor measures of adaptive performance based on past experience, interest, and self-efficacy. However, both exploratory and confirmatory factor analyses yielded difficult to interpret solutions for measures of adaptive performance completed via supervisor ratings, thus suggesting that raters had difficulty separating the dimensions when rating adaptive performance.

While the existing literature reviewed here on adaptive performance identifies a number of important predictors and generally shows good support for the notion of adaptive performance as a relevant construct (e.g. Pulakos et al, 2000), it is not without issues.

First of all, there is considerable conceptual disagreement regarding what adaptability or adaptive performance actually is. Researchers coming from the individual differences perspective such as Ployhart & Bliese (2006) and Cronshaw & Jethmalani (2005) argue that adaptability is something that resides within the individual, and therefore it is the set of personality factors, values, cognitive abilities, and the like that truly define adaptability. On the other hand, work coming from the training perspective such as Smith et al. (1997) argues that adaptability is essentially task performance or effectiveness that is evidenced when people perform well and generalize their skills to a related, but novel task. In this perspective, essential cognitive, behavioral, and affective KSAOs are perceived as being trainable, and it is the training itself that is essential as adaptive performance flows from it. It is important here to highlight the fact that even though these approaches are different, they do not completely contradict one another. In both cases, KSAOs are seen as being important in determining adaptive performance. However, their centrality to the notion of adaptability is debated.

Second, little attention has been paid to the types of task changes that people are adapting to. Empirical work from both the individual difference/selection and outcome/training perspectives on adaptation has been primarily done using an operationalization of adaptive performance that focuses on effectiveness on a novel, more difficult, and/or more complex version of a task that people are already familiar with. While this approach is certainly reasonable in terms of operationalizing adaptive performance as an outcome, it does little to help us understand if and how factors such as training techniques, task knowledge, self-efficacy, personality, cognitive ability, and others predict adaptability to different types of task changes. Initial conceptual work done in this domain by Pulakos and colleague (Pulakos et al 2000; 2002) and Ployhart & Bliese (2006) certainly provides some needed push in this direction, but to date useful empirical work has not followed suit.

Third, and possibly most important, there has been little work focused on understanding what people are actually doing to adapt to changes in their task environment. If one takes the most common perspective of adaptability as consisting of, or evidenced by, performance on a novel, more difficult, and/or more complex version of a learned task, it is hard to ignore the parallels with models of traditional job performance. Specifically, the work by Campbell and colleagues (Campbell, 1990; Campbell et al. 1993) is relevant here as they make a sharp distinction between performance, which is the actual behavior that is under one's control, and effectiveness or productivity, which is the evaluation or results of performance and may be influenced by numerous other factors (for example, the availability of necessary resources). Behavior, and thus performance, is seen as being ongoing, dynamic, and continuous. The current work on adaptability tends to ignore this in search of individual differences or training techniques that ultimately influence what Campbell and colleagues refer to as effectiveness. While a number of studies have examined self-regulatory processes related to behavior during training or skill acquisition (Bell & Kozlowski, 2002; Ford et al., 1998; Kozlowski et al., 2001), these have generally not focused specifically on looking at *in situ* factors that may influence actual behavior during the time period where people are attempting to adapt to a task change.

There are, however, a few exceptions. Although they strongly advocate an individual differences approach to adaptability, Ployhart & Bliese (2006) do provide an initial, albeit very general, discussion of how these individual differences may influence people's ability to identify situational cues that denote the need to change, select appropriate strategies, and monitor and regulate their behavior when trying to adapt. Furthermore, a multilevel empirical study conducted by Chen et al. (2005) examined adaptive performance as transfer performance on a novel version of an attack helicopter flight simulation scenario that was more dynamic and complex than the practice/training scenarios. Chen et al proposed homologous models at the individual and team levels that focused on task knowledge, efficacy, and task skill as predictors of performance through self-regulatory activities related to goal choice and goal striving (e.g. Kanfer, 1990; Mitchell & Daniels, 2003) during adaptation. At the individual level, their results suggested that within-episode goal striving processes mediated the positive relationship between between-episode goal choice activities and adaptive performance. Furthermore, Chen et al. found that task-related role knowledge and individual task skill were directly related to adaptive performance.

While this work is certainly a step in the right direction, it is my assertion that further attention needs to given to each of these issues. Specifically, a model that views adaptation or adaptive performance as a process, rather than just an operationalization or outcome, can help to shed some light on these issues. In the next section, I will propose just such a conceptual model with the intention of using it as a guide to further explore issues related to in situ cognitive and behavioral self-regulatory processes occurring during adaptation as well as how the process of adapting to different types of task change may differ.

## The Adaptation Process

Viewing adaptability as a process essentially entails thinking about it as a multitude of dynamic behaviors and cognitions that are engaged in with the purpose of adapting to a change in one's task environment. While existing definitions of adaptability vary somewhat in focus and scope (see Appendix A), they all include this element of success in responding to a task change. However, as suggested earlier, many of these definitions focus on adaptability as residing within the individual or on adaptability as generalization of trained skills. To think of adaptability as a process, a different type of definition needs to be used, one that focuses on behavior as well as effectiveness. This is consistent with the aforementioned view of Campbell and colleagues (e.g. Campbell, 1990; Campbell et al. 1993) that performance is the actual behavior that people engage in, while effectiveness is the outcome of that behavior. From this perspective, the object of adaptability (i.e. adaptive performance) is to perform effectively (i.e. improve, maintain, or limit decrements) in the new task environment, while adaptability itself can be thought of as the behaviors and cognitions that people engage in toward this end and the process of determining what these behaviors will be. Given this, I will use the following definition of adaptability as the foundation for this study.

> Adaptability, or adaptive performance, is the process of using existing knowledge and skill to appropriately and functionally align behavior with task and/or environment changes in a way that improves, maintains, or limits decrements in performance effectiveness.

In my opinion, this type of dynamic approach to adaptability provides a substantially more appropriate framework for thinking about how people actually adapt to task changes, as opposed to previous work that focuses primarily on what factors predict performance effectiveness in changing situations. In addition, this type of view further opens the door for existing research on job performance and behavior to be incorporated and integrated into theories of adaptive performance.

One such area of research that may be especially useful is related to self-regulation of behavior. Indeed, Chen et al. (2005) provide some initial evidence that in situ self-regulatory activities can be beneficial for adaptation. While encouraging, the work by Chen et al. can best be seen as an initial, broad attempt at showing the importance of self-regulatory factors as essential parts of an adaptability process. The purpose of this section is to further this line of thinking and provide a way of tying adaptation as a process more strongly to existing models of self-regulated behavior.

While a number of views and definitions of self-regulation exist (cf. Kanfer, 1990; Vancouver, 2000), one definition that is especially relevant here is provided by Karoly (1993), who suggests that self-regulation can be thought of as processes "that enable an individual to guide his/her goal-directed activities over time and across changing circumstances" (p. 25). One can easily see the parallel that this perspective has with the view of adaptability described above, as both focus on activities or behaviors over time across changing circumstances or task demands. Furthermore, and consistent with the definition of adaptability offered above, the idea of engaging in behaviors in order to perform at a certain level or standard is considered to be possibly the most ubiquitous and central element of theories of self-regulation (Kanfer, 1990; Vancouver, 2000). However, the self-regulation literature has not generally dealt with how people respond to task or environment driven changes in performance-related goals or standards over time, and thus, has not gained a great deal of traction as a conceptual foundation in the adaptive performance literature.

One perspective on self-regulation that may be especially helpful for thinking about adaptability is that based on control theory. Control theory encompasses a number of related perspectives that tie their roots to mechanical control systems and cybernetics in engineering (e.g. Weiner, 1948), and it was brought into psychology in early iterations by works by Miller, Galanter, and Pribram (1960) and Powers (1973). While a number of more modern variations of control theory exist (Hyland, 1988; Klein, 1989; Lord & Levy, 1994; Carver & Scheier, 1981, 1982, 2001), they share many of the same common features stemming from the initial conceptualizations.

A key feature that serves as the foundation for nearly every one of these models is the negative feedback loop (Klein, 1991; Vancouver, 2000). The negative feedback loop dictates that during goal-directed behavior, people are focused on reducing a discrepancy between their current state and the goal or standard that they are trying to achieve. In general, there are three common types of reactions that are considered to happen in response to goal-performance discrepancies (Carver & Scheier, 1981; Kanfer, 1990). The first would be retaining the same goal and increasing one's effort or changing one's strategy, the second would be to lower one's standard and maintain the level of effort exerted or keep the same strategy, and the final would be to abandon the goal altogether, thus ending the self-regulatory cycle. For example, if an employee had a goal to produce one hundred widgets in an hour, but was only currently producing eighty widgets per hour, the discrepancy would be twenty widgets. The person could work harder or change their strategy to produce more widgets, lower the goal to 80 widgets and work just as hard, or simply quit.

More specifically, control theory-based models of self-regulation suggest that there are a series of specific steps one goes through in an attempt to identify and reduce these goal-performance discrepancies. Figure 1 shows a general control theory-based heuristic of self-regulated behavior. In this type of model, behavior is aimed at reaching a goal or desired end-state, which is thought to serve as a driver of behavior (Kanfer, 1990; Locke, 1968; Locke & Latham, 1990; Vancouver, 2000). As mentioned earlier, a comparison function is used to determine the discrepancy between one's current state or level of performance and the goal or desired state. This discrepancy, then, drives action aimed at reducing it. In the case of a discrepancy, plans are developed and behavior consistent with these plans is enacted. This behavior, along with environmental factors and constraints, results in one's actual level of effectiveness. Subsequently, performance feedback, which can come from a variety of sources, serves as the input that allows for the next comparison between current state and desired goal or standard to be made, thus re-initiating the cycle.

While control theory models of motivated behavior have received support, they are not without their detractors (cf. Klein, 1991; Locke, 1991; Vancouver, 2000). However, the use of control theory here is meant as a heuristic to help describe motivated behavior, and as such is merely a surface level description of control theory models of behavior. This discussion is not intended to fully represent more sophisticated and well-developed control theory models aimed at predicting work motivation and behavior

(Klein, 1989) or motivated behavior in general (Carver & Scheier, 1981, 1982, 2001), but rather to use the foundation of control theory as a platform for thinking about adaptive performance in a dynamic, self-regulated manner and organizing measurement and hypothesis generation.

As suggested earlier, the type of dynamic cognitive and behavioral perspective characterized by control theory models is consistent with a process approach to adaptability. From this type of view, adaptation is not just performance effectiveness at a given point in time; it is an ongoing process of assessing the situation and examining the appropriateness of one's actions and levels of performance against a referent standard or goal. However, one issue with relying on control theory in its heuristic form as described above is that control theory considers these goal-directed regulatory activities as something of a closed system, where it is often assumed (at least implicitly) that one's standard is fairly stable left on its own and that the methods or strategies for reaching that standard, once discovered, should continue to remain viable. I believe that thinking about adaptation in this manner demands more of an "open system" perspective, where the situation or task demands can change, thus rendering previously appropriate strategies or levels of effort insufficient. How then, can control theory be used as a referent for thinking about adaptability? It is my assertion that an additional component must be added that allows for goals or standards and the strategies necessary to achieve them to change over time and, thus, incorporates or merges the process perspective of adaptability into control theory as an overarching framework.

Figure 2 shows an attempt to highlight how adaptability can be thought of from a process perspective, using control theory as a foundation. This heuristic is constructed with the intention of providing a provision for goals or targets to change over time, as is the case in situations that require adaptability. While much of the control theory heuristic as described above remains intact, one critical component is added here. The notion of source determination is based on the idea that when goal-performance discrepancies exist, people will attempt to develop explanations and attributions regarding the source of that discrepancy. Some work based in control theory has dealt with this notion of attributions (Carver & Scheier, 1981; Klein, 1989), but they have primarily focused on attributions aimed at factors related to ability, effort, luck, and task difficulty, in line with the work by Weiner and colleagues (Weiner, 1985: Weiner, Russell, & Lerman, 1979). In regard to adaptability, another type of attribution would need to be considered, one that attributes the cause of the discrepancy not to inadequacies in one's existing ability levels, effort levels, or strategies, but rather to an actual change that has occurred in the nature of the task.

A task change is often novel, and cues that the task is changing can come from a variety of different situations. For example, Louis and Sutton (1991) suggest that cues for change can come from situations that are perceived or experienced as being novel or unusual, unexpected discrepancies or failures, or deliberate requests calling for new strategies or procedures. It is my belief that in order to be able to deal with these cues and changes, people need to go through a series of processes in order to determine the source of the task change and what the appropriate behaviors are to adapt to it.

These steps involve first detecting that a change in the task environment has occurred. Following that, a person must gather appropriate information in order to diagnose the nature of the change in the task. Finally, the person must develop appropriate strategies and act in accordance with them in order to perform well on the task. These steps and their associated outcomes are represented in the process model shown in Figure 3 and will be discussed in greater detail in the following sections.

*Detection*

When a discrepancy occurs on a task, people first need to notice the discrepancy and then they need to determine its source. If that discrepancy results from a change in the task environment, I assert that people need to be able to recognize that it is the task itself that is the cause of the change, not their own failings, in order to successfully adapt. Therefore, the first stage in the adaptation process is detection of a given change.

Detection or recognition of a change is fundamental to determining what kind of change occurred and, ultimately, adapting to that change (Ployhart & Bliese, 2006), as these steps cannot proceed without awareness that a change occurred. Consistent with self-regulatory models of motivated behavior, self-monitoring and self-evaluation should be critical processes for detecting a change. Self-monitoring refers to attention that one gives to different aspects of his or her behavior (Kanfer, 1990; Kanfer & Ackerman, 1989). These processes are thought to provide an individual with information about the consequences of his or her actions. Self-evaluation refers to the process by which individuals compare their progress to their desired goal (Kanfer, 1990; Kanfer & Ackerman, 1989). Feedback plays an important role here as well, as it is the information people use to compare against their goal or plan(s). Monitoring and evaluation, then, allow for goal-performance comparisons and are key processes in identifying discrepancies.

However, I believe that the ability to successfully detect changes in a given task is predicated on having basic knowledge of the given task and environment, which has been shown to be related to adaptive performance (Chen et al, 2005; Ford et al, 1998; Kozlowski et al., 2001). The skill acquisition literature discusses a number of different types of knowledge that underlie skilled performance. Two types of knowledge that are relevant here are declarative knowledge and procedural knowledge.

Declarative knowledge is the most basic level of knowledge about a task or skill. It refers to knowledge of different facts, concepts, definitions, instructions, strategies, etc about a given task (Anderson, 1982). This knowledge, however, is tied directly to the task at hand and it is primarily based on surface level characteristics such as exposure, recall, retention, and memorization rather than deep understanding of the structure of the task. Declarative knowledge, however, does not directly deal with rules or processes that direct behavior.

These rules are part of procedural knowledge (Anderson, 1982; 1993). Procedural knowledge is concerned with links between stimulus-response contingencies and forms the basis for performance of a given task. Procedural knowledge accumulates with time and experience on a given task, and as it develops it allows for performance that is quick and highly accurate.

Declarative and procedural knowledge form the basic understanding of how to behave and perform in relation to a given task, without necessarily containing knowledge of why given strategies, rules, or behaviors are appropriate. Since these types of knowledge can be based primarily on memorization and rote repetition, they do not in and of themselves signify a complex understanding of the key elements of the task and their relationships. Because of this, declarative and procedural knowledge on the existing task should allow people to detect, or notice, that task rules, elements, strategies, etc. that change. When routine experts, i.e. people who posses large amounts of declarative and procedural knowledge (Smith et al, 1997), notice goal-performance discrepancies on a well-learned task, their task knowledge should allow them to attribute the discrepancies to external (i.e. task change) rather than internal sources. However, the declarative and procedural knowledge they possess should not provide any means for them to successfully diagnose the nature of the problem since it is not necessarily based on a well-developed understanding of the task.

A simple task, such as using a remote control to turn on a television, can be used as an example. A person with declarative and procedural knowledge of the task knows that when the objective is turn on the television, he or she can pick up the remote control, point it at the television, and hit the power button, which should result in the television turning on. However, a number of changes could occur such as a dead battery, a new remote control with a different configuration, or something in the way of the television that blocks the signal. Each of these would cause a problem and the end result would be a goal-performance discrepancy in which the television does not turn on. In any case, the person should detect a change and realize that since the previously successful strategy no longer works, something must be wrong and it should be attributed to the task or the environment itself. Therefore, a change is detected, and the person now needs to figure out what exactly has changed and how to adapt to that change. The ability to detect this change, however, is built upon both a foundation of declarative/procedural task knowledge as well as active self-monitoring and self-evaluation that allows that knowledge to be applied.

*Diagnosis*

Diagnosis is the second step in the process of adaptation. Briefly, diagnosis can be defined as ascertaining the cause or nature of change in the given task. Whereas detection deals primarily with answering the question of whether or not a change occurred, diagnosis deals with understanding why and how that change occurred. Diagnosis in this manner is an active, controlled cognitive process (e.g. Ackerman, 1992; Louis, & Sutton, 1991; Schneider & Chein, 2003). When tasks (or components of tasks) do not provide high levels of consistency in terms of the stimuli that occur and/or the appropriate responses, as is the case when elements of a task change, upon detecting the change and attributing it to the task people should need to engage in conscious, effortful processing in order to determine the nature of the change. The process of diagnosis should focus on just this, with the primary initial goal of developing or acquiring additional declarative and procedural knowledge about the novel task that is being faced, which can then be used to understand the nature of the change.

Research on active learning and training provides a bit of a parallel for thinking about how people responding to change may go about learning and understanding the elements of a novel task. In the training literature, active learning approaches give people control over their own learning and skill development (Bell & Kozlowski, 2008; Salas & Cannon-Bowers, 2001) by using techniques such as exploratory learning (Frese et al., 1988; McDaniel & Schlager, 1990) where people are not provided with structured training and instead are encouraged to explore, experiment, and even make errors in order to learn from them (e.g. Frese & Altmann, 1989; Ivancic & Hesketh, 2000; Keith & Frese, 2005). These techniques have been shown to lead to higher levels of knowledge gain and training performance (Frese et al., 1988), as well as adaptability (Ivancic & Hesketh, 2000; Keith & Frese, 2005). Because training interventions do not exist during adaptation, it is likely the case that people who are trying to adapt go about learning about the novel task in a similar manner, by exploring and trying to gain knowledge about the parts of the task that have changed.

However, one large difference exists when trying to adapt to a change as opposed to learning or being trained to do a completely novel task. As the definition of adaptability provided above states, the process of adaptation involves using *existing* knowledge and skills to help in a novel, but not completely new, task. One approach that may be particular useful for understanding how previous knowledge and skill may aid in learning about the key elements of a novel task in an adaptive situation is provided by Lovett and Schunn (1999). In discussing how base-rate and cue-predictiveness information can be used to make decisions, Lovett and Schunn provide a discussion of how people use previous experience and knowledge in a task domain to help learn about, understand, and represent a task. Essentially, a task representation here refers to the features of a given task or problem that people learn and use to gather and filter information to understand the task as a whole. These features include things such as key definitions, information, and contingencies that influence appropriate strategies, decisions, or behaviors. Lovett and Schunn (1999) argue that an individual's existing knowledge regarding the task is used to help define what features of the task are most important or influential and how new information about the task is attended to, gathered, and organized to build understanding of the task itself. Thus, well-developed existing task knowledge can be used to organize and direct the acquisition additional information, which can then be used to diagnose the nature of a task change.

Work on recognition-primed decision making (Klein, 1993) also discusses how previous knowledge and experience can guide processes related to learning about and assessing a task change. Briefly, this work suggests that experts use their knowledge and experience as foundations for consciously assessing a situation in order to understand the goals that can be accomplished and narrow in on information that is potentially useful for understanding the task, problem, or decision at hand.

Going back to the example of the turning on the television with a remote control, in order to diagnose the nature of the change, the person would have to examine and explore the elements of the task (television, remote, environment, etc.) and try to gain additional knowledge about things that may have changed and how they changed. For example, it may be the case that the person has a new television and the remote functions differently. Using existing knowledge, the person may be able to guide their search for information to find a manual and quickly learn new facts, definitions, and so forth regarding the television and remote control and how they operate. This additional knowledge, then, could provide the basis for future strategic and behavioral change. However, as Lovett and Schunn (1999) point out, this would serve primarily as a knowledge base and, therefore, would not necessarily provide direct prescriptions for behavior. While this new task knowledge in and of itself is crucial, the process through which that knowledge is applied in a given situation and used to direct action is vital, and it is the core of strategic and behavioral adaptation.

*Adaptation*

As suggested earlier, adaptation, or adaptive performance, can be thought of as the ability to use existing knowledge and skill to appropriately and functionally align behavior with task and/or environment changes in a way that improves, maintains, or limits decrements in performance effectiveness. One key to understanding the process of adaptation is recognizing that the change that must be adapted to creates a task that contains elements of novelty. By definition, a person performing on a task with novel elements does not have a working pre-existing strategic contingency associated with the task. Therefore, a potentially successful strategy must somehow be created, discovered, or modified from an existing strategy. This process of identifying and implementing a strategy is at the heart of the process of adaptation. Going back to the control theory heuristic presented earlier in Figure 2 and the Campbell and colleagues distinction between performance and effectiveness (Campbell, 1990; Campbell et al. 1993), this final step determines the behavioral output, or performance, of the individual, which in turn influences the effectiveness of adaptability.

While research on adaptability has focused on numerous antecedents to effective adaptive performance such as individual differences, training techniques, and leader behaviors, as well as on the importance of knowledge generalization in training (Kraiger et al., 1993), little work has been done attempting to explicate the processes involved in creating new strategies. Ployhart and Bliese (2006) do briefly touch on the importance of proper strategy selection and implementation, but do little to describe how experience and/or knowledge can influence this process. However, literature related to creativity, problem solving, and decision making provides some insight into how people use their knowledge and experience to devise and select strategies for novel tasks.

Lovett and Schunn (1999) discuss the impact of previous knowledge and experience on strategy development, selection, and implementation. Briefly, they suggest that a person's prior knowledge and experience with a given task will serve as a constraint for the type of strategies that they can develop. Domain relevant knowledge and skills are thought to compose the complete set of response patterns or strategies that an individual currently possesses. These strategies form the foundation or basis from which new strategies or plans can be synthesized or generated when a novel task is encountered. Some of the strategies or pathways to success will be more or less common, well practiced, or more or less obvious than others and, thus, more available to the individual. Furthermore, prior experience with similar tasks can help guide strategy selection and implementation, as some base rate information regarding success may already be present.

A similar perspective is proposed in the creativity literature, in which a strategy or behavior is considered to be creative to the extent that it is both novel and appropriate for the task at hand (Amabile, 1983). One of the major aspects of creativity according to Amabile is the ability of a person to break free from traditional strategies or ways of thinking about a given task. This can take a number of forms. For example, breaking cognitive set (Newell, Shaw, & Simon, 1962) involves abandoning sets of old strategies that are no longer successful, and breaking out of existing performance scripts (Schank & Abelson, 1977) involves actively examining and, potentially, abandoning explicit sets of steps for performing tasks (e.g. scripts or algorithms). The ability to successfully engage in these types of behaviors, then, is predicated on the level of understanding one has regarding the current task and its similarities and differences when compared to tasks where the individual has previous experience.

Work on recognition-primed decision making (Klein, 1993) also provides thoughts on linking existing task knowledge and skill with the ability to systematically create, implement, and evaluate strategies. As described earlier, this approach suggests that experts use their knowledge and experience to help assess and understand a new task situation. Klein (1993) also suggests that existing knowledge and experience can be used to form expectations and identify potential actions and strategies. Experience provides the means for categorizing types of situations, and therefore guides strategy selection and implementation based on the success of strategies used in similar situations.

Returning to the running example, knowledge gained in the diagnosis stage and the person's previous experience with similar tasks can help guide strategy formulation and implementation aimed at using the remote control to turn on the new television. In this case, it may be that the television has to be taken off standby power before being turned on. Information gained from reading the manual, or previous experience with other items of technology with similar features could help lead the person to the appropriate strategy. The enacted strategy and resulting behavior are then fed back into the control cycle, which should lead to successful performance and removal of the existing goal-performance discrepancy, or trigger another cycle of detection, diagnosis, and adaptation should the discrepancy still exist.

## Adaptability to Different Types of Task Change

The steps in the adaptability process discussed above are meant to generalize across the different types of task change that people may face. However, it may be the case that these steps take on different levels of importance for different types of task change. Much of the empirical work conducted on adaptability or adaptive performance, though, has taken something of a "catch-all" approach to manipulating task change and operationalizing adaptive performance. For example, many of the studies using computer simulation tasks (i.e. Bell & Kozlowski, 2008; Chen et al, 2005; Ford et al, 1998; Kozlowski et al., 2001) manipulated change in similar ways, by including multiple changes such as additional targets or task elements, changes in task sequencing or prioritization rules, and/or longer performance trials. While these types of operationalizations are useful as a starting point, they are likely insufficient for work aimed at understand what people are actually doing to adapt to different types of changes or how individual difference characteristics influence adaptability to different types of changes.

One initial approach to categorizing different types of change has been put forth by Pulakos and colleagues (Pulakos et al, 2000; 2002). Recall that Pulakos et al. (2000) focused on constructing a taxonomy of different types of adaptive performance. Pulakos et al. (2000; 2000) described eight dimensions of adaptive performance: (1) solving problems creatively, (2) Dealing with uncertain or unpredictable work situations, (3) learning new tasks, technologies, and procedures, (4) demonstrating interpersonal adaptability, (5) demonstrating cultural adaptability, (6) demonstrating physically oriented adaptability, (7) handling work stress, and (8) handling emergency situations.

This taxonomy serves as a foundation for theoretical work by Ployhart & Bliese (2006) focusing on adaptability as a set of individual differences. Briefly, Ployhart & Bliese suggest that individual differences related to cognitive ability, personality, interests, and physical ability differentially predict adaptive performance based on the type of task change one is facing.

While the work by Pulakos and colleagues (Pulakos et al, 2000; 2002) and Ployhart and Bliese (2006) is certainly valuable, it focuses primarily on different types of tasks that people have to respond to change in rather than the underlying structure of the task and what parts of a given task are actually changing. This approach is something of a "between task approach", which is useful for differentiating among large classes of tasks. This type of approach, though, does little in helping to understand how people actually respond to different types of task change.

An alternative approach that focuses on breaking down the elements of a given task and classifying change based upon them should be more useful to this end, as it could potentially serve as a foundation for determining cognitive and motivational processes related to adaptation and how they may differ when different parts or elements of the task change. This would be more of a "within task approach", focused on what parts of a given task are actually changing over time. This type of approach would not conflict with the existing framework provide by Pulakos et al. (2000), but instead could be used to further understand how people go about responding the different types of change identified therein and what individual differences should be predictive of these different types of change.

One categorization of task elements that could be useful in examining tasks from this type of perspective is that proposed by Wood (1986). Wood (1986) provides an approach to viewing tasks that focuses primarily on the behaviors required for performing them. This type of viewpoint helps to isolate task characteristics from other factors such as person characteristics, motivation, and environmental constraints that can also be related to one's ability to perform tasks and adapt to task changes. From a theoretical standpoint, this is desirable as it helps to more clearly separate different tasks from one another and articulate the different types of changes in a given task itself that necessitate adaptation.

According to Wood's (1986) framework, tasks can be broken down into three core components that are thought to describe their basic form and structure. These core components can be used to describe the parameters of a given task as long as the task includes some sort of behavioral act(s) and has a readily identifiable product.

*Products* can be thought of as the observed and measurable results of acts (Wood, 1986). Products are the results of given behaviors and can be observed and measured independently of the given behaviors. The product of an act is the actual effectiveness, and would be the comparison point used for determining goal-performance discrepancies. In order to break a task down into its core components, Wood suggests that the product of a given task must first be identified. Once specified and described, the attributes of a task such as quantity, quality, timeliness, etc. provide the basis for identifying the other core components of the task.

The second core component of a task, according to Wood (1986), is the required set of behavioral acts. *Acts* can be thought of as the behavioral responses a person should engage in during a given task in order to achieve the specified level and type of performance effectiveness suggested by the product of the task. While behaviors can be broken down into many different levels (neural level, individual movement, etc.), a behavioral act in this framework is best thought of as a "pattern of behaviors with some identifiable purpose or direction" (Wood, 1986, p. 5). The purpose is usually identifiable as an entire behavior such as "lifting a box", "scanning an item", or "printing a document".

The final core component of tasks according to the Wood (1986) framework is the informational cue. *Informational cues* are bits of information about the characteristics of a task stimulus that an individual can use to make decisions and judgments during performance on the given task. It is important to note that not all stimuli received during task engagement can be classified as informational cues. Informational cues are only those stimuli that can be used make discriminations between different potential behaviors or courses of action.

In order to understand adaptability, it is essential to understand the nature of task(s) being performed. The Wood (1986) task framework as described above can be very useful in this pursuit. From a theoretical perspective, identification of the outcomes, behavioral acts, and informational cues that define the given task environment provide the foundation for understanding not only the task(s) at hand, but it also helps to understand and make sense of any potential changes that can happen in the task that will necessitate adaptation. As suggested earlier, task change may take on different forms based what parts of the task are actually changing. Understanding the products, behavioral acts, and informational cues that make up the task, then, provides a starting point for determining and classifying types of change.

To assess the type of change in the task, a framework for utilizing these task elements to interpret and organize the types of change is needed. Wood (1986) provides a starting point in this pursuit by using these elements to identify a number of different types of task complexity, which should help to describe some different types of task change and, subsequently, the type of adaptation they demand. Task complexity describes the relationships between task inputs (behavioral acts and information cues) and outputs (products or effectiveness), and it is suggested to be "an important determinant of human performance through the demands it places on the knowledge, skills, and resources of individual task performers" (Wood, 1986, p. 66). I assert that changes to task characteristics related to different types of complexity should be directly related to differences in the adaptation process required by those changes. Wood (1986) discusses these types of changes in his description of *dynamic complexity*, which occurs when the cause and effect relationships between different components of the task change over time. It is the other two types of complexity Wood discusses, however, which may be especially useful for categorizing types of task change.

The first of these is referred to as *component complexity*. Tasks with high levels of component complexity have a large number of distinct acts to perform and information cues to process. Thus, the higher the number of distinct acts that need to be performed and information cues that need to be processed, the higher the component complexity of the given task. Increases or changes in component complexity necessitate that people learn how to complete new acts or properly process new cues in striving for the same product or type/level of performance effectiveness. One example of component complexity task changes are seen in work by Keith & Frese (2005) who required students to perform tasks in a computer program that they had not previously completed.

*Coordinative complexity* refers to the types of relationships between different aspects of the task and the timing or order they need to be performed in. Wood (1986) suggests that the ordering and sequencing of acts in terms of timing, frequency, and location requirements form one type of component complexity. In this sense, more complex tasks likely have longer sequences of tasks with higher levels of importance regarding proper ordering or structuring of specific behavioral acts. Another type of coordinative complexity has to do with the form and strength of relationships between different types of informational cues, related behavioral acts, and related products. When examining the form of the relationship between task inputs and products, tasks become more complex as the degree of linearity changes. For example, tasks with direct linear relationships between intensity or frequency of a behavioral act and performance have low levels of coordinative complexity. On the other hand, tasks that require optimal levels of a given behavioral act and/or coordination among different acts with different optimal levels are more complex, as they require people to discover exactly what the optimal levels of frequency or intensity for a given act are. Changes in coordinative complexity, then, would result in having to learn different sequences or configurations of behaviors to reach the same product or outcome. Examples of this type of change in the existing adaptability literature can be seen in Chen et al. (2005), whose operationalization of adaptability required participants to use routes with steps that needed to be correctly ordered (e.g. more "waypoints") in order to properly execute the task and Kozlowski et al. (2001) who included changes in task scoring rules related to certain behavioral acts.

While the two dimensions of complexity above are useful for thinking about types of task change, one other important task factor that Wood (1986) does not explicitly address is task difficulty. While increases in component or coordinative complexity can certainly make a task more "difficult" or harder to perform well on, difficulty here can be thought of as the total number of behavioral acts that one has to engage in to complete the task, as well as the amount of time that one has to complete these acts. Changes in difficulty in this sense can operate completely independently from component and coordinative complexity changes. For example, one could have a task with low sequencing requirements and relatively few distinct acts, but the person may be required to complete many of the same acts in a short period of time. While not addressed in the Wood (1986) framework, the notion of task difficulty changes as drivers of the need to adapt is supported by numerous studies that include responses to task difficulty changes in their operationalizations of adaptive performance (e.g. Bell & Kozlowski, 2008; Chen et al, 2005; Ford et al, 1998; Kieth & Frese, 2005; Kozlowski et al., 2001).

Considering the types of change discussed above results in a three factor framework based primarily on the distinct task elements described by Wood (1986). While Wood's discussion of task complexity also serves as a foundation for identifying types of change, it is certainly not complete; adding a task difficulty factor helps extend and clarify the framework while remaining consistent with previous empirical work and operationalizations of adaptive performance. These three factors certainly do not represent every type of change that one could face, or the possible combinations of multiple types of change in a given task. However, this type of simple framework can serve as a first step in helping to gain additional understanding regarding how people adapt to different types of task change, and that is one of the key foci of this study.

Based upon the previous discussion of the three-step adaptability process of detection, diagnosis, and adaptation, Figure 4 presents a model of different "pathways" to adaptation based on the different types of change identified above. Briefly, this model attempts to lay out the proposed importance of cognitive and motivational factors in influencing detection, diagnosis, and adaptation to difficulty, coordinative, and component task changes. It is important to note that the aim of this study is not to validate this process model of adaptation. The steps of detection, diagnosis, and adaptation here are used primarily as a heuristic for thinking about adaptation as a process and organizing the measurement of cognitive and motivational factors as predictors of adaptive performance effectiveness. Generally, this heuristic suggests that one needs to detect that a change in the task has occurred, gather and leverage relevant knowledge about the change in order to figure out what has changed, and then devise and implement appropriate strategies in order to perform effectively. This type of mediating model is roughly analogous to much of the existing research on adaptability, which primarily shares a conceptual frame whereby individual differences (e.g. personality, cognitive ability) influence mediating processes of some sort (e.g. goals, task knowledge/expertise) which in turn influence how people perform in response to change (Ployhart & Bliese, 2006). However, this model is not as interested in individual difference factors (although they will be touched on later) and its primary focus is on in situ mediating processes such as new knowledge development and strategy development/selection, which have received little attention in the adaptability literature other than a general investigation by Chen et al. (2005).

This model suggests that what is relevant or appropriate in terms of knowledge to acquire and strategies to implement may vary substantially from one type of change to another. This is one place where the breaking down tasks into their component parts and classifying different types of change based upon them provides value. Even though the process of adapting is generally the same for different types of change, the things that people need to focus on are vastly different. This suggests that there are different pathways to success for each type of change based on the knowledge and strategies necessary for adaptation.

For task *difficulty* changes, the pathway to success should be primarily motivational. As stated earlier, a change in task difficulty involves an increased number of behavioral acts that one has to engage in or a decreased amount of time that one has to complete the same number of acts. Detection of this type of change should be primarily driven by monitoring goal-performance discrepancies and noticing that performance is no longer appropriate. Upon detection of a change, diagnosis via additional relevant knowledge acquisition should be limited to learning about the increase in the number of required behavioral acts. Furthermore, strategy development and selection, which is primarily a cognitive process, should be limited to ascertaining that one needs to apply existing knowledge, skills, and strategies in a more efficient or speedy manner. Therefore, someone who is proficient in the task to begin with, and thus has knowledge and skill that can be adapted, should be able to continue to use their existing knowledge and skill as the foundation for their behavior. However, to be successful this person will need to work harder and exert additional effort to complete the additional behavioral acts required by the change in task difficulty. Thus, adaptability to difficulty changes should be most influenced by task effort, and the primary pathway to success should be motivational in nature.

For *component* task changes, the pathway to success should be both motivational and cognitive. A component change involves additional distinct information cues that need to be processed and/or additional distinct acts that need to be performed. Detection of this type of change, like detection of a difficulty change, should be primarily driven by monitoring goal-performance discrepancies and noticing that performance is no longer appropriate. Diagnosis, however, should be more cognitively demanding, as an individual will need to learn new information about the task to allow him or her to properly interpret the new informational cues or learn about the new acts that need to be engaged in. However, barring corresponding coordinative changes, strategy development and selection should not be overly cognitively taxing. Once new appropriate knowledge about cues and acts is developed, the individual should be able to "plug it in" to his or her existing strategy, as many of the contingencies, rules, etc. that were learned should still apply. The key, however, is the use of newly understood cues and acts within these strategies. Of course, task effort should be important here as well, as it should be a direct determinant of adaptive performance once knowledge of the new cues and acts is integrated and ready to be applied.

For *coordinative* task changes, the pathway to success should be both cognitive and motivational, with cognitive processes being the dominant factor. A coordinative change involves new sequencing of behavioral acts in terms of timing, frequency, and location and/or different forms of relationships between informational cues and related acts and products. As with the other types of change, detection should be driven by monitoring goal-performance discrepancies. Similar to component change, diagnosis of a coordinative change should be cognitively demanding, as the person will have to learn about the new rules or contingencies that govern the relationships between information cues and associated behavioral acts. However, strategy development and selection should be more cognitively demanding here than for difficulty or component changes, as one must be able to successfully implement their new knowledge in order to allocate his or her attentional resources and make correct sequencing and prioritization decisions regarding cues and acts on the task at hand. This is a more inferential process than what should be necessary for a component change, and it should be more cognitively complex and demanding. Once again, task effort itself should be important here, but its primary effect should be on strategy implementation and it should only lead to higher levels of adaptive performance effectiveness if the correct strategy is in place.

Based on this discussion of the different pathways to success for different types of task change as well as the general structure of the adaptation process outlined previously, a number of hypotheses can be developed. These hypotheses will focus on the importance of outcomes related to in situ processes of detection, diagnosis, and adaptation as predictors of adaptive performance effectiveness and they will be presented in a proximal to distal fashion, with each set of variables intended to mediate the effects of the more distal predictors.

The process of adaptation, as discussed above, primarily deals with using existing knowledge and skill to help develop, select, and implement appropriate task strategies.

While little work has focused on the importance of in situ strategy development, selection, and implementation on adaptive performance, Chen et al. (2005) provide some evidence that general goal striving was related to higher levels of adaptive performance on a radar simulation task that combined elements of difficulty, component, and coordinative change. Goal striving there was a factor that included both effort and cognitive strategy components, and therefore has some parallel to the notion of appropriate strategies here. Based on this, and the discussion above, Hypothesis 1 suggests that appropriate strategy change, a result of processes related to adaptation, should positively predict adaptive performance effectiveness.

More specifically, condition specific sub-hypotheses can be generated based upon the previous discussion regarding the importance of motivational and cognitive pathways to success in adapting to different types of task change. For task difficulty changes the pathway to success should be primarily motivational, and the appropriate strategy should be to exert additional effort using what is already known about the task. However, while still predictive, task effort alone should less directly predict success in adaptation to component and coordinative task changes, as knowledge acquisition and strategy development/use is more cognitively demanding in both. For component changes, appropriate cognitive strategy use should involve incorporating new knowledge and skill into existing strategies. Coordinative task changes should require the highest cognitive load in terms of strategy selection, development, and appropriate use. In response to this type of task change, appropriate cognitive strategy use should involve using newly learned task rules and contingencies to make correct sequencing and prioritization decisions regarding cues and acts on the given task.

*Hypothesis 1a: Task related effort will be most strongly positively related to adaptive performance when people are facing changes in task difficulty.*

*Hypothesis 1b: When facing a component task change, the correct use of new information cues and/or acts will positively predict adaptive performance.*

*Hypothesis 1c: When facing a coordinative task change, the correct sequencing and prioritization of behavioral acts will positively predict adaptive performance.*

Processes related to diagnosis primarily focus on ascertaining the cause or nature of change in the given task. It is suggested above that this is primarily done through the use of previous task knowledge and experience to guide the additional development and acquisition of task knowledge relevant to the novel aspects of the changed task. Work on skill acquisition (e.g. Anderson, 1982; Kanfer & Ackerman, 1989) firmly focuses on the importance of declarative and procedural task knowledge as foundations for the development of task skill. Similarly, numerous studies on adaptability from the training/outcome perspective have focused on the importance of task knowledge before change as a predictor of adaptive performance (Chen et al., 2005; Ford et al., 1998; Ivancic & Hesketh, 2000; Keith & Frese, 2005; Kozlowski et al., 2001). However, none of these studies have focused on the role of new, appropriate knowledge development during the process of adaptation as a predictor of adaptive performance.

In concordance with the discussion above on the importance of in situ diagnosis-related knowledge development for identifying and implementing proper strategies, and ultimately adaptive performance effectiveness, Hypothesis 2 suggests that task appropriate in situ declarative knowledge development should positively predict appropriate strategy selection and implementation. More specifically, for a task difficulty change, gaining knowledge regarding the increased or changed number of behavioral acts that one has to engage in to perform well should directly influence the amount of effort that one exerts in trying to perform. For a component task change, gaining knowledge and understanding of new information cues or necessary acts should form the foundation for appropriately incorporating the new knowledge and skills into existing task strategies. Finally, for a coordinative task change, knowledge gained regarding changes in task rules or contingencies should provide the foundation for the proper strategy development and execution in terms of correctly prioritizing and sequencing behaviors.

*Hypothesis 2a: When facing a task difficulty change, declarative knowledge development regarding increases in the number of required behavioral acts should positively predict task related effort.*

*Hypothesis 2b: When facing a component task change, declarative knowledge development regarding new information cues or necessary acts should positively predict the correct strategic use of new information cues and/or acts.*

*Hypothesis 2c: When facing a coordinative task change, declarative knowledge development regarding changes in task rules and contingencies should positively predict the correct sequencing and prioritization of behavioral acts.*

The process of detection is primarily focused on noticing goal-performance discrepancies and attributing those discrepancies to a change in the task at hand. Detection is thought to be a fundamental process to adaptation (Ployhart & Bliese, 2006) as it is not possible to learn about a change and eventually adapt one's strategies appropriately if there is no knowledge that a change in the task occurred. To this point, the empirical literature on adaptability has not focused on examining change detection as an important part of adaptability. While research such as that done by LePine et al. (2000) has focused on how well people perform on tasks with unforeseen change that necessitate adaptability, detection of the change itself has not been a variable of interest. In this study, I intend to investigate the importance of change detection as a predictor of adaptive performance effectiveness through its effects on processes related to diagnosis and adaptation. Hypothesis 3 suggests that change detection will positively predict appropriate declarative knowledge development for the given type of task change.

*Hypothesis 3a: When facing a task difficulty change, change detection will positively predict declarative knowledge development regarding increases in the number of required behavioral acts.*

*Hypothesis 3b: When facing a component task change, change detection will positively predict declarative knowledge development regarding new information cues or necessary acts.*

*Hypothesis 3c: When facing a coordinative task change, change detection will positively predict declarative knowledge development regarding changes in task rules and contingencies.*

## Metacognition and Adaptive Performance

While the model of adaptation discussed previously was seated within control theory as a guiding heuristic, the hypotheses developed to this point deal directly with factors related to how well people are able to engage in self-regulatory processes related to critical factors such as monitoring goal-performance discrepancies and evaluating the effectiveness of given strategies. These types of factors, though, are considered to be critical for successful goal-directed behavior (Kanfer, 1990). However, past research has found that adults often fail to monitor their thinking and behavior or to use their knowledge and experience to direct future behavior toward successfully accomplish their goals (Garner & Alexander, 1989; Osman and Hannafin, 1992). Because this study is predicated on thinking about adaptability as a self-regulated process, I believe that it is essential for factors related to self-regulatory ability or skill to be examined.

One type of self-regulatory factor that has received attention in adaptability literature is metacognition. Metacognition deals explicitly with strategy development, implementation, monitoring, and revision and can be loosely defined as the knowledge about one's own cognitions and the monitoring and regulation of behavior based upon it (Flavell, 1979; Brown, 1987). More specifically, metacognitive control processes are thought to deal with the in situ regulation how well one is making plans, monitoring performance effectiveness, and evaluating the success of one's plans or strategies (Schraw & Moshman, 1995; Winne, 1995; 1996).

Metacognition is a set of active processes that deal with the regulation and control of one's behavior or thinking (Ertmer & Newby; 1996). From a motivational perspective, one can think of these processes as a central determinant of the direction of behavior. These processes are suggested to be important to both learning and performance in this respect (Reeve & Brown, 1985), and these effects likely carry over to influence adaptability as well (Ford et al., 1998; Bell & Kozlowksi, 2008). There are three primary dimensions of metacognitive control processes; they are commonly referred to as planning, monitoring, and evaluating (Brown, Bransford, Ferrara, & Campione, 1983; Ertmer & Newby, 1996).

*Planning* refers to strategic behaviors that are engaged in before actual task performance behaviors begin. Ertmer and Newby (1996) identify three major tasks that are essential to the planning process. The first is setting or accepting a goal. This goal can come in the form of a self-set goal based on knowledge of the task at hand and what is required for successful performance or in the form of an outside goal set by and external stakeholder (e.g. supervisor, manager, etc.). Once an individual has a goal or target in mind, his or her focus should shift toward identifying possible strategies for accomplishing that goal. This decision is thought to be based primarily on the declarative knowledge possessed regarding task demands as well as past experience dealing with how well their currently available strategies could match the demands of the task at hand. The final step in the planning process involves identifying potential obstacles that may stand in the way of successfully achieving one's goal. This involves forethought in that one must rely on previous experience or mental simulations to try to identify the types of problems that may occur and how to deal with them.

*Monitoring* is the second dimension of metacognitive control and is suggested by Schraw and Moshman (1995, p. 355) to be "one's on-line awareness of comprehension and task performance." The process deals primarily with the identification of possible discrepancies between current levels of performance and targeted levels as specified by plans and goals. Like planning, there are three major steps or parts of the monitoring process that people who are metacognitively active engage in while performing on a given task. The first of step involves actively monitoring performance in order to observe exactly what actions are being performed and how these actions are translating into task performance effectiveness. The second step is the comparison of current progress to desired progress. This is akin to looking for goal-performance discrepancies and helps to determine the utility of one's current strategy. If all is going well, the strategy should be seen as appropriate and the individual can simply continue to monitor his or her behavior. However, if a discrepancy is found the person will have to revert to a pre-formed contingency strategy should it exist, or reformulate plans in order to increase performing successfully. This re-planning is the third major step involved in monitoring and is somewhat different from that involved in the planning stage in that it occurs in real time while the performer is working on the task. It is also different in that the performer now has more information to work with and may be better able to formulate strategies based upon it.

*Evaluating* is the final dimension of metacognitive control, and it happens at the conclusion of the goal striving process. This step involves assessing the strategies and behaviors employed to attain one's goals and the product achieved (Ertmer & Newby, 1996), how successful they were, and why they were or were not successful. This process of reflection, then, is thought to be a key factor in helping people to learn from their experiences and influence future planning and strategy selection for similar tasks.

Metacognition has been shown to be positively related to numerous outcomes related to learning, classroom performance, and problem solving. The primary theme driving these studies is that individuals with greater metacognitive skills should be able to learn or acquire skills well because they can quickly identify the problems they are having and remedy them by implementing or devising different, more appropriate strategies. For example, Pintrich and DeGroot (1990) found that high levels of metacognition were correlated with higher GPA as well as with better performance on a number of different aspects of classroom achievement such as exam performance and proficiency in writing class reports. Landine and Stewart (1998) also found that high levels of metacognition were positively related to GPA in high school students. In a similar vein, Minnaert and Janssen (1999) found that college students with higher levels of metacognition were more academically successful than were those who exhibited low levels of metacognition.

For the most part, these types of studies have focused on broad or general learning objectives, where there is likely a large amount of background knowledge and classroom structure. The relationship between metacognition and learning, problem solving, or task performance may become more variable as the task becomes more complex or more novel, such as that which would be faced in an environment that requires adaptability. Self-regulation theory grounded in a resource allocation perspective (e.g. Kanfer and Ackerman, 1989) might suggest that regulatory activities early in adaptation may be harmful because attention could be better spent on learning the basics of the new task. However, I believe that enough existing knowledge of the task, or similar tasks, would exist to buffer this type of effect. Furthermore, without engaging in processes related to metacognition or self-regulation, people may not be able to detect that a change has occurred in the first place. This is similar to thoughts by Earley, Connolly, and Ekegren (1989), who suggest that in learning a new task, high initial task demands might inhibit the effectiveness of strategy search and selection. It is likely, then, that people with high levels of metacognitive skill may be better able to perform well initially even when task learning demands are high. I would argue that adaptive situations where the task changes somewhat, but not completely, pose a similar type and level of novelty. Therefore, the strategic benefits of using metacognition may help guide attention and result in more targeted and adaptive strategy selection, thus influencing adaptive performance. This is consistent with suggestions by Schmidt and Ford (2003) that metacognition should be especially useful in situations that contain little external structure or guidance. Indeed, a number of studies have investigated the effects of metacognition in these types of situations.

While not strictly focusing on adaptability, Clause, Delbridge, Schmitt, Chan, & Jennings (2001) examined the influence of metacognitive control processes on the ability of people applying for entry-level law enforcement positions to apply knowledge regarding departmental procedures to a number of different simulated situations. Clause et al. (2001) found that higher levels of metacognitive control during test preparation lead to higher levels of effort, the use of more complex learning strategies, and through them higher test performance.

As described earlier, Ford et al. (1998) examined the impact of metacognition on task knowledge, skills, affect, and adaptive performance/training transfer. Ford et al. found that levels of metacognition during training were positively related to transfer performance through their effects on task knowledge and skill development as well as levels of self-efficacy.

In a similar vein, Bell and Kozlowski (2008) examined the impact of various types of active learning techniques on knowledge and skill development as well as analogical and adaptive transfer. While their study focused on numerous cognitive, motivational, and emotional mediating variables and processes, one key finding was that levels of metacognition during active learning directly lead to higher levels of self-evaluation, intrinsic motivation, and self-efficacy, which in turn had positive effects on task knowledge development as well as analogical and adaptive transfer performance.

Taken together, these studies provide evidence for the general efficacy of metacognition for influencing learning, problem solving, and task skill development. Furthermore, the latter set of studies support the viewpoint of Earley et al. (1989) that high levels of metacognitive or self-regulatory processes can benefit performance in novel or difficult learning or problem solving situations and extend findings to show that metacognitive activity during training can influence adaptability through the development of task knowledge, skill, and self-efficacy. Because of these types of findings, and the general findings proposed earlier that adults often do not engage in these types of metacognitive activities on their own accord, it comes as no surprise that people have focused on conducting interventions aimed at training people to more successfully use metacognitive skills related to planning, monitoring, and evaluating one's strategies and behavior.

In the educational psychology literature there is a history of developing metacognitive interventions with the primary purpose of examining their effectiveness on learning and knowledge development. While not explicitly tested, it is also thought that the techniques taught to individuals to help them regulate their learning can be transferred to and successfully used on other tasks as well (Reeve & Brown, 1985). As Reeve and Brown (1985, p. 345) state, "...the aim [of metacognitive training] is the generalization of skills." Unfortunately, researchers in educational psychology have not addressed the ability of interventions to lead to strategies that generalize across of a number of tasks, although many studies focusing on interventions have found promising results for their given tasks.

These interventions have taken a number of different forms. In a set of studies examining a reciprocal teaching technique, Brown and Palincsar (Brown & Palincsar, 1982; 1985; Palincsar & Brown, 1984) encouraged the students and teachers to alternate in presenting passages and leading dialogue in order to get the student to engage self-review, self-questioning, and clarifying processes, all of which were thought of as metacognitive control processes. Their results showed students using these techniques exhibited large gains on both classroom and standardized tests of reading comprehension.

King and colleagues (King, 1989; King, 1990; King 1991a; King, 1992; King & Rosenshine, 1993) had students utilize generic question stems such as "How are ... and ... similar" or "How does ... affect ..." to generate questions during learning that would help them to monitor their comprehension as well as to integrate and recall previous knowledge more successfully. These questioning strategies lead to greater increases in understanding and reading comprehension across academic levels ranging from grade 5 to college.

Berardi-Coletta, Buyer, Dominowski, & Rellinger (1995) asked participants questions aimed directly at assessing strategy use and monitoring during performance on simple problem solving tasks. These questions such as "how do you know that this is a good move?" were thought to focus participants on monitoring their success and planning for upcoming behavior, and those who received them showed higher levels of problem solving performance.

In a related study, King (1991b) required students to ask similar questions of themselves and partners throughout learning pertaining to the metacognitive control processes of planning (e.g. "what is our plan"), monitoring (e.g. "are we on the right track"), and evaluating (e.g. "what would we do differently next time"). Students using these questions outperformed students asking self-generated questions or students who asked no questions of each other on tests of written problem solving ability and the ability to solve a problem on a novel task.

Delclos and Harrington (1991) used a similar questioning technique, but paired it with task and problem solving training. The self-questions that students used were similar to those used by King (1991b) and aimed at helping them monitor their performance at different stages of task completion. As expected, students engaging in self-questioning were able to solve more difficult problems correctly than students who received task training only or task and problem solving training.

While the study of metacognitive interventions primarily began in educational psychology using relatively simple learning or problem-solving tasks, recent work in Industrial/Organizational psychology has also shown some support for the efficacy of these types of interventions using somewhat more complex and organizationally relevant tasks.

Schmidt and Ford (2003) conducted a study in which they examined the impact of metacognitive interventions on a number of different learning and performance outcomes using a self-guided webpage construction training task. Schmidt and Ford's metacognitive training intervention consisted of three parts that were aimed at increasing elements of metacognitive control. The first utilized self-questioning strategies and generic question stems similar to those used by King and colleagues (King, 1989; King, 1990; King 1991a; King, 1992; King & Rosenshine, 1993), the second instructed individuals to delay self-questioning briefly after studying so that judgments of progress were more accurate (e.g. Nelson & Dunlosky, 1991), and the third part involved prompting trainees every 10 minutes throughout training to assess their current levels of learning and understanding. Schmidt and Ford's (2003) results showed that metacognitive training interacted with individuals' performance-avoidance goal orientations (e.g. Elliot & Church, 1997; VandeWalle, 1997) to impact metacognitive activity. More specifically, individuals not afraid of demonstrating incompetence were more receptive of the metacognitive intervention. Metacognitive activity, then, was related to higher levels of declarative knowledge regarding the webpage design task and higher levels of performance on the webpage building task, although no direct effect of the metacognitive intervention was found.

As a whole, this work shows that metacognitive interventions hold promise for influencing metacognitive monitoring, learning, and skill acquisition. However, the tasks used along with these interventions were primarily in the vein of classroom learning and training. Based on work by Ford et al. (1998) and Bell and Kozlowski (2008), one would expect that these interventions may also be useful in organizational settings, as they show the efficacy of metacognitive activity there. Furthermore, Smith et al. (1997) tout the potential of metacognitive training for influencing levels of adaptive expertise and helping to aid in skill generalization across tasks. However, to this point only one study has focused on examining the effects of a metacognitive intervention during training on adaptive performance.

Keith and Frese (2005) examined the effects of a metacognition training intervention combined with an error-based training intervention for predicting analogical and adaptive transfer on an overhead slide creation task. The metacognitive intervention used by Keith and Frese primarily involved self-questioning of the same nature used by King (1991b) and Schmidt and Ford (2003). Briefly, their results suggested that analogical transfer was the same for groups receiving (a) error avoidant training, (b) error management training, and (c) error management training coupled with a metacognitive intervention. For adaptive transfer, both error management training groups outperformed the error avoidant training group, but they did not differ from each other. However, Keith and Frese suggested that error management training itself spurs metacognitive activity, and showed that the effects of error avoidant vs. error management training on adaptive transfer were mediated by metacognitive activity engaged in during training.

Together, the work by Ford et al. (1998), Bell and Kozlowski (2008), and Keith and Frese (2005) provide some evidence for the importance of metacognitive activity in predicting factors related to adaptive performance as well as adaptive performance itself. While this work in encouraging, it is far from comprehensive, especially when viewing adaptability as a process or series of behavioral and cognitive events rather than just performance at one point in time.

From this point of view, it makes sense to consider metacognitive activity during adaptation, rather than just during training. Research and theory regarding metacognitive interventions and their influence on transfer (e.g. Ivancic & Hesketh, 2000; Keith & Frese, 2005) primarily rely on the transfer appropriate processing principle (Schmidt & Bjork, 1992), which suggests that activities desired during transfer should be practiced and engaged in during training. Because of this, it is argued that the effects of metacognitive training should reach forward and influence metacognitive activity during transfer or adaptive performance. While this may be the case, none of the studies examining metacognition and adaptability have actually looked at metacognitive activity during adaptive performance, presumably because of the static view of adaptive performance that primarily focuses on effectiveness.

Unlike task knowledge and skill, though, metacognitive skills are general in nature and are not restricted to a certain type of task. Therefore, it is reasonable that one could prompt the use of these skills during the process of adaptation rather than simply hoping or positing that they carry over from a training environment. This type of prompting would be much less hands on and resource intensive than continuous task training, and it should also be more robust in reaction to various types of task change as the focus is on monitoring and evaluating the success of strategies and overall performance regardless of the underlying content domain or type of change.

It is not difficult to see how metacognition could influence each step of the adaptability process as described earlier. The key processes involved in detection of a

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task change are evaluating goal-performance discrepancies and being able to attribute newly existing discrepancies to changes in the task. A person who is metacognitively active by definition is monitoring his or her task environment and looking for these types of goal-performance discrepancies, and thus should be more likely to detect them than someone who is not. Diagnosis deals with attempting to understand the nature of the change, and a key part of it should be using existing knowledge and experience to guide knowledge development and acquisition regarding the novel elements of the task at hand. Metacognitive planning processes primarily deal with using task knowledge to form plans for upcoming goal behavior. While the actual strategy and plan development involved in metacognitive planning falls more within the realm of the adaptation process as discussed here, people who are metacognitively active and trying to form plans should realize that the understanding that they have of the task is not sufficient and should then shift focus on acquiring additional information, knowledge, and understanding to help diagnose the nature of the change so that these plans can be made. Finally, the adaptation part of the process, which deals with the development, selection, and execution of plans should be directly influenced by metacognitive activity related to planning, monitoring, and evaluation, which should serve to help gauge strategic success and inform future strategy development should one's goal of high levels of adaptive performance not be initially reached. This type of cyclical process, of course, ties back to the larger, more general, control theory model of self-regulated behavior discussed earlier and should help in understanding the potential broad ranging positive effects of metacognition during adaptation.

This discussion argues for the potential efficacy of a metacognitive intervention that focuses on getting people to actively engage in planning, monitoring, and evaluating activities during adaptation. In fact, based on this discussion and the existing empirical evidence showing the efficacy of metacognition during training as predictor of adaptive performance (e.g. Bell & Kozlowski, 2008; Ford et al., 1998; Keith & Frese, 2005), as well as the effectiveness of metacognitive interventions on promoting metacognitive activity, learning, and problem solving performance (e.g. Berardi-Coletta et al.1995, Brown & Palincsar, 1982; 1985; King, 1989; King, 1990; King 1991a; King, 1991b; King, 1992; King & Rosenshine, 1993, Palincsar & Brown, 1984; Schmidt & Ford, 2003), I expect that a metacognitive intervention conducted during adaptation will lead to higher levels of adaptive performance effectiveness.

However, in consideration of the different types of task change discussed previously and the motivational and cognitive demands of each, I think that this type of general hypothesis regarding the effectiveness of an in situ metacognitive intervention can be made more specific. Specifically, I believe that the overall load or importance of cognitive factors in adapting to each type of change should be directly related to how large of an influence a metacognitive intervention will have on adaptation to that type of change.

For each type of change, detection of a task change is absolutely essential, as one cannot adapt to a change that they don't know is occurring. Therefore, monitoring the task environment for changes and comparing current vs. desired performance is important for each type of change, and a metacognitive intervention should positively influence this process.

However, for task difficulty changes, as suggested earlier, the pathway to success should be primarily motivational. Once someone detects a task difficulty change, the only additional information they need to learn is that there are more acts that need to be completed (or a lesser amount of time to complete the acts). The strategy that follows should be very basic and straightforward: work harder. This is what Wood & Locke (1990) refer to as a "Stored Universal Plan", and they argue that they are so common and familiar to people that they are essentially "built into goals" and, thus, serve to direct goal-directed behavior. Because of the common nature of this type of strategy, people should easily have access to it and, therefore, much of the influence that metacognition could have on knowledge acquisition, strategy development, and evaluation may be minimized.

For component task changes, processes related to diagnosis (i.e. acquiring declarative knowledge) should take on higher importance once a task change is detected. The correct plan should be to gain and leverage appropriate declarative knowledge about the necessary new information cues and/or behavioral acts. This should require additional regulation and cognitive effort, as one must not only determine what knowledge is appropriate, but he or she must also regulate and monitor new knowledge acquisition. Once knowledge is acquired, however, the cognitive load associated with implementing and leveraging that knowledge (i.e. adaptation) should be fairly low. As suggested earlier, people may be able to plug that new knowledge in to an existing strategy of sorts. Therefore, along with monitoring process that should drive the detection of goal-performance discrepancies, processes related to engaging in and monitoring proper knowledge acquisition should make metacognition more important for adapting to component task changes than task difficulty changes.

Finally, for coordinative task changes, it was suggested earlier that each step of the adaptation process should be cognitively demanding, and therefore a metacognitive intervention may have its largest effect adaptive performance effectiveness in response to this type of change. Like the process for adapting to a component task change, both detection and diagnosis-related processes should be quite cognitively complex and taxing. However, processes related to strategy development and implementation should carry the highest level of cognitive demand here, as one must successfully leverage newly acquired task knowledge or experience into a new strategy that properly sequences and prioritizes how information cues are interpreted and behavior acts are engaged in. In line with this discussion, the following hypothesis is offered:

*Hypothesis 4: A metacognitive intervention conducted during the adaptation process will have the largest positive effect on adaptive performance effectiveness in response to coordinative task changes and the lowest positive effect on adaptive performance effectiveness in response to task difficulty changes.*

Consistent with this rationale, this study will test for mediation of the effects of the metacognition intervention on adaptive performance effectiveness. As suggested above, the pathways to success when moving from difficulty to component to coordinative task changes should become increasingly cognitive loaded, with detection being the primary cognitive process of importance for difficulty task changes; detection and diagnosis being primary cognitive processes of importance for component task changes, and detection; and detection, diagnosis, and adaptation being primary cognitive processes of importance for coordinative task changes. If this is the case, one would expect that the primary cognitive processes of importance, given uniform or constant levels of motivation, should mediate the relationship between the metacognitive intervention and adaptive performance effectiveness. Based on this, the following hypotheses are offered:

*Hypothesis 5a: For difficulty changes, change detection will fully mediate the relationship between metacognitive training and adaptive performance.*

*Hypothesis 5b: For component complexity changes, change detection and relevant knowledge gain will fully mediate the relationship between metacognitive training and adaptive performance.*

*Hypothesis 5c: For coordinative complexity changes, change detection, relevant knowledge gain, and proper strategy use will fully mediate the relationship between metacognitive training and adaptive performance.*

## Individual Differences and Adaptive Performance

While I earlier eschewed the individual differences or selection perspective to adaptability, instead proposing a model and hypotheses that strongly focus on adaptability from a process perspective, this does not mean that individual differences in cognitive ability, personality, values, interests, and the like cannot function as useful predictors of adaptability. While I strongly maintain my earlier assertion that adaptability is best thought of as a set of cognitive and behavioral processes, I believe that it is also important to attempt to understand different individual difference factors that can influence processes related to detection, diagnosis, adaptation, and adaptive performance effectiveness. However, LePine et al. (2000) argue that because the behavioral requirements underlying performance in changing contexts have not been given appropriate attention, one can expect ambiguity in research findings regarding predictors of adaptability. Viewing adaptability from a process perspective, then, may help us to comprehend some of these necessary behaviors and provide an elegant and effective way to understand why certain individual differences influence adaptability and how their effectiveness may differ across different types of task change. This would be consistent with Ployhart & Bliese's (2006) notion that individual difference factors have differential weightings in predicting different types of adaptive performance, although clearly they are dealing with different types of adaptive performance (i.e. Pualkos et al., 2000) rather than task change and believe that adaptability resides within these individual differences.

The upcoming section focuses on describing and reviewing existing empirical work that has focused on individual difference predictors of adaptability. From this, and based on work above that focuses on adaptability from a process perspective, a number of hypotheses regarding how key individual differences related to cognitive ability, goal orientation, and personality differentially influence adaptability to different types of task change will be proposed and investigated as a starting point for trying to understand some of these effects. The factors reviewed here are in no way intended to represent the entire domain of possible individuals that can influence adaptive performance. Rather, the intent is to try to understand why individual differences examined in past work influence adaptability and suggest why their effects may actually differ across different types of task change.

One individual difference that has received considerable attention in work on adaptability is cognitive ability. General cognitive ability, often referred to as *g*, can be thought of as an individual difference related to one's information processing ability, reasoning ability, and capability to learn (Carrol, 1993; Hunter, 1986; LePine et al, 2000). Cognitive ability is thought to be the best predictor of training performance or effectiveness (Schmidt & Hunter, 1998) and has also been shown to predict job performance across a large number of different jobs and contexts, with these effects being more pronounced for tasks or jobs that are more complex or novel than in tasks can be considered routine (Hunter & Hunter, 1984). Cognitive ability has also discussed as a predictor of one's ability to adapt existing knowledge and experience to novel tasks (Pulakos et al., 2002; Snow & Lohman, 1984). In this vein, it is suggested that people with higher levels of *g* should be able to use their experiences more effectively to gain knowledge and influence future behavior and performance.

In line with these findings and beliefs, a handful of studies have focused on examining the effects of cognitive ability on adaptive performance. As mentioned earlier, LePine et al. (2000) examined the impact of general cognitive ability on decision-making accuracy during an initial block of trials and during two subsequent blocks of trials where decision-making rules changed. Based on the notion that participants faced higher information processing demands when the decision making rules changed, they hypothesized that the relationships between *g* and decision making performance would be more pronounced during the blocks of trials where these rules changed. In line with this, they found that cognitive ability was indeed a better positive predictor of decision-making accuracy when people had to adapt to changes in decision making rules. Similarly, Pulakos et al. (2002) found that cognitive ability was positively related to supervisor ratings of adaptive performance, and Kozlowski et al. (2001) found that cognitive ability was positively related to declarative knowledge levels acquired during training, which in turn influenced adaptive performance both directly and through its effects on training skill and knowledge structure development.

With this discussion in mind, I believe that the importance of cognitive ability as a predictor of adaptive performance may vary across the different types of task change suggested earlier. Considering LePine et al.'s (2000) rationale that cognitive ability should be more strongly related to performance in situations with higher cognitive or information processing demands, it makes sense to argue that as one goes from task difficulty changes, to component task changes, to coordinative task changes, the cognitive complexity of the change and requisite information processing demands increase. This leads to the following hypothesis:

*Hypothesis 6: Cognitive ability will differentially predict adaptive performance effectiveness in response to different types of task change.*

Another individual difference that has received attention in adaptability research is goal orientation, specifically learning or mastery goal orientation. In general, goal orientation can be thought of as the type of goals an individual tends to pursue across achievement situations. People with a learning or mastery goal orientation tend to focus on goals that deal with learning and competence development (e.g., Dweck, 1986; Dweck & Leggett, 1988). Also, they are thought to be adaptive in response to situations that are challenging or novel, as they gravitate toward and excel in these types of situations and are resilient and persistent in the face of challenge (Kozlowski et al., 2001). Furthermore, they espouse the belief that ability is malleable and that effort directed toward a task leads to improvements in related outcomes (Ames, 1992; Dweck, 1986). Recent meta-analytic evidence show that across a number of studies, learning orientation was positively related to effective use of learning strategies, feedback seeking behavior, and job performance (Payne, Youngcourt, & Beubien, 2007).

Learning orientation in the adaptability literature has usually been examined as a predictor of various training outcomes, which in turn are thought to influence adaptive performance. For example, Ford et al. (1998), Kozlwoski et al. (2001), and Bell and Kozlowksi (2008) all provide evidence that those with a learning goal orientation have higher levels of self-efficacy at the end of training, and that self-efficacy reaches forward to influence adaptive performance. Furthermore, both Ford et al. (1998) and Bell and Kozlowski (2008) show that learning orientation positively influences metacognitive activity, which in turn positively influences task knowledge (and in the case of Ford et al., task skill and self-efficacy). This task knowledge, then, positively predicts adaptive performance. While these findings do show the importance of considering learning goal orientation during training, researchers have not considered the impact it may have during processes related to adaptation.

If people with a learning orientation truly gravitate toward and excel in challenging or novel situations, believe that they can work to improve their abilities, and focus on learning and competence development, it would make sense that they would adapt to task changes better than those without a learning orientation. This may be especially true in regard to task changes that require new knowledge and strategy development, as people with a learning orientation should enjoy and embrace these challenges and persist in trying to develop competence on the newly novel elements of a given task. If changes are primarily motivational in nature, such as task difficulty changes, these sorts of competency and learning-based challenges likely don't exist, and one may not expect learning orientation to positively relate to adaptability. Based on this, the following hypothesis is offered:

*Hypothesis 7: Learning orientation will differentially predict adaptive performance effectiveness in response to different types of task change.*

Personality factors have also received attention as potential predictors of adaptive performance. In general, the exploration of these factors has been limited to "Big-5" factors of conscientiousness and openness to experience (e.g. Costa & McCrae, 1992). While somewhat limited in scope in terms of the personality factors examined, this type of research in important in that it keeps up with the field of personality research in I/O psychology which has "moved beyond the search for significant correlations between Big Five dimensions and general measures of job performance and is focused on understanding in greater depth the nature of personality and job performance, and how they are linked" (Johnson, 2003, p. 84-85).

A person who is conscientious is said to be self-disciplined, organized, reliable, planful, responsible, systematic, and persevering, among other things (Costa & McCrae, 1992). Researchers propose that conscientiousness is comprised of two key elements, one that is based on responsibility or dependability and another that centers around volition (Barrick & Mount, 1991; Costa & McCrae, 1992). Characteristics such as responsible, diligent, organized, careful, reliable, dependable, and many more (Costa & McCrae, 1992) clearly highlight the role of responsibility. On the other hand, characteristics such as persevering and hard working reflect the aspect of will or volition. There is a history of meta-analytic research on conscientiousness that links it to a number of desirable work outcomes such as job performance (Barrick & Mount, 1991); goal-setting, self-efficacy, and expectancy motivation (Judge & Ilies, 2002); motivation to learn (Colquitt & Simmering, 1998); and goal commitment (Gellatly, 1996). While this type of research is interesting in that it highlights the potentially positive benefits of having employees who are high on conscientiousness, there is still not much known with regard to how conscientiousness may influence performance in rapidly changing environments.

One study that directly examined the effects of conscientiousness on adaptive performance was conducted by LePine et al. (2000). Due to the high levels of commitment, motivation, and perseverance associated with high conscientiousness, LePine et hypothesized that conscientiousness would be a be a better predictor of decision making accuracy on a task once the rules change in an unforeseen manner than before. Their results, however, ran counter to this expectation and showed that high levels of conscientiousness were negatively related to decision making accuracy after a change in decision rules. LePine et al. (2000) attributed this finding to the fact that, when broken apart, high levels on the dependability or responsibility aspects of conscientiousness were negatively related to adaptive performance on their task. However, scores on the volitional or achievement facets were not significantly related to adaptive performance in either direction.

It is important to note here, however, that the type of task LePine et al. (2000) used to examine adaptive performance essentially involved a coordinative complexity change. Decision rules were changed in a manner that was not obvious to participants, and it was up to them to discover the new rules and make correct decisions based upon them. This type of change, as described above, should be quite cognitively taxing and even though people with high levels of conscientiousness should be committed and motivated to perform well on a task, the change may be too much for them deal with if they rely on motivation alone. However, it may be the case that this type of commitment and motivation is ideally suited for promoting high levels of adaptive performance for other types of task change. Recall that adaptation to task difficulty changes is posited to primarily occur through a motivation pathway in which extra effort and perseverance are likely to lead to higher levels of adaptive performance, as proper strategy selection is based on working harder and faster to apply existing knowledge and skills. With this in mind, and based on prior arguments, as one goes from task difficulty changes, to component task changes, to coordinative task changes, and the cognitive complexity of the change and requisite information processing demands increase while the direct motivational impacts decrease, conscientiousness may become less strongly positively related to, or even negatively related to adaptive performance. This leads to the following hypothesis:

*Hypothesis 8: Conscientiousness will differentially predict adaptive performance effectiveness in response to different types of task change.*

A second personality factor that has received attention as a predictor of adaptive performance, also primarily by LePine et al. (2000), is openness to experience. Openness to experience involves traits such as being broad-minded, curious, imaginative, and original (Barrick & Mount, 1991; Costa & McCrae, 1992). People with high levels of openness to experience are thought to be very intellectually curious, fond of finding new ways of doing things, and interested in seeking out novel experiences (LePine et al., 2000). Furthermore, open individual have been found to engage in higher levels of self-monitoring (Blickle, 1996; Busato, Prins, Elshout, & Hamaker, 1999), which is suggested to be important for detecting change, monitoring performance, and learning when task elements change (LePine et al., 2000). Although openness has not generally been found to have direct relationships with job performance across a wide variety of jobs (Barrick & Mount, 1991), findings that those high in openness perform better in training contexts (Barrick & Mount, 1991) indicate that openness may be important for both knowledge and skill acquisition in training, and potentially for new knowledge acquisition and strategy development when task parameters change.

Using this type of rationale, LePine et al. (2000) investigated the effects of openness to experience on decision making task. They hypothesized that because those high in openness to experience tend to be more creative and receptive to change (Costa &

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McCrae, 1992; King, Walker, & Broyles, 1996), openness to experience would be more positively related to decision making performance after an unforeseen change in the task context than before. Indeed, their results suggested that this was the case, with people high in openness making more accurate decisions after task decision rule changes than those low in openness. While not explicitly examining adaptive performance, a study by Thoresen, Bradley, Bliese, & Thoreson (2004) found similar results in that openness to experiences was positively related to job performance level and growth for salespeople during job transitional periods, which were discussed as situations where methods and strategies were undefined and employees had to potentially learn new skills (Murphy, 1989; Thoreson et al., 2004). .

If the mechanism for openness to influence adaptive performance truly involves embracing novel experience, intellectual curiosity, and the development of new and novel task strategies, then it may be the case the openness best predicts adaptive performance effectiveness on task changes that require a great deal of strategy manipulation and reformulation. Recall that LePine et al.'s (2000) task primarily involves coordinative task changes, where decision rules are manipulated without notifying participants. In this case, the "cognitive playfulness" of those with high openness to experience may help them not only to discover, but also to embrace and react to changes in decision rules, thereby spurring them to develop new strategies and eventually adapt more successfully to task change. In situations where adaptive performance effectiveness is more motivationally driven, however, this playfulness or curiosity may not have a chance to manifest itself, and high levels of openness to experience may not necessarily predict adaptive performance effectiveness. Based on this, the following hypothesis is offered:

*Hypothesis 9: Openness to experience will differentially predict adaptive performance effectiveness in response to different types of task change.*

## Method

### *Participants*

The participants for this study were 378 Michigan State University undergraduate students recruited via the MSU Psychology student subject pool. Due to study piloting, incomplete data, and technical problems, the final sample included 283 participants, with a range of 43 to 50 participants per condition. Participants in the analyzed data ranged from 18 to 30 years of age ($M = 19.6$ years) and were 54.8 % female. Participants were volunteers and their participation was contingent upon informed consent (see Appendix B for consent form). Each participant received course credit commensurate with the length of his or her participation in the study.

### *Design*

The foundation of the study is a 2 x 3 between subjects design in which both the type of task change being faced (difficulty change, component change, or coordinative change) and the provision of a metacognitive intervention were orthogonally manipulated. In practice, this design operated much like three separate studies, as mean comparisons across the difficulty change conditions were not of primary interest. Participants were randomly assigned to conditions on the basis of the experimental sessions that they attended.

### *Task*

A version of the PC-based radar tracking simulation program TANDEM (Dwyer, Hall, Volpe, Cannon-Bowers, & Salas, 1992) was used for the study. TANDEM serves as a decision-making task in which participants must generally defend a geographic area by gathering information about a number of different targets and using that information to make engagement decisions regarding whether or not to attack each target. More speci

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specifically, participants saw an emulated radar station console in which multiple targets could initially be seen. Once the simulation started, participants selected specific targets and gathered information cues regarding three different characteristics of each target: Type, class, and intent. Using decision rules that could be acquired throughout the training period, participants then used the information cues to classify each target based on its type, class, and intent and finally decided whether to engage (i.e. shoot down) or clear each target from the screen depending on the given classification. Participants received points toward their overall score based on the success of these engagements decisions, as well as other factors such as target prioritization, which will be discussed in further detail below.

*Procedure*

Upon registering for the experiment, participants gave informed consent and completed an online questionnaire that included measures of demographic information, ACT/SAT scores, learning goal orientation, and personality. Participation in the experiment was contingent on completing this questionnaire. Once the questionnaire was completed, participants were able to sign up and attend an experimental session.

When participants arrived at their scheduled session, they first received an initial introduction to the TANDEM task. They were informed that they would progress through twelve three-minute trials in which their goal was to do their best to perform well on the task. Each task trial was preceded by a two-minute period in which the individuals could study an online task manual that contained requisite declarative knowledge. Also, each task trial was followed by a two-minute period where participants had an opportunity to view feedback on numerous aspects of their performance and effectiveness for the preceding trial.

After the first six trials (i.e. practice or training trials), the metacognition and task change interventions were implemented for participants in the appropriate conditions. Participants then completed a set of six adaptation trials in which their instructions for the task were generally the same and the structure of the trials (i.e. view manual, perform on the simulation, view feedback) was the same. Because change detection is a critical part of the theoretical model for this study, participants were not informed that a task change would occur. Rather, it was entirely up to them to discover this change and take appropriate actions (i.e. study the manual, practice, view feedback) to adapt to the changes.

It should also be noted that the task manual and feedback were changed at this time to include new elements and information relevant to each of the different types of task change that participants *could* face (i.e. difficulty, component, or coordinative). Although direct comparison between conditions was not a primary concern of this study, and therefore this was not strictly essential for the study design, this was done to more closely resemble actual situations where multiple sources and stores of knowledge exist that people can attempt to tap into in order to adapt to task change. If only the requisite information for adapting to the given type of task change exists, the implications of successful metacognition and self-regulation as well as the importance of processes related to diagnosis and strategy adaptation may be minimized. However, when multiple types of new information exist that can be discovered, learned, and leveraged into action, the processes of proper change diagnosis and strategic adaptation, as well as the implication of proper metacognition, likely take on a much more important, and realistic, role.

Upon completion of the sixth and final adaptation trial, participants completed a questionnaire that contained the task change detection probes, the declarative knowledge quiz, and the metacognitive intervention manipulation check items. Following completion of the questionnaire, participants were debriefed (see Appendix C for debriefing form) and thanked for their participation in the study.

*Manipulations*

*Task change type.* As described earlier, the task change manipulation focused on three different types of task change with the goal of orthogonally manipulating each between-subjects. The first type of task change is *task difficulty*, which can be thought of as the total number of behavioral acts that one has to engage in to complete a task in a given amount of time. Recall that Wood (1986) discusses behavioral acts as patterns of behavior with a particular purpose in mind such as "lifting a box" or "printing a document". In TANDEM, the primary behavioral act is "prosecuting a target", which deals with collecting information about targets and making decisions about their class, type, and intent as well as whether or not to destroy them. To increase task difficulty in TANDEM, then, one must increase the number of required behavioral acts, which can be done most elegantly by simply increasing the number of targets that participants need to prosecute. The task difficulty change manipulation in this study focused on doing exactly that, by increasing the number of targets in the adaptation trials by 50% (from 12 to 18).

The second type of change, *component task change*, is rooted in Wood's (1986) notion of component task complexity, which can be thought of as number of *distinct* acts and information cues that need to be dealt with in a particular task. To increase component complexity for a given task, then, one would need to increase the number distinct acts and/or cues that people need to engage in or process during the performance of a task. For TANDEM, this increase could involve a number of different things. The manipulation chosen here, however, focused specifically on new information cues that individuals must process in order to correctly prosecute targets. Specifically, this manipulation involved adding new informational cues that need to be used to help ascertain the type, class, and intent of each target. Upon implementation of the manipulation, these cues were completely unique and novel to participants, and thus signified a change in component task complexity. The old information cues remained, however, but they were given values that were "out of range" and did not conform to the decision rules used to make class, type, and intent decisions, therefore rendering them useless.

The final type of task change, *coordinative task change*, is based up on Wood's (1986) definition of coordinative complexity. As stated earlier, coordinative complexity refers to the types of relationships between different aspects of the task and the timing or order they need to be performed in. Based upon this, changes in coordinative complexity required individuals to learn different sequences or configurations of behavioral acts to reach the same levels of performance. Given that prosecuting a target constitutes the primary behavioral act in TANDEM, a coordinative task change must involve altering the sequence or configuration of prosecuting targets in some way. In this study, the importance or "threat level" of each target was the same during the training periods. Thus, the ordering or sequence of prosecuting targets took on no real importance for determining one's level of performance effectiveness. However, altering this level of importance or threat for different targets should give higher levels of priority to certain targets, and thus necessitate that they take precedent. In this study, the importance or "threat level", and thus the sequencing of target prosecution decisions, was altered in two ways. First of all, a defensive perimeter was activated in the task that imposed a penalty each time a target crossed it. Thus, targets closing in on the defensive perimeter took higher precedent than others, as they harmed performance by taking away points from one's overall score if they crossed the defensive perimeter. Secondly, some of targets were changed from normal targets to "pop-up" targets. These targets did not initially appear on the radar screen, but instead they "popped-up" close to the defensive perimeter sometime during the trial. These targets should take immediate precedent over other targets, as they moved toward the defensive perimeter immediately once they appeared on the screen.

As stated earlier, these three manipulations were intended to be orthogonal. For the task difficulty change, additional targets were added, but they involved only task cues and behavioral acts that are already learned and did not impose additional sequencing requirement, as they all carried the same level of importance. For the component task change, the number of targets was kept constant, but novel informational cues needed to be used to correctly prosecute the targets. This type of change also had no impact on how behavioral acts are sequenced, as each target retained the same level of priority or threat. Finally, for the coordinative task change, new sequencing requirements were imposed by activating a defensive perimeter and changing some targets from the standard to the pop-up variety. However, both the overall number of required behavioral acts or targets and the informational cues needed to correctly prosecute the targets remained the same.

*Metacognition intervention.* The metacognitive intervention was designed to help participants successfully use metacognitive control processes to regulate and control their behavior and cognition during adaptation; it contained two parts. The first part of the intervention (Appendix D), which was conducted prior to adaptation trials 1 and 4, involved providing the participants with a brief overview of the important aspects of metacognition and informing them of the potential usefulness of making plans, monitoring their levels of knowledge and understanding, and evaluating the success of the different strategies they may use while going through the web-page training program. This was designed to aid participants in forming an accurate representation of the potential usefulness of metacognitive control strategies

The second part of the intervention, which was conducted prior to adaptation trials 2, 3, 5, and 6, involved having participants respond to a set of four open-ended probe questions related to whether or not they were engaging in activities related to using prior experience to make plans for upcoming learning and performance, monitoring current levels of understanding and performance, and evaluating the success of previously used strategies (see Appendix E for probes). The questions were similar in nature to those found to be successful as drivers of metacognitive activity in previous research (e.g. King, 1991b; Delclos and Harrington, 1991; Schraw, 1998). In addition, these questions were presented after participants had an opportunity to review task-related feedback for each trial, not directly after individuals performed the task. This approach is consistent with past work that shows that delaying self-questioning can lead to more accurate assessments of current levels of understanding and performance than self-questioning done immediately after covering new information (Nelson & Dunlosky, 1991), and this should be especially true in this case given that participants had the opportunity to view veridical, descriptive feedback regarding their previous performance prior to responding to these questions.

*Measures*

*Control variables.* Participants were asked to provide demographic information related to their gender. Also, computer and video game experience was assessed using a single item, "How often do you play video games", with responses given on a 5-point scale ranging from "never" to "very frequently".

*Cognitive ability.* Cognitive ability was assessed via self-reports of participants' ACT or SAT college admission test scores. Twenty-one participants in the analyzed data did not provide usable ACT or SAT scores, and in these cases mean substitution was utilized. College admission test scores are generally considered to be valid indicators of general cognitive ability (Schmidt, 1988; Schmidt & Ford, 2003). Furthermore, research has shown that self-reports of test scores tend to correlate very strongly with actual test scores (Gully, Payne, Kiechel, & Whiteman, 1999).

*Learning orientation.* Participants completed a five-item scale of trait learning orientation adapted from VandeWalle (1997). Appendix F lists these items. The responses to these items were made using a 5-point scale ranging from "strongly disagree" to "strongly agree".

*Conscientiousness and openness to experience.* Conscientiousness and openness to experience were measured with scales from NEO-PI-R personality inventory (Costa &

McCrae, 1992). Each scale included forty-eight items that are thought to capture the dimension as a whole as well as sub-facets underlying each dimension. Appendices G and H list the conscientiousness and openness to experience items, respectively. The responses to these items were made using a 5-point scale ranging from "strongly disagree" to "strongly agree".

*Detection.* Change detection was assessed by a self-report measure. Participants in all conditions responded to a question aimed at ascertaining if a change in the task was detected (i.e. "Did you notice a change in the TANDEM task you were working on?"). This measure served as the primary measures of detection, and it was administered at the conclusion of the study to avoid priming participants to look for task change.

*Declarative task knowledge development.* Relevant declarative task knowledge development was suggested earlier to be a key outcome of processes related to diagnosis. General declarative task knowledge development was assessed by a 16-item multiple-choice quiz administered at the conclusion of the study (see Appendix I for items).

The relevance of task knowledge was thought to vary based on the type of task change that each participant faced. For difficulty task changes, relevant declarative knowledge development was operationalized as knowledge regarding the number of targets that were in the simulation during the adaptation trials, and was assessed by one multiple-choice item. For component task changes, relevant declarative knowledge development was operationalized as knowledge regarding the values of the new informational cues that they encountered as well as how to make class, type, and intent decisions based upon them, and it was assessed by three multiple-choice items. Finally, for coordinative task changes, relevant declarative knowledge development was operationalized as knowledge regarding correct target prioritization such as where the defensive perimeter was, changes in scoring rules or target threat levels based on defensive perimeter crossings, and what pop-up targets were. This was be assessed by four multiple-choice items.

*Appropriate strategy use.* As described above, the appropriate strategies for adaptive performance were suggested to vary based upon the type of task change that people faced. For task difficulty changes, the appropriate strategy was thought to be primarily motivational or effort-based and should focus on engaging in the highest number of behavioral acts possible. Thus, for difficulty changes, appropriate strategy use (i.e. increased task effort) was operationalized as the overall number of targets that participants prosecuted. For component and coordinative task changes, effort was also thought to be important, but appropriate cognitive strategies are thought to take on higher levels of importance. When participants faced a component task change, they had a number of new information cues to learn about and master in order to make correct type, class, and intent decisions. Thus, appropriate strategy use for component task changes was operationalized as the number of correct class, type, and intent decisions that were made. When participants faced a coordinative task change, it was though that they would need to learn about the importance and meaning of the defensive perimeter and how it influenced target prioritization. Thus, appropriate strategy use for coordinative task changes involved sequences of behavioral acts (i.e. target prosecutions) and was operationalized as the number of high priority and pop-up targets that were engaged, as these targets represent the highest levels of threat at any given point in time. The measures of each of these operationalizations were taken directly from the simulation for performance during the final adaptation trial.

*Adaptive performance effectiveness*. In all cases, performance effectiveness was assessed using performance composite scores generated by the TANDEM simulation. These scores were based on correct target prosecution as well as defensive perimeter intrusions when applicable. For the practice trials, each participant's overall score was a function of receiving 100 points for every correct target prosecution, whereby all four of the decisions for the target (i.e. type, class, intent, and final engagement) were made correctly, and losing 100 points for every incorrect target prosecution, whereby one or more of the decisions for the target was incorrect. This same scoring scheme applied for the adaptability trials in the difficulty and component task change conditions. For the coordinative task change condition, the activation of the inner defensive perimeter had implications for scoring. Participants still received 100 points for each correct target prosecution and lost 100 points for each incorrect target prosecution. However, participants also lost 100 points for each target that crossed the defensive perimeter without being prosecuted. The measure of adaptive performance effectiveness used for necessary hypothesis tests was taken from the final adaptation trial for each condition.

*Metacognition intervention manipulation check*. After the final adaptation trial, all participants were asked to respond to a series of four questions regarding whether or not they were instructed to focus on metacognitive activities related to planning, monitoring, and evaluating throughout the adaptation trials. Appendix J lists these items. The responses to these items were made using a 5-point scale ranging from "strongly disagree" to "strongly agree".

## Results

Means, standard deviations, intercorrelations, and alpha reliabilities (on diagonal when applicable) for the variables of interest across the entire sample are shown in Table 1. Similarly, Means, standard deviations, and intercorrelations within task change condition for difficulty, component, and coordinative task changes are reported in Tables 2, 3, and 4, respectively.

### *Control Variables*

Gender, computer experience, and practice performance effectiveness (taken from trial 6) were used as control variables for tests of each of the hypotheses. Furthermore, task effort (number of targets engaged) was included as a control variable for tests of hypotheses 1b and 1c.

### *Analysis Plan*

There are three primary types of hypotheses in this study: (1) direct effect hypotheses, (2) interaction or moderation hypotheses, and (3) mediation hypotheses. A description of how each of these types of hypotheses was examined, as well as the specific hypotheses that fall into each category, is provided below.

The direct effect hypotheses in this study primarily deal with the influence of different parts of the proposed adaptation process on one another (i.e. detection, diagnosis, adaptation). For example, hypothesis 1b suggests that when facing a component task change, the correct use of new information cues and/or acts should positively predict adaptive performance. Other hypotheses of this type include hypotheses 1c, 2a, 2b, 2c, 3a, 3b, and 3c. Because these direct effect hypotheses are concerned with linear relationships between two variables, a separate hierarchical linear regression analysis was conducted to test each of these whereby the dependent variable of interest was regressed onto the control variables at step one and the independent variable of interest at step two. For each test, the given null hypothesis was rejected if the unstandardized regression coefficient was statistically significant at $\alpha = .05$, one-tailed.

The interaction or moderation hypotheses in this study deal with the multiplicative or interactive effects of two independent variables on a given dependent variable. Hypotheses 1a, 4, 6, 7, 8, and 9 all fall into this category, and were tested using similar approaches. For each of these hypotheses, a separate hierarchical linear regression analysis was conducted whereby the dependent variable of interest was regressed onto the control variables at step one, the independent variables of interest at step two (which were centered when possible), and the interaction terms (product of the independent variable and moderator variables) at step three. Task change type, which effectively served as the moderator in each of these hypotheses, was dummy coded into two variables with the first indexing differences between the difficulty and component change conditions and the second indexing differences between the difficulty and coordinative change conditions. For each test, the given null hypothesis was rejected if the $\Delta R^2$ from step two to step three is statistically significant at $\alpha = .05$, two-tailed. For any significant interactions, the slope differences depending on task change type were examined in accordance with procedures outlined by Aiken and West (1991).

The mediation hypotheses, in this case hypotheses 5a, 5b, and 5c, were tested using procedures outlined and discussed by James and Brett (1984) and Baron and Kenny (1986). This involved a series of four analyses to show that (A) the independent variable of interest is related to the outcome of interest, (B) the independent variable of interest is related to proposed mediator(s), (C) the proposed mediator(s) are related to the outcome, and (D) the effect of the independent variable of interest no longer exists when the effect of the mediator(s) on the dependent variable are controlled for. For each of the mediation hypotheses, hierarchical linear regression analyses was used to test for each of these components, with the first step predictors always being the aforementioned control variables.

For tests of the moderation hypothesis (1a, 4, 6, 7, 8, and 9), variables related to appropriate strategy use (i.e. task effort) and adaptive performance were standardized within conditions for task change type for consistency of interpretation across conditions. For all other hypothesis tests, which were done within one level of the task change condition only, all variables were left in their original metrics for ease of interpretation.

*Hypothesis 1*

In general, hypothesis 1 suggested that appropriate strategy change should positively predict adaptive performance effectiveness once a change in the task occurs. Based upon this, three specific sub-hypothesis were generated in consideration of the different types of task change that participants could have faced.

Hypothesis 1a suggested that task related effort, operationalized as the number of targets prosecuted, would be most strongly positively related to adaptive performance effectiveness when people were facing changes in task difficulty, as opposed to component or coordinative task changes. Consistent with expectations, and as shown in Table 5, the results of the analysis of hypothesis 1a showed a significant interactive effect of task related effort and task change type on levels of adaptive performance (Step 3 $\Delta R^2 = .02, p < .05$).

Figure 5 shows the plot of this significant interaction effect. To further probe this interaction, the differences in slopes for the relationship between task related effort and adaptive performance for different types of task change was investigated by examining the unstandardized regression weights for the two interaction terms, which provide explicit tests for the slope differences between the index condition (i.e. difficulty change) and the other conditions (Aiken & West, 1991). As can be seen in Table 5, the strength of the relationship between the number of targets prosecuted and adaptive performance effectiveness is significantly different for the difficulty and coordinative change conditions ($b = -.34$, $p < .05$). However, the strength of the relationship between the number of targets prosecuted and adaptive performance effectiveness was not significantly different for the difficulty and component change conditions ($b = -.03$, $p = .77$). Based on these findings and the examination of Figure 6, it can be concluded that task related effort was least strongly related to adaptive performance effectiveness when people faced coordinative task changes, which provides partial support for Hypothesis 1a.

Hypothesis 1b predicted that when facing a component task change, the correct use of new information cues and/or acts would positively predict levels of adaptive performance. Results were consistent with this hypothesis. As shown in Table 6, the number of correct type, class, and intent (TCI) decisions made positively predicted adaptive performance effectiveness when people were facing a component task change ($b = 159.31$, $p < .05$).

Finally, hypothesis 1c predicted that when facing a coordinative task change, the correct sequencing and prioritization of behavioral acts would positively predict levels of adaptive performance. As shown in Table 7, the findings did not support this hypothesis.

The number of high priority targets that were engaged did not significantly predict adaptive performance effectiveness when people were facing a coordinative task change ($b = -52.07$, $p = .10$).

*Hypothesis 2*

In general, hypothesis 2 suggested that task appropriate in situ declarative knowledge development would positively predict appropriate strategy selection and implementation. Based upon this, three specific sub-hypothesis were generated in consideration of the different types of task change that participants could have faced.

Hypothesis 2a focused on task difficulty changes and proposed that when facing a task difficulty change, declarative knowledge development regarding increases in the number of required behavioral acts would positively predict task related effort. The results of the test of this hypothesis are shown in Table 8. Briefly, it can be seen that increases in knowledge regarding the number of targets in the simulation did not significantly predict the number of targets that individuals engaged when facing a task difficulty change ($b = .88$, $p = .14$)

Hypothesis 2b suggested that when facing a component task change, declarative knowledge development regarding new information cues or necessary acts would positively predict the correct strategic use of new information cues and/or acts. As shown in Table 9, the findings supported this hypothesis. More specifically, declarative knowledge development regarding new informational cues positively predicted the number of correct type, class, and intent decisions participants made when facing a component task change ($b = 11.45$, $p < .05$).

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Hypothesis 2c predicted that when facing a coordinative task change, declarative knowledge development regarding changes in task rules and contingencies would positively predict the correct sequencing and prioritization of behavioral acts. As shown in Table 10, the results were consistent with this hypothesis. When facing a coordinative task change, levels of participant declarative knowledge development regarding changes in task rules and contingencies positively predicted the number of high priority targets that were engaged ($b = .18$, $p < .05$).

*Hypothesis 3*

Hypothesis 3 suggested that change detection would positively predict appropriate declarative knowledge development for the given type of task change. Similar to hypothesis 1 and hypothesis 2, three specific sub-hypothesis were generated in consideration of the different types of task change that participants could have faced.

Hypothesis 3a suggested that when facing a task difficulty change, change detection would positively predict declarative knowledge development regarding increases in the number of required behavioral acts. This hypothesis was not supported. As shown in Table 11, change detection did not significantly predict declarative knowledge development regarding the increase in the number of targets in the simulation ($b = -0.13$, $p = .14$).

Hypothesis 3b predicted that when facing a component task change, change detection would positively predict declarative knowledge development regarding new information cues or necessary acts. The results of the test of this hypothesis are shown in Table 12. Indeed, the results supported hypothesis 3b in that change detection significantly and positively predicted the acquisition of declarative knowledge regarding new informational cues ($b = 0.28, p < .05$).

Finally, hypothesis 3c predicted that when facing a coordinative task change, change detection would positively predict declarative knowledge development regarding changes in task rules and contingencies. As shown in Table 13, the results did not support this hypothesis. Change detection did not significantly predict declarative knowledge development regarding changes in task rules and contingencies ($b = .41, p = .16$).

*Hypothesis 4*

Hypothesis 4 focused on the importance of a metacognitive intervention for influencing adaptive performance effectiveness, presumably through its influences on key in situ self-regulatory processes. It was suggested the influence of the intervention would vary based on the level of cognitive "load" or demand that the type of change necessitated, and thus, Hypothesis 4 predicted that a metacognitive intervention conducted during the adaptation process would have the largest positive effect on adaptive performance effectiveness in response to coordinative task changes and the lowest positive effect on adaptive performance effectiveness in response to task difficulty changes.

As stated earlier, hierarchical linear regression was used to test this hypothesis, the results of which are shown in Table 14. As can be seen by the incremental variance explained in step three of the regression, the interaction of the presence or absence of the metacognitive intervention with the type of task change did not significantly influence adaptive performance effectiveness (Step 3 $\Delta R^2 = .00, p = .52$). Furthermore, there was no significant main effect of the metacognitive intervention on adaptive performance effectiveness across the different types of task change ($b = -.17$, $p = .11$ two-tailed). Therefore, it appears that the metacognitive intervention had little to no direct influence on adaptive performance effectiveness in response to the different types of task change investigated in this study.

While failure to support this hypothesis is certainly a disappointment, it is not a complete surprise when information regarding the metacognitive intervention manipulation check is considered. As Table 1 shows, the mean on this scale across all conditions was 3.85, suggesting that on average, people responded that they believed they were told to focus on activities related to planning, monitoring, evaluating, and adapting their strategies. In addition, and even more challenging, is the lack of a significant ($r = .05$) correlation between the presence or absence of the metacognitive intervention and scores on the metacognitive intervention manipulation check. Obviously, this is problematic as it suggests that people were confused about the implementation of the intervention and, thus, their reactions in accordance with it are likely not what was expected. Regardless, the intervention was implemented in a sound fashion during the study.

*Hypothesis 5*

Broadly, hypothesis 5 suggested that some combination of change detection, relevant knowledge gain, and proper strategy use would mediate the effects of the metacognitive intervention on adaptive performance for each type of task change that was studied. This hypothesis was not formally evaluated, however. As shown by the results of the tests for hypothesis 4, the first step in the mediation analysis, that the independent variable of interest is related to the outcome of interest, did not receive support. Furthermore, separate tests conducted to examine potential main effects of the metacognitive intervention on adaptive performance effectiveness independently for each type of task change returned similar results and that the metacognitive intervention was not found to significantly influence adaptive performance effectiveness in response to any of the types of task change. Therefore, it can be concluded that there are no direct effect to be mediated.

However, it may be the case that any effects of the metacognitive intervention have indirect influences on adaptive performance effectiveness that manifest themselves through their influences on change detection, relevant knowledge acquisition, and/or proper strategy use. In this case, step one of the proposed sequence of tests for investigating mediation would not necessarily need to be satisfied. To investigate this possibility, a series of analysis was conducted examining potential effects of the metacognitive intervention on change detection, relevant knowledge acquisition, and proper strategy use separately for each task change condition. However, as shown in Tables 15 – 23, the results of these analyses were not statistically significant in any case, thus suggesting that the metacognitive intervention had little to no effect on adaptive performance effectiveness either directly, as shown above, or indirectly through influences on change detection, relevant declarative knowledge acquisition, or proper strategy use.

*Hypothesis 6*

Hypothesis 6 predicted that the influence of cognitive ability on adaptive performance effectiveness would be moderated by task change type such that cognitive ability would more strongly predict adaptive performance effectiveness in response to coordinative and component task changes than to task difficulty changes.

The results of the hierarchical linear regression used to test this hypothesis are shown in Table 24. Contrary to expectations, cognitive ability and task change type did not interact to influence adaptive performance effectiveness (Step 3 $\Delta R^2 = .01, p = .26$). However, there was a statistically significant positive main effect of cognitive ability on adaptive performance effectiveness across all types of task change ($b = .03, p < .05$). In any case, hypothesis 6 was not supported, as the proposed moderating effects of task type were not found.

*Hypothesis 7*

Hypothesis 7 predicted that the influence of learning goal orientation on adaptive performance effectiveness would be moderated by task change type such that learning goal orientation would more strongly predict adaptive performance effectiveness in response to coordinative and component task changes than to task difficulty changes.

The results of the test of this hypothesis are shown in Table 25. As can be seen, learning goal orientation levels and task change type did not interact to influence adaptive performance effectiveness (Step 3 $\Delta R^2 = .00, p = .60$). Furthermore, there was not a statistically significant positive main effect of learning goal orientation on adaptive performance effectiveness across all types of task change ($b = .14$, $p = .11$). Thus, hypothesis 7 was not supported.

*Hypothesis 8*

Hypothesis 8 predicted that task change type would moderate the influence of conscientiousness on adaptive performance effectiveness such that the effects of conscientiousness would be positive for task difficulty change, and null or even negative in relation to component and coordinative task changes.

Hierarchical regression results for the test of this hypothesis are shown in Table 26. This hypothesis was not supported. As can be seen, the interaction of conscientiousness and task type did not significantly predict adaptive performance effectiveness (Step 3 $\Delta R^2 = .00$, $p = .90$). Furthermore, but as anticipated, there was not a significant main effect of conscientiousness on adaptive performance effectiveness across task change types ($b = .01$, $p = .93$ two-tailed).

*Hypothesis 9*

Hypothesis 9 predicted that task change type would moderate the influence of openness to experience on adaptive performance effectiveness such that the positive effects of openness to experience would be largest for coordinative task change and smallest for component task change.

The results of the test of this hypothesis are shown in Table 27. It was found that task change type and openness to experience did not significantly interact to influence adaptive performance effectiveness (Step 3 $\Delta R^2 = .00$, $p = .88$). Furthermore, there was not a statistically significant positive main effect openness to experience on adaptive performance effectiveness across all types of task change ($b = .15$, $p = .15$). Based on this, it can be concluded that hypothesis 9 was not supported.

Discussion

The focus of this study was on extending existing work on adaptive performance effectiveness. The prevailing view of work in current organizations is that it now takes place in dynamic work environments where existing skills and knowledge constantly need to be built upon (Ilgen & Pulakos, 1999; Smith, Ford, & Kozlowski, 1997, Cascio, 2003). Accordingly, researchers and theorists have noted a shift in what is considered to be important for job performance, and adaptive performance has been suggested to be an important component of many different types of current jobs (Ployhart & Bliese, 2006; Pulakos et al, 2000). While research on a multitude of predictors of adaptive performance has followed, the current adaptive performance literature is characterized by a number of areas that are unexplored.

One problem with the current adaptive performance literature is that it has primarily treated the construct as a static operationalization of performance after some sort of task change occurs. This is reflected in both training and selection perspectives and approaches to influencing adaptive performance. However, very little attention has been given to adaptive performance as a process by trying to explicate what sorts of things people have to do or go through to adapt to a change in the nature of a learned task. Without recognizing some of the potentially critical process-oriented aspects of adaptive performance, it is difficult to predict or understand how or why individual differences, training techniques, or the like should influence adaptive performance. Based on heuristic models of self-regulation, one critical focus of this study was to provide a foundation for thinking about some of these more process-oriented aspects of adaptive performance by building a conceptual model of adaptation as a process and examining the effects of change detection, new relevant knowledge development, and strategy change on adaptive performance.

A second focus of this study was on explicitly considering the nature of task change that people were trying to adapt to. The extant work primarily treats adaptive performance as performance on a task that is novel, ill-defined, more difficult, and/or more complex than previous tasks that people have experience with. While it is reasonable to expect that all of these types of task change require adaptability in some form, until now there have been no specific attempts to delineate different components of tasks that can change. Accordingly, three different types of task change were identified based on Wood's (1986) taxonomy of task complexity. Furthermore, and in accordance with the first focus of this study as specified above, a number of hypotheses were generated and tested regarding the importance of various cognitive and motivational factors related to change detection, new knowledge development, and strategy change on adaptive performance with the expectation that some factors would be more or less important in response to different types of task change.

This study also indirectly focused on the importance of in situ self-regulatory processes during the process of adaptation. While recent research has highlighted the potential value of self-regulatory processes that are thought to translate existing task knowledge, skill, and efficacy into adaptive performance (i.e. Chen et al., 2005), there has been little discussion of how or if these self-regulatory processes can be influenced. There is, however, a stream of work related to metacognition that deals explicitly with some of these self-regulatory processes and how different types of interventions can influence them. Based on this, the current study examined the potential effects of a metacognitive intervention on adaptive performance effectiveness in response to the different types of task change that were identified.

The final focus of this study was on examining the influences of a number of different individual difference factors on adaptive performance. Individual differences factors related to cognitive ability, personality, and goal orientation have been found to influence adaptive performance in previous studies (e.g. Ford et al., 1998; Kozlowski et al., 2001), but the mechanisms through which they have their effects have not received much attention. As an initial step in addressing these types of issues, the conceptual process model of adaptation developed herein was used as a guide for developing hypothesis aimed at assessing potential differential influences of these individual differences on adaptive performance in response to different types of task change.

*Findings and Specific Limitations*

The hypotheses investigated in this study can be grouped into three general themes. In accordance with the conceptual model of adaptive performance proposed earlier, hypotheses 1, 2, and 3 focused on examining the effects of change detection, relevant knowledge acquisition, and strategy effectiveness on one another and adaptive performance effectiveness in response to different types of task change. The second theme was reflected by hypotheses 4 and 5, which focused on the influence of a metacognitive intervention on adaptive performance effectiveness in response to different types of task change. Finally, hypotheses 6, 7, 8, and 9 consider the potential effects of individual differences in cognitive ability, goal orientation, and personality on adaptive performance effectiveness in response to different types of task change. The following dis

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discussion of the research findings and specific limitations related to each will be organized around these three themes.

*Hypotheses 1, 2, and 3.* Hypothesis 1 predicted that appropriate strategy change would positively predict adaptive performance effectiveness across the different types of task change examined in this study. More specifically, it was predicted that when facing task difficulty changes, the pathway to successful adaptive performance effectiveness would be primarily motivational and the appropriate strategy would be to exert additional effort using what is already known about the task. However task effort alone was not expected to directly predict success in adaptation to component and coordinative task changes as strongly as it did for difficulty changes. For these types of changes, cognitive factors related to proper strategy use were also expected to play important roles in predicting adaptive performance effectiveness. For component changes, appropriate cognitive strategy use was suggested to involve incorporating new task knowledge into existing strategies, whereas the use of newly learned task rules and contingencies to make correct sequencing and prioritization decisions was suggested to be the appropriate strategic activity for coordinative task changes.

Hypothesis 1 was generally supported. Hypothesis 1a, which suggested that the influence of task effort on adaptive performance effectiveness would be the strongest for task difficulty changes and the weakest for coordinative task changes received support. Consistent with the notion that task effort would not be as strong of a predictor of adaptive performance effectiveness in response to changes that were more cognitive in nature, these results (see Figure 6) show that task effort had its smallest effect on adaptive performance effectiveness in relation to a coordinative complexity change. Also in support of hypothesis 1, the results suggested that effective strategy use was positively related to adaptive performance effectiveness in response to component task changes. However, hypothesis 1c was not supported in that the measure of effective strategy use was not significantly related to adaptive performance effectiveness in response to coordinative task changes.

Taken as a whole, these findings provide some support for the notion that different types of task changes require different types of strategies or different "pathways" to success and also support the importance of in situ strategy development, selection, and implementation for adaptive performance effectiveness. For difficulty changes, it appears that effort alone was a strong predictor of adaptive performance effectiveness. While effort also predicted adaptive performance effectiveness in response to more cognitively-based types of task change, proper strategy use also had an effect in some cases. These findings support the earlier assertion that when thinking about predictors of adaptive performance effectiveness, it is important to explicitly consider the type of task change that individuals are facing, as the appropriate strategies (e.g. "work hard" vs. "work smart") may vary.

However, some caution is necessary when interpreting these results. An examination of Tables 2, 3, and 4 show that the correlations (and thus the corresponding $R^2$ values) between the strategy variables and adaptive performance effectiveness were very high for both the difficulty and component task change conditions ($r$ = .93, .88, respectively). While correlations this high are not generally observed, it is not unreasonable in this context as the operationalizations of appropriate strategies in each of these conditions were behaviors that were coupled almost directly to performance effectiveness. For example, in the difficulty change condition the appropriate strategy was to exert extra effort, which primarily consisted of using the same knowledge and skills developed during the practice period, but more frequently. Since the practice period was designed to build high levels of competence, it comes as no surprise that the relationship between the total number of targets prosecuted (both correct and incorrect) and adaptive performance effectiveness was so high, as there were likely very few errors by participants after twelve trials. Of course, it is not always reasonable to expect this tight of a coupling between strategy use and performance effectiveness, especially when strategies are complex, as there are numerous environmental and task constraints such as available resources, technology, etc. that may constrain adaptive performance effectiveness even when people are able to devise appropriate strategies.

Furthermore, the lack of a relationship between the operationalization of proper strategy use and adaptive performance effectiveness for the coordinative task change condition is surprising, and somewhat suspect. Given that this was the condition where cognitive factors and, presumably, proper strategy development would be most important, this finding seems a bit off base. However, a closer examination of the operationalization of proper strategy use for this condition reveals a potential issue that could be responsible for the lack of significant findings. As stated earlier, this operationalization focused on the overall number of high priority and pop-up targets that were engaged, as these targets had the highest priority at any given point in time. However, this measure did not specifically look at the sequence of high priority target prosecution or the time it took to prosecute the high priority targets. Thus, the actual sequencing of target prosecutions was not directly examined, and a "brute force" approach of simply engaging targets as quickly as possible may have resulted in a similar score on this variable as a more complex strategic approach that actually considered the importance of sequencing engagements based on priority levels. To address this, potential alternative operationalizations of proper strategy use for the coordinative task change condition could be examined. For example, it is possible to examine the sequence in which targets were prosecuted in order to ascertain whether the "pop-up" high priority targets were given precedent once they appeared on the screen. Another alternative operationalization involves examining not only how many of the high priority targets crossed the defensive perimeter, but also how long these targets spent there before they were prosecuted. These operationalizations could both help to provide richer information regarding when the high priority targets were engaged, and thus may index how strategic people were in prosecuting targets.

Hypothesis 2 predicted that task relevant in situ declarative knowledge development would positively predict appropriate strategy selection and implementation. While the necessary relevant knowledge was suggested to vary based on the type of task change people faced, the general prediction was expected to hold across all different types of task change.

For the most part, hypothesis 2 was supported. As predicted, relevant declarative knowledge gain was positively related to proper in situ strategy use and development in response to both component and coordinative task changes. This was not the case for task difficulty changes, however, as declarative knowledge development was not related to increased levels of task effort.

One potential explanation for the lack of a significant finding in the task difficulty change condition has to do with the measure of knowledge acquisition. As shown in Appendix I, the item that assessed relevant knowledge acquisition for the difficulty condition focused on knowledge of the absolute number of targets in the simulation rather than the relative number. It could be the case that participants detected a change, figured out that were *more* targets, and correspondingly increased their effort without actually knowing the exact number of targets in the then-changed simulation scenario. However, a follow-up test using an alternative operationalization of relevant knowledge acquisition as knowledge that there are *more* targets (i.e. 18 or 25) rather than knowledge of the absolute number of targets did not yield any differences in the pattern of results.

However, upon further examination it appears that the lack of findings related to both operationalizations of relevant knowledge acquisition for the difficulty task change may be explained by the relative lack of people who did not realize that there were more targets. Indeed, 85% of people in the difficulty task change condition correctly identified the absolute number of targets in the adaptation trials, with an additional 12% (e.g. 97% total) identifying that there were more targets, even if they did not correctly identify the absolute number. Furthermore, the original operationalization correlated significantly with practice performance ($r = .21, p < .05$), which in turn was a positive predictor of task effort levels. This suggests that even though there was a marginal level of variance regarding whether or not people correctly identified the absolute number of targets in the difficulty change adaptability trials, the collinearity between this variable and practice performance, as well as the fact that practice performance was entered first in the regression model, may have made it difficult to find a statistically significant relationship between this variable and task related effort.

Taken together, however, these findings provide some support for the importance of new knowledge development for influencing proper strategy use and development when trying to adapt to changes in the nature of one's task. This new knowledge development is thought to be a manifestation of processes related to diagnosis, which focuses on ascertaining the cause or nature of change in the given task. When people are aware that a task change of some sort has occurred, the model presented earlier specifies that it is imperative that they attempt to understand the nature of the change before successful adaptation can occur. As these findings suggest, the development of new knowledge regarding additional necessary behavioral task elements or acts, informational cues, and sequencing requirements can allow individuals to devise and act in accordance with proper task strategies.

Hypothesis 3 suggested that change detection would positively predict appropriate declarative knowledge development for the given type of task change. Change detection has been suggested to be a key predictor of adaptive performance effectiveness (Ployhart & Bliese, 2006), as one should not be able to learn about a change and adopt the necessary strategies to perform well in response to it if there is no knowledge that a change in the task actually occurred. Here, it was suggested that the effects of change detection would manifest through diagnosis-related processes that lead to relevant task knowledge acquisition. As with hypothesis 2, the type of relevant knowledge examined here was expected to vary based on the type of task change faced, but the general hypothesis was expected to hold across different types of task change.

Hypothesis 3 was only supported for the component task change condition. Here, it was found that change detection was positively related to knowledge acquisition regarding changes in the distinct information cues that needed to be used to prosecute targets. Change detection was not related to knowledge acquisition regarding the increased number of targets in the difficulty change condition or knowledge acquisition regarding target prioritization and sequencing information in the coordinative change condition.

While the results of hypothesis 3 are not generally supportive, there may be a number of reasons why the relationships between change detection and relevant knowledge acquisition were not significant for the difficulty and component change conditions. First of all, there was little variance in whether or not participants reported noticing a change in the task. In the difficulty, component, and coordinative conditions, the percentages of participants who reported noticing a task change were 88%, 97%, and 92%, respectively. This comes as no surprise, as the nature of the task and the way the study was constructed in the laboratory made change detection a relatively straightforward process for all conditions. This lack of variance, then, makes finding relationships difficult. However, a significant relationship between change detection and relevant knowledge acquisition was found for the component change condition, so this explanation is not completely sufficient.

*Hypotheses 4 and 5.* Hypothesis 4 focused on the importance of a metacognitive intervention for influencing adaptive performance effectiveness. It was suggested that the influence of the intervention would vary based on the level of motivational and cognitive "load" or demand that the type of change necessitated. Therefore, it was expected that the metacognitive intervention would have the largest positive effect on adaptive performance effectiveness in response to a coordinative task change and the smallest positive effect on adaptive performance effectiveness in response to a task difficulty change.

The results of the study failed to support this hypothesis, though. The findings suggested no differential relationships between the metacognitive intervention and adaptive performance effectiveness across the different types of task change. Furthermore, the metacognitive intervention did not have an omnibus positive main effect on adaptive performance effectiveness, either, thus suggesting little influence of the intervention.

Hypothesis 5 focused on the potential mediating effects of change detection, relevant knowledge gain, and proper strategy use on the proposed relationships between the metacognitive intervention and adaptive performance effectiveness as specified in hypothesis 4. More specifically, it was suggested that since the pathways to success when moving from difficulty to component to coordinative task changes should become increasingly cognitive loaded, the relationship between the metacognitive intervention and adaptive performance effectiveness would be fully mediated by change detection by itself for difficulty task changes; change detection and relevant knowledge gain for component task changes; and change detection, relevant knowledge gain, and effective strategy change for coordinative task changes. However, since the initial conditions for examining mediation tested in hypothesis 4 received no support, this hypothesis was not formally evaluated.

The results of hypotheses 4 and 5 generally run counter to existing findings that have shown the ability of metacognitive interventions to influence learning and problem solving (e.g. Brown & Palincsar, 1982, 1985; Delclos & Harrington, 1991; King, 1991b). However, they are not entirely inconsistent with work studying the influences of metacognitive interventions on task performance or adaptive performance effectiveness. For example, Schmidt and Ford (2003) found no direct effects of their metacognitive intervention on training performance, although some indirect effects through metacognitive activity and declarative knowledge development were found. Perhaps more applicable to this study are the findings of Keith and Frese (2005). Recall that Keith and Frese found no incremental effect of a metacognitive intervention on adaptive transfer over a general error-based training intervention. Rather, their results suggested that the error-based training in and of itself lead to higher levels of metacognition because participants had the freedom to explore the task, make mistakes, and learn from any errors they made.

There is a pair of limitations related to the use of the metacognitive intervention in this study that could be responsible for the lack of findings, however. First of all, and similar to the findings of Keith and Frese (2005), it may have been the case that other elements of the task induced metacognitive activity and overruled the influence of the intervention. The design of the task in this study involved providing the participants with an opportunity to study the task manual before each trial and view feedback after each trial. While the participants did not have to spend time doing these things, they still had to close out of the manual and quickly page through the feedback to be able to advance through the study. If adaptability truly involves an ongoing process of assessing the situation, examining effectiveness, and trying to devise and implement appropriate strategies as was suggested earlier, this ongoing cycle of looking at the manual and viewing feedback after each trial in and of itself may have prompted individuals to think more about their performance and strategies, thus mitigating some of the potential effects of the metacognitive intervention.

A second limitation related to these hypotheses involves the design of the metacognitive intervention. Recall that the intervention focused on providing participants with an overview of the potential importance of metacognitive activity related to planning, monitoring, and evaluating as well as having them respond to probe questions regarding whether or not they were engaging in these sorts of activities. While these aspects of the intervention were designed to prompt people into action, participants may have simply saw the intervention as a suggestion of sorts and responded to the probe questions in a descriptive manner instead of using them as an opportunity to evaluate their levels of metacognitive activity. It may be the case that explicitly requiring individuals to make plans for upcoming trials, monitor current levels of understanding and performance through feedback, and evaluate and think about the success of their strategies is necessary if one expects to create a successful metacognitive intervention.

*Hypotheses 6, 7, 8, and 9.* Hypothesis 6 focused on the importance of cognitive ability as a predictor of adaptive performance across different types of task change. Briefly, it was believed that cognitive ability would play a more important role in predicting adaptive performance effectiveness in response to task changes that were more cognitively complex in nature. This hypothesis was in line with past research findings as well as LePine et al.'s (2000) speculation that cognitive ability should be more strongly related to performance in situations with higher cognitive or information processing demands.

The results of the test of this hypothesis, however, were not supportive. Cognitive ability was not differentially related to adaptive performance effectiveness across the different types of task change. However, the results did suggest a significant positive omnibus main effect of cognitive ability on adaptive performance effectiveness. Based on this, it appears that higher levels of cognitive ability provided at least some platform for being able to better recognize and adapt to task changes. Of course, these findings need to be interpreted cautiously as there was not a specific omnibus main effect hypothesis offered and the effects of cognitive ability on outcomes related to change detection, relevant knowledge acquisition, and proper strategy use were not explicitly tested.

Hypothesis 7 suggested that learning goal orientation would differentially predict adaptive performance effectiveness in response to different types of task change. This hypothesis was predicated on the notion that those with higher levels of learning goal orientation would excel in cognitively demanding, novel situations such as those presented by component and, especially, coordinative task changes.

However, hypothesis 7 was not supported. Those with higher levels of learning goal orientation did not exhibit higher levels of adaptive performance in general, and furthermore no significant differential effects of learning goal orientation on adaptive performance effectiveness across different types of task change were found. This is somewhat surprising given recent meta-analytic evidence that learning orientation is generally positively related to effective use of learning strategies, feedback seeking behavior, and job performance (Payne et al., 2007).

Hypothesis 8 focused on the role of conscientiousness as a potential predictor of adaptive performance effectiveness. This hypothesis suggested that conscientiousness would differentially predict adaptive performance effectiveness in response to different types of task change. More specifically, because conscientiousness is thought to breed commitment and effort on a given task, hypothesis 8 surmised that it would be an especially important predictor of adaptive performance effectiveness for changes that were primarily motivationally-based. This hypothesis was in line with previous research findings by LePine et al. (2000), who found that high levels of conscientiousness were negatively related to adaptive performance effectiveness in response to what was essentially a coordinative task change where cognitive strategy change was essential for adaptive performance effectiveness.

However, the results of this study showed that conscientiousness was not differentially related to adaptive performance effectiveness and, furthermore, there was no omnibus effect of conscientiousness on adaptive performance effectiveness in either direction. This finding is especially surprising in relation to the task difficulty condition, where the high levels of commitment, motivation, and perseverance thought to be associated with high conscientiousness seem particularly well suited to influencing adaptive performance effectiveness.

Hypothesis 9 was also concerned with the effects of personality on adaptive performance effectiveness, but its focus was on the potential effects of openness to experience. People with high levels of openness to experience are thought to be intellectually curious and fond of novel experiences, and because of this it was predicted that high openness to experience would positively relate to adaptive performance effectiveness. This was expected to be the case even more so when task changes were more cognitive in nature and thus required a greater deal of strategy manipulation and reformulation.

Similar to conscientiousness, openness to experience was not found to significantly predict adaptive performance effectiveness differentially across task change types or in an omnibus manner. Again, this is somewhat surprising due to the supposed intellectual curiosity and fondness for novel experiences or change associated with high levels of openness to experience. Furthermore, this contradicts past findings regarding the positive effects of openness to experience on adaptive performance effectiveness in response to a coordinative task change (LePine et al., 2000).

As a whole, the individual difference hypotheses in this study failed to receive support. While this comes as something of a surprise, there are some limitations with the study that could help to explain why these hypotheses were not supported. First of all, this study focused on measuring adaptive performance effectiveness and its hypothesized knowledge and strategy determinants six trials after the task given task change occurred. While the approach taken here was reasonable as a starting point, it may be the case that some of the hypothesized effects could have happened but did not manifest themselves at the particular point in time that they were measured. While this limitation is likely important for all of the hypotheses tested in this study, is may be especially relevant for the individual difference predictors, as it is reasonable to argue that the effects related to them could manifest themselves within a few trials of the task change. Thus, over time these effects could be "washed away" if simple exposure and practice on the newly-changed task allowed those with differing levels of cognitive ability, learning orientation, openness to experience, and conscientiousness to "catch up", essentially homogenizing performance across different levels of these factors. This argument points to the importance of explicitly considering the timeframe in which effects unfold, as well as the level or magnitude of effects at a given point in time.

As described above, the findings related to personality effects on adaptive performance effectiveness do not align with past findings (i.e. LePine et al., 2000). Another potential reason for this may have to do with the generality of the personality measures used here. Rather than looking at broad level personality factors, some scholars have suggested that facet level predictors be examined as they are more behaviorally specific than broad, overarching measures of personality like the ones used here (Ashton, 1998; Schneider, Hough, & Dunnette, 1996). Indeed, LePine et al. (2000) provide some evidence for the efficacy of examining personality factors at the facet level in relation to adaptive performance; their supplementary analyses suggested that their negative relationship between conscientious and adaptive performance effectiveness could be primarily attributed to dependability-related facets of conscientiousness. However, LePine et al.'s findings regarding facets of openness to experience were less clear-cut, as there were uniformly positive relationships between each of the facets and adaptive performance effectiveness. These findings, however, do point to the importance of explicitly considering the types of behaviors that are of interest in a study and more specifically considering personality factors or facets as potential predictors.

*Contributions*

In general, the relationships proposed in hypotheses 1, 2, and 3 were supported. Based on these findings, a number of contributions to the extant literature on adaptive performance can be identified. First of all, this study is the first to treat adaptive performance as a process by trying to explicate what sorts of things people have to do or go through to adapt to a change in the nature of a learned task. While research by Chen et al. (2005) and theoretical work by Ployhart & Bliese (2006) provided an initial step in this direction, this study is the first to systematically examine the effects of in situ change detection, task knowledge development, and strategy use on adaptive performance effectiveness.

By taking this type of approach, and providing support for the importance of these types of in situ factors, this study should help to shift thinking about adaptive performance away from more traditional, static views that primarily deal with performance effectiveness toward more dynamic or process-oriented views. These types of perspectives, then, could help to further address key questions regarding "what", "why", and "when" people are engaging in activities related to adaptive performance instead of simply focusing on questions pertaining to levels of adaptive performance effectiveness.

In a similar vein, this study was the first to explicitly consider the nature of task and the type of task change that people were attempting to adapt to. As noted earlier, much of the existing empirical work conducted on adaptability or adaptive performance has taken something of a "catch-all" approach to manipulating task change and operationalizing adaptive performance by looking at changes that result in tasks that are longer, more difficult, and/or more complex. By relying on the Wood (1986) taxonomy of task complexity, a categorization of different types of task change was derived that served as a foundation for examining the potential differential effects of various cognitive and motivational factors on adaptive performance in response to different types of task change.

While the results of the hypotheses tested herein did not generally find a moderating effect of task change type, there are a few specific findings related to task change type that deserve to be highlighted. As noted above, the results of hypotheses 1a did suggest that the importance of a motivationally-based task strategy (i.e. increased effort) varied depending on the type of task change that people facing such that effort was more strongly related to adaptive performance effectiveness in response to task changes that were less cognitively-based. Furthermore, it was found that relevant declarative knowledge gain, which focused on different types of knowledge for each type of task change, was important for predicting strategic variables that were thought to be important predictors of adaptive performance effectiveness in response to component and coordinative task changes. These findings, then, provide some initial evidence for the importance of considering what is actually changing in a given task when trying to predict and understand the process of adaptation as well as the end result, adaptive performance effectiveness.

*General Limitations*

*Sample*. The sample for this study was composed entirely of undergraduate college students who were participating in the study in exchange for course credit. There were two possible concerns or limitations in this study regarding the sample. The use of students in and of itself may be problematic from the standpoint of broad generalization.

One concern related to this is the lack of random selection and the relative homogeneity of the participants in this sample. While this has the potential to be problematic, it is not a challenge that is limited to this study or the laboratory setting in general. In support of this, Colquitt (2008) suggests that samples in field studies typically have fairly homogenous samples as well. Furthermore, since the participants in this study are likely faced with situations where they have to learn new information and skills and potentially adapt their knowledge and skill to new situations, the use of these students as a sample does not seem overly problematic. In addition, it is reasonable to think that environments where adaptive performance is a key concern (organizations, for example) are populated with people who are educated to at least the high school and more likely the college level. Therefore, this sample likely reflected the target population fairly well.

A second potential concern with use of student participants was their motivation to perform on the task. As mentioned earlier, the primary reward for participation in this study was class credit commensurate with the amount of time that the students spent participating in the study. However, no monetary incentives of any type were offered, and participants did not receive more or less credit based on how well they performed. While it may seem like this would be detrimental in terms of the amount of effort that students exerted, the data collected in the study does not reflect this. Indeed, it appears that the participants worked quite hard on the task as the mean number of targets prosecuted during the final trial, which was used as an index of effort in this study, was 11.5 out of 12 for component change condition, 11.6 out of 12 for the coordinative change condition, and 13.2 out of 18 for the difficulty change condition. Taken together, this suggests that participant effort due to lack of external, performance-based rewards was not likely to be an appreciable problem.

*Research setting*. As with any psychological research conducted in a laboratory, the setting itself may lead to questions regarding the external validity of any findings. In addressing these types of questions, two points need to be made.

When dealing with questions regarding the relevance of external validity and the "realism" of a given study, scholars such as Mook (1983) note the importance of considering the nature of the research question. In discussing different types of realism that can be achieved through experimental studies, Aronson & Carlsmith (1968) and Aronson, Wilson, and Akert (1994) broadly distinguish three ways in which an experiment can be said to be realistic. *Experimental realism* comes about when the situation is involving to the participants, they take it seriously, and it influences them in some way. *Mundane realism* deals with the extent to which events occurring in the research setting are likely to occur in the normal course of participants' lives and how well the research setting represents the "real world". Finally, *psychological realism* addresses the extent to which the psychological processes that occur or are necessary in an experiment represent those that would occur if a similar situation was faced in everyday life.

For the purpose of this study, the focus was squarely on creating a situation where participants would be engaged by the nature of the study and the key psychological processes related to adaptive performance effectiveness would be adequately represented and measured. Thus, the objective was to create strong senses of both experimental and psychological realism. As noted earlier, participants seemed to be involved and focused on the study as they exerted high levels of effort, even toward the tail end of the study. Furthermore, the design of the task necessitated that learning, effort, strategy change, and the like would be important for adaptive performance effectiveness, and the results of the study provided some support for these notions. Thus, it appears that the laboratory design and setting was quite successful for the purposes and goals of this study, even though the mundane realism was not necessarily strong.

Furthermore, while external validity is certainly a concern with any study conducted in the laboratory or the field, the laboratory setting in and of itself may not be as strong of a barrier to generalizability as many think, even with the apparent lack of mundane realism. First off, there are no boundary conditions or formal aspects of the conceptual model from this study that I am aware of that would that influence things to the extent that the hypothesized relationships in this study would not be supported if they truly existed in the population of interest. Furthermore, Anderson, Lindsay, and Bushman (1999) report that the correlations between the effect sizes found in research using laboratory settings and field settings generally exceed .70. Thus, there is evidence that hypothesis tests using field and laboratory settings can and likely do lead to similar findings, and it appears likely that this would be the case given the apparent psychological realism of the processes studied herein.

*Statistical power*. Another potential limitation in this study as whole is a lack of statistical power. Statistical power can be thought of as the probability of correctly rejecting the null hypothesis given (a) the sample size, (b) the effect size, (c) alpha, and (d) the power of the statistical test (Cohen, 1969). Lack of statistical power, then, renders it difficult to find significant relationships and potentially inflates Type II error rates.

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Due to incomplete data, technical problems, and general time constraints, the analyzable sample for this study was 283 participants, or 43 to 50 per condition. While these sample sizes were likely sufficient even by conservative estimates for tests of the main effect hypotheses, they may have been toward the low end of acceptability for tests of the interaction hypotheses.

Aguinis and colleagues (Aguinis, 1995; Aguinis, Boik, & Pierce, 2001; Aguinis & Stone-Romero, 1997) keenly discuss the potential problem of low statistical power in moderated multiple regression. However, based on the findings (or lack thereof) for the moderation hypotheses in the current study, it is difficult to conclude that the available statistical power was a hindrance. Specifically, the interaction proposed in hypothesis 1a predicted approximately 2.3 percent of the incremental variance in adaptive performance effectiveness and was found to be statistically significant. However, the interactions proposed in hypotheses 4, 6, 7, 8, and 9 predicted one percent or less of the incremental variance in adaptive performance effectiveness over and above any of the effects of the given control variables and main effects. Given this, it seems that collecting additional data in order to increase power to the point where these effects were statistically significant would not be a useful pursuit. It would likely be the case that if enough power was obtained to render any of these findings statistically significant, the practical significance would be lacking.

*Consideration of time.* It has been argued throughout this paper that explicit attention needs to be paid to thinking about adaptive performance from more of a process perspective. Specifically, a conceptual model of adaptive performance was proposed based on a heuristic control-theory model of self-regulation. This model was intended to help spu

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help spur thinking about adaptability as a multitude of dynamic cognitions, behaviors, and the like that people engage in to functionally align their behavior with given changes in their task environment. This type of dynamic perspective inherently entails an explicit consideration of time, and some of the key mechanisms proposed for the process of adaptability are thought to involve cycles of change detection, source determination, strategy change, performance, and feedback.

As it was mentioned earlier, this study incorporated time to a certain extent through the causal and implied temporal relationships between change detection, relevant knowledge development, strategy change, and adaptive performance effectiveness. This is consistent with past empirical work conducted by Chen et al. (2005) as well as theoretical work by Ployhart and Bliese (2006), both of which focused somewhat on processes related to self-regulation in a dynamic manner as determinants of adaptive performance effectiveness. However, it is still the case that the variables assessed in this study were measured at similar points in time (i.e. during trail 12 and directly after it) and that the dynamic nature of these processes was not investigated in a longitudinal manner. While this is by no means a damning indictment of the findings, the fact remains that time can and likely should be considered even more explicitly in future work on adaptive performance.

*Future Research Directions*

While the current study attempted to address some gaps in the extant literature on adaptive performance, a number of additional avenues for future research can be identified that will help to further understanding about the nature of adaptive performance and its antecedents.

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One valuable future direction for research on adaptive performance involves a more explicit consideration of time. Mohammed, Hamilton, and Lim (2008) discuss four different ways in which time can be considered or built into research. While Mohammed et al. focus on the importance of considering time for research on team effectiveness, the ways of considering time that they discuss are likely relevant for individual level research as well. Two of these types of time considerations may be especially relevant for work examining adaptive performance.

The first, and most obviously needed, is longitudinal research. The current conceptualization of adaptive performance relies on a process-oriented perspective whereby cycles of detection, diagnosis, and strategic adaptation are thought to influence one's ability to adapt to changes in a given task. However, existing research on adaptive performance has focused almost exclusively on examining adaptive performance at a single point in time. This study takes an initial step toward a more dynamic perspective by examining an implied causal and temporal ordering between factors related to change detection, relevant knowledge acquisition, strategy change, and adaptive performance effectiveness, but more needs to be done. Adaptive performance should be examined over multiple occasions in order to study the potential cyclical effects of different regulatory processes and cycles and to more closely examine the shape, form, and trajectory of adaptive performance within individuals.

A second type of time consideration identified by Mohammed et al. (2008) involves the incorporation of time-referenced or time-oriented constructs into cross-sectional research. Obviously, it is not always feasible to conduct longitudinal research, although that limitation is more applicable to field than laboratory research, especially with re

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with regard to adaptive performance. Regardless, our understanding of potentially important cognitive and behavioral processes and the way they unfold over time to influence adaptive performance can potentially be bolstered by incorporating time oriented constructs into research. For example, it was suggested earlier that a major part of adapting to coordinative task changes involves appropriately sequencing and prioritizing relevant behaviors. Building on Chen et al.'s (2005) findings that goal choice processes have implications for adaptive performance effectiveness, time could be incorporated into these goal choice and planning measures to assess not only what people are planning on doing, but when they are planning to do different things and how their behaviors will be prioritized. This type of consideration could clearly advance our understanding of adaptive performance from a more dynamic perspective, even if longitudinal data is not available.

Related to the notion of more carefully considering time is the need for more a more focused examination of in situ regulatory processes that may influence adaptive performance. The conceptual model of adaptation used as a foundation for this study was based in control theory models of self-regulation, which deal directly with the way that an individual guides "his/her goal-directed activities over time and across changing circumstances" (Karoly, 1993; p. 25). These models discuss the importance of processes related to performance monitoring, goal-performance discrepancy detection, plan development, and strategy enactment as predictors of performance.

While the current study used these types of models to guide the measurement of variables that were hypothesized to be important predictors of adaptive performance effectiveness, it is important to point out that the actual regulatory processes in and of items

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themselves were not directly manipulated or assessed. Rather, this study focused on the outcomes of change detection, relevant knowledge development, and strategic behavior that were suggested to be the results or manifestations of some of these key regulatory processes and on a metacognitive intervention that was expected to prompt planning, monitoring, and evaluating processes. Results from Chen et al. (2005) shed some initial light on the importance of in situ self-regulatory processes related to goal choice and goal striving, but a more specific investigation of these processes, especially from a longitudinal perspective, could prove quite useful in increasing our understanding of adaptive performance. This may be especially true if links between these regulatory processes and the suggested outcomes discussed in this paper can be empirically established. This would provide not only an additional understanding of how and why people are able to adapt to task changes, but it could also serve as a platform for better understanding the influences of numerous other factors that have been shown to predict adaptive performance such as self-efficacy, training knowledge/skill, and task knowledge structure (e.g. Ford et al., 1998; Kozlowski et al., 2001).

Another need for future research involves the further examination of individual difference factors as predictors of adaptive performance effectiveness. While the individual difference hypotheses in this study were not supported, previous research has established that factors such as cognitive ability, personality, and goal orientation can have effects (LePine et al., 2000; Pulakos et al., 2002). One potentially useful direction for future research involves more critically examining these individual difference factors in terms of what types of tasks change they may best predict adaptive performance in response to as well as how they may have their effects. This type of approach is consistent with recent theoretic work by Ployhart & Bliese (2006) who discuss the potential importance of myriad individual difference factors for adaptability and how their predictive strength may vary depending on different types of tasks that change. The current study may provide some help in this vein by providing initial support for the importance of change detection, relevant knowledge acquisition, and strategy change as important predictors of adaptive performance effectiveness and offering different types of task changes as a starting point for investigating the influences of individual differences on adaptive performance.

In a similar vein, future research on adaptive performance could benefit from considering the importance of additional individual difference factors. The factors examined in this literature are traditionally cognitive and behavioral in nature, but certain affective individual differences may also be important predictors. One such potentially interesting individual difference is emotion control (e.g. Kanfer & Ackerman, 1989; Kanfer et al., 1996). Emotion control is suggested to be a motivational skill that deals with regulating one's reactions to anxiety and negative-emotion inducing events during skill acquisition or performance. These skills are suggested to protect essential on-task attention and effort in the face of difficulty. Keith & Frese (2005) provide some initial support for the importance of emotion control in predicting adaptive transfer performance, but future work examining this and similar affective individual differences as predictors of adaptive performance would likely be valuable.

Another possibly useful direction for future research centers on more critically examining adaptive performance at the team level. While adaptive performance has not received as much attention at the team level as it has at the individual level, this is not to say tha

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say that work has not been done. Theoretical work by Kozlowski and colleagues (Kozlowski, 1998; Kozlowski et al. 1996a, 1996b, 1999) and empirical work by LePine (2003) and Chen et al. (2005) have began to discuss the importance of team composition and process factors, among other things, as important determinants of team adaptive performance. Similar to the individual level adaptive performance literature, however, there is ample opportunity for future work investigating key in situ team processes that may have an impact on team adaptive performance effectiveness.

Researchers such as Marks, Mathieu, and Zaccaro (2001) discuss a number of team processes that are relevant for performance, and many of these may also be crucial predictors of adaptive performance effectiveness. Chen et al. (2005) provide some initial support for the importance of team transition and action phase processes as predictors of adaptive performance effectiveness in teams, but more work can be done. These processes, which include things such as mission analysis, goal specification, strategy formulation, monitoring progress toward goals, and backing-up behaviors, deserve further examination as predictors of adaptive performance. Furthermore, the findings of the current study which suggest that change detection, relevant knowledge acquisition, and strategy change may be important predictors of adaptive performance effectiveness at the individual level may be of use as a platform for attempting to understand how or why different team processes have effects on team adaptive performance.

## APPENDIX A

Definitions of Individual Adaptation and Adaptive Performance

| Authors | Definition |
|---|---|
| Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell (2001) | The generalization of trained knowledge and skills to new, more difficult, and more complex situations. |
| Ployhart & Bliese (2006) | An individual's ability, skill, disposition, willingness, and/or motivation, to change or fit different task, social, and environmental features. |
| Joung, Hesketh, & Neal (2006); Hesketh & Neal (1999) | An individual's capacity to deal with changing work requirements and novel or unusual situations. |
| Fine & Cronshaw (1999); Cronshaw & Jethmalani (2005) | Competencies that enable people to manage themselves in relation to the demands of conformity and/or change in particular situations. |
| Chen, Thomas, & Wallace (2005) | The capability to modify knowledge, skill, and other characteristics acquired during training to effectively meet novel, difficult, and complex situations. |
| Ivancic & Hesketh (2000); Bell & Kozlowski (2008); Keith & Frese (2005) | Using one's existing knowledge base to change a learned procedure, or to generate a solution to a completely new problem. |
| Smith, Ford, & Kozlowski (1997) | Adaptability...is evidenced when the individual responds successfully to changes in the nature of the trained task. |
| Pulakos, Arad, Donovan, & Plamondon (2000) | Situations in which individuals modified their behavior to meet the demands of a new situation or event or a changed environment. |

APPENDIX B

Consent Form

Research Participant Information and Consent

You are being asked to participate in a research project. Researchers are required to proved a consent form to inform you about the study, to convey that participation is voluntary, to explain the potential risks and benefits of participation, and to empower you to make an informed decisions. You should feel free to ask the researchers any questions that you may have.

**Study Title:**
Strategic Radar Simulation

**Investigator Names:**
Dustin Jundt & Dr. Steve Kozlowski

**Purpose of Research**
You are being asked to participate in a research study examining how different personal characteristics, thoughts, and beliefs influence learning, skill acquisition, and performance on a complex radar simulation task. You have been selected as a possible participant because of your membership in the psychology subject pool. In the entire study, approximately 300 people are being asked to participate.

**Description and Explanation of Procedure:**
Your participation in this study involves completing an online questionnaire and participating in a lab session. If you agree to participate, you will be asked to complete an online questionnaire that involves demographic information and measures of a number of different personal characteristics. This questionnaire should take approximately 30 minutes to complete. Once the questionnaire is completed, you will schedule a time to participate in a 2.5 hour lab session where you will learn and work with a radar simulation task. For this part of the study, you will go to the ADAPT LAB in room 204 Psychology Building. Upon arrival at your scheduled session, you will receive basic training on the Strategic Radar Simulation task and will then complete a number of trials on the simulation where you'll have to opportunity to further learn about the simulation and show your levels of skilled performance. Throughout these trials, you will be asked questions about your reactions, thoughts, task knowledge, and behaviors. At the conclusion of the lab session, you will be debriefed regarding the purpose of study and how your participation contributed to it. Research findings will not be immediately available upon your completion of the lab session but can be obtained by contacting the lead researcher (Dustin Jundt) in the future.

**Estimated time required and credits:**
Online questionnaire: 30 Minutes (1 Psychology subject pool credit)
Laboratory session: 2.5 hours for the (5 Psychology subject pool credits)

Total: 3 hours (6 Psychology subject pool credits).

**Potential Benefits:**
There are a number of potential benefits to you for taking part in this study. Throughout this study, you will gain experience with several standard, often used psychological measures. In addition, you will gain experience with a computer-based simulation task and training system similar to what is frequently used in organizations. Finally, you will gain knowledge about the process of conducting and participating in psychological research.

**Potential Risks and Discomforts:**
Although no foreseeable risks are expected from participating in this study, you may experience some fatigue during the experiment. The information collected from you and your privacy will be kept confidential to the maximum extent allowable by law, however there is a very slight risk of loss of privacy regarding the data that is provided.

**Researcher Contact Information:**
You will be able to view your responses at a later date and be fully debriefed on their meaning and implications if you so desire. The investigators will be available to answer any questions you may have. If, at any time, you feel your questions have not been adequately answered or you want to discuss the research, please contact the lead experimenter, Dustin Jundt (jundtdus@msu.edu; 775-2196) or the principal investigator, Dr. Steve Kozlowski (stevekoz@msu.edu; 353-8924).

**IRB Contact Information:**
If you have questions regarding your role and rights as a subject of research, would like to obtain information or offer input, or would like to register a complain about this study, you may contact, anonymously if you wish, Michigan State University's Human research Protection Program at 517-355-2180, fax: 517-432-4503, e-mail: irb@msu.edu, or regular mail at 202 Olds Hall, Michigan State University, East Lansing, MI 48824.

**Your Rights to Participate, Say No, or Withdraw.**
Your agreement to participate in this research is completely voluntary; you have the right to say no. You are free to withdraw consent and discontinue participation in this project at any time without penalty. If you choose to withdraw from the study prior to its completion, you will receive credit for the time you have spent in the study (1 credit per 30 minutes). Within one year of your participation, a computerized copy of this consent form will be provided to you upon request.

**Privacy and Confidentiality**
The data collected from this study will be kept confidential. All data will be stored on password-protected computers that can only be directly accessed by the two investigators listed above. If you agree to participate in this study, you will be asked to report your NAME, PID, and MSU email address at the beginning of the subsequent online questionnaire. While this questionnaire is internet-based, your IP addresses will not be logged. The reason you are asked for your name and PID is to ensure that you receive

full credit for your participation in the study. Your identity will not be associated with your responses, and it will be kept secure and confidential. Furthermore, once your credit is assigned and registered all identifying information will be erased from our records and any data published or presented in professional sources will be done at an aggregate level; your responses will not be identifiable. Your privacy will be protected to the maximum extent allowable by law.

**Consent**
If you voluntarily agree to participate in this study, you will be asked to check a box below that indicates your consent.

APPENDIX C

Debriefing Form

**Strategic Radar Simulation Study Debriefing Form**

Thank you for your participation in this investigation. The study in which you just participated was designed to examine the effects of an intervention aimed at prompting metacognitive on the ability of people to perform well on the Tactical Action Simulation (TAS) and adapt to a number of different types of task change. The instructions that you received throughout the study were designed to influence how you approached thinking about the task and monitoring the success of your learning, strategies, and performance throughout the task, but even more so for the last six trials. The questions that you answered at different points during the study will allow us to help assess your personal characteristics, learning, beliefs, goals, and thoughts and how they influenced your performance and adaptability to changes in the TAS task.

Most of the questions that you answered have no correct or incorrect answers and have absolutely no significance other than to help us understand your performance and adaptation on the TAS task. We have not recorded your identity with the data that we collected, and we will keep this data confidential to the fullest extent possible. All of the information that we have collected will be used to try to help us to more completely understand how people are able to adapt to different types of task changes and if or how having people in engage in metacognitive activities related to making specific plans and strategies, monitoring progress toward goals, and evaluating the effectiveness of these plans and strategies influences this adaptation and performance process.

If you have any questions about this study or would like to receive a copy of the results when they are complete, please notify the investigator at this time. We have tried to make your experience in this study interesting for you and we are open to suggestions for improvement. If you think that we can improve this study in any way, please feel free to talk to us now or in the future. If you have any additional questions about the study or your involvement in it, please contact the Research Coordinator or Principal Investigator, or you can speak with the investigator at this time. If you have questions or concerns about your rights as a research participant, please contact UCRIHS.

| **Research Coordinator** | **Principal Investigator** | **UCRIHS** |
|---|---|---|
| Dustin Jundt | Dr. Steve Kozlowski | ucrihs@msu.edu |
| jundtdus@msu.edu | stevekos@msu.edu | 355-2180 |
| 775-2196 | 353-8924 | |

# APPENDIX D

## Metacognitive Intervention Text

Developing skill and performing well on a complex simulation like the TAS can be challenging. However, decades of research show that focusing on being aware of and managing your thoughts, strategies, and behaviors as you work on these types of tasks can be extremely beneficial. Psychologists use the term "meta-cognitive awareness" to describe this process of actively focusing on and managing your thoughts, strategies, and behaviors while performing on a task. Metacognitive-awareness has 4 key features that have repeatedly been shown to positively predict learning, skill development, and performance on a variety of tasks, especially those like the TAS.

• ***Planning*** what you will study in the manual and how you will use TAS simulation practice opportunities to work toward developing skill, performing well on the task, and achieving the goals that you set and commit to.
• ***Monitoring*** your study and practice activities to see if you are focusing on information and actions that help you perform well on TAS and achieve your goals.
• ***Evaluating*** your TAS feedback to figure out which strategies or techniques worked well in previous trials and which did not so that you can improve.
• ***Adapting*** or changing your strategies and actions to improve future TAS performance and success.

Throughout the next set of trials, you should focus on specifically ***planning*** for performance and improvement, ***monitoring*** your performance levels and feedback, ***evaluating*** the quality of your strategies and techniques, and ***adapting*** or changing those strategies that are not successful.

# APPENDIX E

## Metacognitive Intervention Probes

To what extent are *you* actively *planning* (or thinking about) how you will achieve your TAS goals through the use of study and practice opportunities?

To what extent are *you* actively *monitoring* your study and practice activities to see if you are attending to information and actions that help you achieve your TAS goals?

To what extent are *you evaluating* and using your TAS feedback to figure out what worked well and what did not in previous trials so that you can improve?

To what extent are *you* actively *adapting* or changing your strategy and actions in an effort to improve your progress toward your TAS goals?

## APPENDIX F

### Learning Orientation Scale Items

### Adapted from VandeWalle (1997)

I am willing to select a challenging assignment that I can learn a lot from.
I often look for opportunities to develop new skills and knowledge.
I enjoy challenging and difficult tasks where I'll learn new skills.
For me, development of my ability is important enough to take risks.
I prefer situations that require a high level of ability and talent.

*Response Options*

1: strongly disagree
2: disagree
3: neutral
4: agree
5: strongly agree

APPENDIX G

Conscientiousness Scale Items

From Costa & McCrae (1992)

I'm known for my prudence and common sense.
I don't take civic duties like voting very seriously.
I keep myself informed and usually make intelligent decision.
I often come into situations without being fully prepared.
I pride myself on my sound judgment.
I don't seem to be completely successful at anything.
I'm very competent person.
I am efficient and effective at my work.
I would rather keep my options open than plan everything in advance.
I keep my belongings neat and clean.
I am not a very methodical person.
I like to keep everything in its place so I know just where it is.
I never seem to be able to get organized.
I tent to e somewhat fastidious or exacting.
I'm not compulsive about cleaning.
I spend a lot of time looking for things I've misplaced.
I try to perform all the tasks assigned to me conscientiously.
Sometimes I'm not as dependable or reliable as I should be.
I pay my debts promptly and in full.
Sometimes I cheat when I play solitaire.
When I make a commitment, I can always be counted on to follow through.
I adhere strictly to my ethical principles.
I try to do jobs carefully, so they won't have to be done again.
I'd really have to be sick before I'd miss a day of work.
I am easy-going and lackadaisical.
I have a clear set of goals and work toward them in an orderly fashion.
When I start a self-improvement program, I usually let it slide after a few days.
I work hard to accomplish my goals.
I don't feel like I'm driven to get ahead.
I strive to achieve all I can.
I strive for excellence in everything I do.
I'm something of a "workaholic."
I'm pretty good about pacing myself so as to get things done on time.
I waste a lot of time before settling down to work.
I am a productive person who always gets the job done.
I have trouble making myself do what I should.
Once I start project, I almost always finish it.
When a project gets too difficult, I'm inclined to start a new one.
There are so many little jobs that need to be done that I sometimes just ignore them all.
I have a lot of self-discipline.

Over the years I've done some pretty stupid things.
I think things though before coming to a decision.
Occasionally I act first and think later.
I always consider the consequences before I take action.
I often do things on the spur of the moment.
I rarely make hasty decisions.
I plan ahead carefully when I go on a trip.
I think twice before I answer a question.

*Response Options*

1: strongly disagree
2: disagree
3: neutral
4: agree
5: strongly agree

## APPENDIX H

### Openness to Experience Scale Items

### From Costa & McCrae (1992)

I have a very active imagination.
I try to keep all my thought directed along realistic lines and avoid flights of fancy.
I have an active fantasy life.
I don't like to waste my time daydreaming.
I enjoy concentrating on a fantasy or daydream and exploring all its possibilities, letting it grow and develop.
If I feel my mind starting to drift off into daydreams, I usually get busy and start concentrating on some work or activity instead.
As a child I rarely enjoyed games of make-believe.
I would have difficulty just letting my mind wander without control or guidance.
Aesthetic and artistic concerns aren't very important to me.
I am sometimes completely absorbed in music I am listening to.
Watching ballet or modern dance bores me.
I am intrigued by the patterns I find in art and nature.
Poetry has little or no effect on me.
Certain kinds of music have an endless fascination for me.
Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement.
I enjoy reading poetry that emphasizes feelings and images more than story lines.
Without strong emotions, life would be uninteresting to me.
I rarely experience strong emotions.
How I fell about things is important to me.
I seldom pay much attention to my feelings of the moment.
I experience a wide range of emotions or feelings.
I seldom notice the moods or feelings that different environments produce.
I find it easy to empathize - to feel myself what others are feeling.
Odd things – like certain scents or the names of distant places – can evoke strong moods in me.
I'm pretty set in my ways.
I think it's interesting to learn and develop new hobbies.
Once I find the right way to do something, I stick to it.
I often try new and foreign foods.
I prefer to spend my time in familiar surroundings.
Sometimes I make changes around the house just to try something different.
On a vacation, I prefer going back to a tried and true spot.
I follow the same route when I go someplace.
I often enjoy playing with theories or abstract ideas.
I find philosophical arguments boring.
I enjoy solving problems or puzzles.
I sometimes lost interest when people talk about very abstract, theoretical matters.

I enjoy working on “mind-twister” – types puzzles.
I have little interest in speculating on the nature of the universe or the human condition.
I have a lot of intellectual curiosity.
I have a wide range of intellectual interests.
I believe letting students hear controversial speakers can only confuse and mislead them.
I believe that laws and social policies should change to reflect the needs of a changing World.
I believe we should look to our religious authorities for decisions on moral issues.
I believe that the different ideas of right and wrong that people in other societies have may be valid for them.
I believe that loyalty to one’s ideals and principles is more important than “open-mindedness”.
I consider myself broad-minded and tolerant of other people’s lifestyles.
I think that if people don’t know what they believe in by the time they’re 25, there’s something wrong with them.
I believe that the “new morality” of permissiveness is no morality at all.

*Response Options*

1: strongly disagree
2: disagree
3: neutral
4: agree
5: strongly agree

APPENDIX I

Declarative Knowledge Quiz Items

If you want to "hook" a target, what would you do?
a. Left-click on the target
b. Right-click on the target
c. Select "clear" from the final engagement menu
d. Zoom in on the target

If a target's Response is Given, what is the likely Intent of the target?
a. Military
b. Hostile
c. Civilian
d. Peaceful

Which type of target would travel at a Speed of 27 knots?
a. Air
b. Sub
c. Surface
d. Unknown

If a target's Intelligence is Platform, what Class does this suggest for the target?
a. Civilian
b. Military
c. Surface
d. Unknown

If a target's Response = No Response, which of the following actions should you take?
a. Choose class is Civilian
b. Choose intent is Hostile
c. Choose intent is Peaceful
d. Choose type is AIR

Which is the proper order for making proper cue decisions?
a. Class, Type, Intent, Final Engagement
b. Intent, Class, Type, Final Engagement
c. Type, Class, Intent, Final Engagement
d. Type, Intent, Class, Final Engagement

A Final Engagement decision of "Shoot" should be made for a target with which of the following characteristics?
a. Type = Air, Class = Military, Intent = Peaceful
b. Type = Sub, Class = Military, Intent = Unknown
c. Type = Surface, Class = Unknown, Intent = Hostile
d. Type = Sub, Class = Civilian, Intent = Peaceful

How many points are awarded for making all four cue decisions correctly?

a. 10
b. 25
c. 50
d. 100

During the last set of trials, how many targets were in the simulation?

a. 8
b. 12
c. 18
d. 25

If a target's Altitude/Depth is 30, which of the following actions should you take?

a. Choose class is Civilian
b. Choose intent is Hostile
c. Choose intent is Peaceful
d. Choose type is AIR

What Direction of Origin would a Military Class target come from?

a. Blue Lagoon
b. Indian Ocean
c. Red Sea
d. Unknown

A target with a Hostile Intent would engage in which of the following Countermeasures?

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

If you've just noticed three targets near your inner perimeter, which of the following is the best thing to do next?

a. Engage the target closest to the inner perimeter
b. Engage the fastest target near the inner perimeter
c. Examine the area for "pop-up" targets
d. Zoom-In to check how close targets are to the inner perimeter

What is a "pop-up" target?

a. A target that appears suddenly anywhere on your screen.
b. A target that appears suddenly near the inner defensive perimeter.
c. A target that appears suddenly near the outer defensive perimeter.
d. A target that appears suddenly near your ship.

Where is

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Where is the inner defensive perimeter located?

a. 4 NM
b. 10 NM
c. 20 NM
d. 40 NM

How many points are lost when a target crosses the inner defensive perimeter?

a. 10
b. 25
c. 50
d. 100

## APPENDIX J

### Metacognitive Intervention Manipulation Check Items

During the session, were you told and did you hear that you should focus on...

- Planning how to achieve your TAS goals through the use of study and practice opportunities?

- Monitoring your study and practice activities to see if you are attending to information and actions that help you achieve your TAS goals?

- Evaluating your TAS feedback to figure out what did or did not work well in previous trials?

- Actively adapting or changing your learning strategy and actions to improve progress toward your TAS goals?

*Response Options*

1: strongly disagree
2: disagree
3: neutral
4: agree
5: strongly agree

# APPENDIX K

## Tables

Table 1

*Means, Standard Deviations, Intercorrelations, and Reliabilities for Key Variables Across All Conditions (n = 283)*

| | | | | Correlations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1. | Gender[a] | 1.45 | 0.50 | - | | | | | | | | | | | |
| 2. | Computer Experience | 2.58 | 1.05 | .58* | - | | | | | | | | | | |
| 3. | Practice Performance | 1047.70 | 256.17 | .10 | .12 | - | | | | | | | | | |
| 4. | Cognitive Ability | 24.61 | 3.39 | .11 | .19* | .17* | - | | | | | | | | |
| 5. | Learning G.O. | 3.83 | 0.48 | .13* | .20* | .14* | .08 | *.78* | | | | | | | |
| 6. | Conscientiousness | 3.40 | 0.39 | -.04 | -.02 | .03 | -.14* | .36* | *.91* | | | | | | |
| 7. | Openness to Experience | 3.51 | 0.39 | -.20* | .04 | .15* | .12* | .28* | .01 | *.90* | | | | | |
| 8. | M.C. Intervention[b] | 0.52 | 0.50 | -.01 | .03 | .01 | -.03 | -.04 | .05 | -.01 | - | | | | |
| 9. | M.C. Manipulation Check | 3.85 | 0.75 | -.12* | -.02 | .10 | .01 | .15* | .22* | .17* | .05 | *.88* | | | |
| 10. | Task Change Code 1[c] | 0.33 | 0.47 | .01 | .05 | -.05 | .15* | .05 | -.02 | .11 | .02 | .01 | - | | |
| 11. | Task Change Code 2[d] | 0.34 | 0.47 | -.02 | .00 | .09 | -.12* | -.03 | .05 | -.01 | -.01 | .13* | -.50* | - | |
| 12. | Task Effort (standardized) | 0.00 | 1.00 | .06 | .16* | .30* | .18* | .10 | -.01 | .10 | -.03 | .17* | .00 | .00 | - |
| 13. | Adaptive Performance Effectiveness (standardized) | 0.00 | 1.00 | .13* | .14* | .42* | .19* | .14* | .01 | .11 | -.08 | .19* | .00 | .00 | .72* |

* = $p < .05$

[a] Gender (1 = Female, 2 = Male)

[b] M.C. Intervention (0 = No Intervention, 1 = Intervention)

[c] Task Change Code 1 (0 = Difficulty, 1 = Component)

[d] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table 2

*Means, Standard Deviations, Intercorrelations, and Reliabilities for Key Variables in the Difficulty Task Change Condition (n = 95)*

| | | | | Correlations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1. | Gender | 1.45 | 0.50 | - | | | | | | | | | | |
| 2. | Computer Experience | 2.51 | 1.07 | .64* | - | | | | | | | | | |
| 3. | Practice Performance | 1034.74 | 325.76 | .16 | .22* | - | | | | | | | | |
| 4. | Cognitive Ability | 24.48 | 3.93 | .27* | .37* | .21* | - | | | | | | | |
| 5. | Learning G.O. | 3.81 | 0.46 | .21* | .27* | .17 | .12 | - | | | | | | |
| 6. | Conscientiousness | 3.38 | 0.38 | -.13 | -.10 | .10 | -.16 | .32* | - | | | | | |
| 7. | Openness to Experience | 3.46 | 0.36 | -.01 | .18 | .27* | .07 | .26* | .06 | - | | | | |
| 8. | M.C. Intervention | 0.52 | 0.50 | -.09 | -.07 | -.07 | -.11 | .12 | .00 | .06 | - | | | |
| 9. | Detection | 1.88 | 0.32 | -.07 | .11 | .26* | .16 | -.08 | -.06 | .19 | -.15 | - | | |
| 10. | Relevant Knowledge Acquisition | 0.85 | 0.36 | .08 | .06 | .21* | .17 | .13 | -.02 | .18 | -.05 | -.06 | - | |
| 11. | Task Effort | 13.24 | 3.38 | .24* | .35* | .55* | .28* | .21* | .04 | .20 | -.08 | .24* | .21* | - |
| 12. | Adaptive Performance Effectiveness | 1231.58 | 397.94 | .25* | .30* | .63* | .26* | .23* | .05 | .23* | -.08 | .25* | .21* | .93** |

* = $p < .05$

Table 3

*Means, Standard Deviations, Intercorrelations, and Reliabilities for Key Variables in the Component Task Change Condition (n = 93)*

| | | | | Correlations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1. | Gender | 1.46 | 0.50 | - | | | | | | | | | | | |
| 2. | Computer Experience | 2.66 | 1.02 | .51* | - | | | | | | | | | | |
| 3. | Practice Performance | 1027.96 | 241.09 | .07 | .03 | - | | | | | | | | | |
| 4. | Cognitive Ability | 25.33 | 3.18 | .20 | .21* | .13 | - | | | | | | | | |
| 5. | Learning G.O. | 3.86 | 0.46 | .08 | .07 | .10 | .09 | - | | | | | | | |
| 6. | Conscientiousness | 3.39 | 0.41 | .05 | .03 | -.10 | -.18 | .36* | - | | | | | | |
| 7. | Openness to Experience | 3.57 | 0.44 | -.24* | .05 | .08 | .17 | .29* | -.13 | - | | | | | |
| 8. | M.C. Intervention | 0.54 | 0.50 | .04 | .09 | .13 | .11 | -.10 | .04 | -.12 | - | | | | |
| 9. | Detection | 1.97 | 0.18 | .05 | .18 | -.03 | .12 | -.03 | .05 | .15 | -.05 | - | | | |
| 10. | Relevant Knowledge Acquisition | 2.95 | 0.23 | .13 | .11 | .03 | .16 | .07 | -.13 | .04 | -.03 | .23* | - | | |
| 11. | Task Effort | 11.54 | 1.32 | .00 | .08 | .16 | .17 | -.08 | -.07 | .10 | -.02 | .21* | .53* | - | |
| 12. | Correct TCI Decisions | 34.27 | 4.62 | .04 | .10 | .17 | .15 | -.04 | -.06 | .09 | -.02 | .21* | .56* | .98* | - |
| 13. | Adaptive Performance Effectiveness | 1061.29 | 273.87 | .08 | .15 | .15 | .06 | .04 | -.06 | .09 | -.10 | .18 | .49* | .79* | .88** |

* = $p < .05$

Table 4

*Means, Standard Deviations, Intercorrelations, and Reliabilities for Key Variables in the Coordinative Task Change Condition (n = 95)*

| | | | | Correlations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1. | Gender | 1.44 | 0.50 | - | | | | | | | | | | | |
| 2. | Computer Experience | 2.58 | 1.06 | .60* | - | | | | | | | | | | |
| 3. | Practice Performance | 1080.00 | 179.60 | .04 | .07 | - | | | | | | | | | |
| 4. | Cognitive Ability | 24.03 | 2.87 | -.20 | -.08 | .22* | - | | | | | | | | |
| 5. | Learning G.O. | 3.81 | 0.53 | .09 | .24* | .18 | .02 | - | | | | | | | |
| 6. | Conscientiousness | 3.42 | 0.38 | -.04 | .01 | .08 | -.05 | .41* | - | | | | | | |
| 7. | Openness to Experience | 3.51 | 0.36 | -.37* | -.16 | .08 | .07 | .29* | .14 | - | | | | | |
| 8. | M.C. Intervention | 0.52 | 0.50 | .01 | .07 | .01 | -.09 | -.13 | .11 | .04 | - | | | | |
| 9. | Detection | 1.92 | 0.28 | .04 | .06 | .12 | .11 | .34* | .07 | .06 | -.07 | - | | | |
| 10. | Relevant Knowledge Acquisition | 2.46 | 1.09 | -.20* | -.13 | -.01 | .26* | .04 | -.06 | .24* | .14 | .01 | - | | |
| 11. | Task Effort | 11.59 | 0.82 | -.05 | .04 | .05 | .08 | .17 | .00 | -.01 | .00 | .08 | .12 | - | |
| 12. | High Priority Engagements | 6.77 | 0.61 | -.25* | -.19 | -.12 | -.06 | -.05 | -.13 | .11 | .08 | -.05 | .36* | .66* | - |
| 13. | Adaptive Performance Effectiveness | 1023.16 | 212.61 | .04 | -.04 | .44* | .25* | .15 | .06 | .01 | -.06 | .07 | .17 | .45* | .17 |

* = $p < .05$

Table 5

*Interactive Effects of Task Effort and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. Targets Prosecuted | .66* | .57 | .39* |
| Task Change Code 1[a] | .01 | | |
| Task Change Code 2[b] | -.03 | | |
| 3. Targets Prosecuted X Task Change Code 1 | -.03 | .60 | .02* |
| Targets Prosecuted X Task Change Code 2 | -.34* | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table 6

*Effects of the Use of New Information Cues on Component Change Adaptive Performance Effectiveness (n = 93)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | 24.24 | .63 | .63* |
| Computer Experience | 17.07 | | |
| Trial 6 Performance | .02 | | |
| Targets Prosecuted | 161.75* | | |
| 2. Correct TCI Decisions | 159.31* | .90 | .26* |

* = $p < .05$

Table 7

*Effects of Behavioral Act Prioritization on Coordinative Change Adaptive Performance Effectiveness (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | 66.01 | .41 | .41* |
| Computer Experience | -36.65 | | |
| Trial 6 Performance | .51* | | |
| Targets Prosecuted | 115.68* | | |
| 2. High Priority Engagements | -52.07 | .42 | .01 |

* = $p < .05$

Table 8

*Effects of Relevant Declarative Knowledge Development on Difficulty Change Task Effort (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.02 | .36 | .36* |
| Computer Experience | .78* | | |
| Trial 6 Performance | .01* | | |
| 2. Relevant Declarative Knowledge | .88 | .37 | .01 |

* = $p < .05$

Table 9

*Effects of Relevant Declarative Knowledge Development on Component Change Correct Use of New Information Cues (n = 93)*

| Step | DV Name *b* | $R^2$ Total | $\Delta R^2$ |
|---|---|---|---|
| 1. Gender | -.31 | .04 | .04 |
| Computer Experience | .51 | | |
| Trial 6 Performance | .00 | | |
| 2. Relevant Declarative Knowledge | 11.45* | .35 | .31* |

* = $p < .05$

Table 10

*Effects of Relevant Declarative Knowledge Development on Coordinative Change Behavioral Act Prioritization (n = 95)*

| Step | DV Name *b* | $R^2$ Total | $\Delta R^2$ |
|---|---|---|---|
| 1. Gender | -.27 | .08 | .08 |
| Computer Experience | -.03 | | |
| Trial 6 Performance | .00 | | |
| 2. Relevant Declarative Knowledge | .18* | .17 | .10* |

* = $p < .05$

Table 11

*Effects of Change Detection on Relevant Declarative Knowledge Development for Difficulty Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .05 | .05 | .05 |
| Computer Experience | -.01 | | |
| Trial 6 Performance | .00 | | |
| 2. Change Detection | -.13 | .06 | .01 |

* = $p < .05$

Table 12

*Effects of Change Detection on Relevant Declarative Knowledge Development for Component Change (n = 93)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .04 | .02 | .02 |
| Computer Experience | .01 | | |
| Trial 6 Performance | .00 | | |
| 2. Change Detection | .28* | .07 | .05* |

* = $p < .05$

Table 13

*Effects of Change Detection on Relevant Declarative Knowledge Development for Coordinative Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.42 | .04 | .04 |
| Computer Experience | -.02 | | |
| Trial 6 Performance | .00 | | |
| 2. Change Detection | .41 | .05 | .01 |

* = $p < .05$

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Table 14

*Interactive Effects of the Metacognitive Intervention and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. M.C Intervention | -.17 | .20 | .01 |
| Task Change Code 1[a] | .00 | | |
| Task Change Code 2[b] | -.08 | | |
| 3. M.C Intervention X Task Change Code 1 | -.24 | .20 | .00 |
| M.C Intervention X Task Change Code 2 | -.07 | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table 15

*Effects of the Metacognitive Intervention on Change Detection for Difficulty Task Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.16 | .11 | .11* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .00* | | |
| 2. M.C Intervention | -.09 | .13 | .02 |

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Table 16

*Effects of the Metacognitive Intervention on Relevant Declarative Knowledge Development for Difficulty Task Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .05 | .05 | .05 |
| Computer Experience | -.01 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | -.02 | .05 | .00 |

* = $p < .05$

Table 17

*Effects of the Metacognitive Intervention on Difficulty Task Change Effort (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.02 | .36 | .36* |
| Computer Experience | .78* | | |
| Trial 6 Performance | .01* | | |
| 2. M.C Intervention | -.18 | .36 | .00 |

* = $p < .05$

Table 18

*Effects of the Metacognitive Intervention on Change Detection for Component Task Change (n = 93)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.02 | .04 | .04 |
| Computer Experience | .04 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | -.02 | .04 | .00 |

* = $p < .05$

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Table 19

*Effects of the Metacognitive Intervention on Relevant Declarative Knowledge Development for Component Task Change (n = 93)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .04 | .02 | .02 |
| Computer Experience | .01 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | -.02 | .02 | .00 |

* = $p < .05$

Table 20

*Effects of the Metacognitive Intervention on Component Change Correct Use of New Information Cues (n = 93)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.31 | .04 | .04 |
| Computer Experience | .51 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | -.48 | .04 | .00 |

* = $p < .05$

Table 21

*Effects of the Metacognitive Intervention on Change Detection for Coordinative Task Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .01 | .02 | .02 |
| Computer Experience | .01 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | -.04 | .02 | .01 |

* = $p < .05$

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Table 22

*Effects of the Metacognitive Intervention on Relevant Declarative Knowledge Development for Coordinative Task Change (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.42 | .04 | .04 |
| Computer Experience | -.02 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | .32 | .06 | .02 |

$* = p < .05$

Table 23

*Effects of the Metacognitive Intervention on Coordinative Change Behavioral Act Prioritization (n = 95)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | -.27 | .08 | .08 |
| Computer Experience | -.03 | | |
| Trial 6 Performance | .00 | | |
| 2. M.C Intervention | .11 | .09 | .01 |

$* = p < .05$

Table 24

*Interactiv*

*on Adapti*

| Step |
|---|
| 1. Gen |
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| Tria |
| 2. Cog |
| Tas |
| Tas |
| 3. Co |
| Ta |
| Co |
| Ta |

* = *p*

[a] Tas

[b] Tas

Table 24

*Interactive Effects of Cognitive Ability and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| Step | DV Name | | |
|---|---|---|---|
| | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. Cognitive Ability | .03* | .20 | .01 |
| Task Change Code 1[a] | -.03 | | |
| Task Change Code 2[b] | -.06 | | |
| 3. Cognitive Ability X Task Change Code 1 | -.03 | .21 | .01 |
| Cognitive Ability X Task Change Code 2 | .04 | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table

*Inter*

*Type*

Step

1.

2.

3.

*

a.

b

Table 25

*Interactive Effects of Learning Goal Orientation and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| | DV Name | | |
|---|---|---|---|
| Step | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. Learning G. O. | .14 | .19 | .01 |
| Task Change Code 1[a] | .00 | | |
| Task Change Code 2[b] | -.07 | | |
| 3. Learning G. O. X Task Change Code 1 | -.29 | .19 | .00 |
| Learning G. O. X Task Change Code 2 | -.11 | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table

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b

Table 26

*Interactive Effects of Conscientiousness and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| Step | DV Name $b$ | $R^2$ Total | $\Delta R^2$ |
|---|---|---|---|
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. Conscientiousness | .01 | .19 | .00 |
| Task Change Code 1[a] | .00 | | |
| Task Change Code 2[b] | -.10 | | |
| 3. Conscientiousness X Task Change Code 1 | -.10 | .19 | .00 |
| Conscientiousness X Task Change Code 2 | .06 | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Table 2

*Interac*

Type c

| Step |
| --- |
| 1. C |
| C |
| T |
| 2. |
| 3. |

* =

[a] T

[b]

Table 27

*Interactive Effects of Openness to Experience and Task Change Type on Adaptive Performance Effectiveness (n = 283)*

| Step | DV Name | | |
|---|---|---|---|
| | *b* | $R^2$ Total | $\Delta R^2$ |
| 1. Gender | .10 | .19 | .19* |
| Computer Experience | .06 | | |
| Trial 6 Performance | .002* | | |
| 2. Openness to Experience | .15 | .19 | .01 |
| Task Change Code 1[a] | -.02 | | |
| Task Change Code 2[b] | -.10 | | |
| 3. Openness to Experience X Task Change Code 1 | -.05 | .19 | .00 |
| Openness to Experience X Task Change Code 2 | -.18 | | |

* = $p < .05$

[a] Task Change Code 1 (0 = Difficulty, 1 = Component)

[b] Task Change Code 2 (0 = Difficulty, 1 = Coordinative)

Figure 1

A Cont

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APPENDIX J

Figures

Figure 1

A Control Theory-Based Heuristic of Self-Regulation

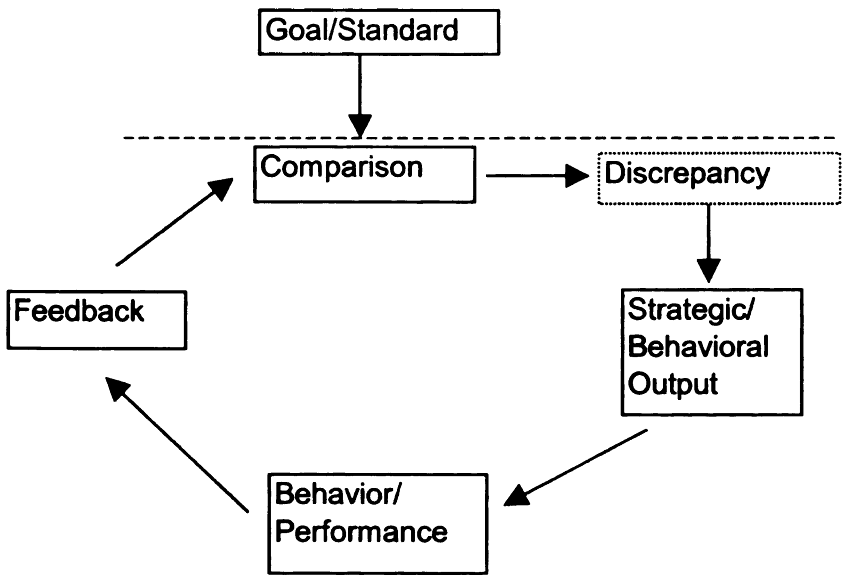


Figure 2

A Control Theory-Based Heuristic of Adaptation

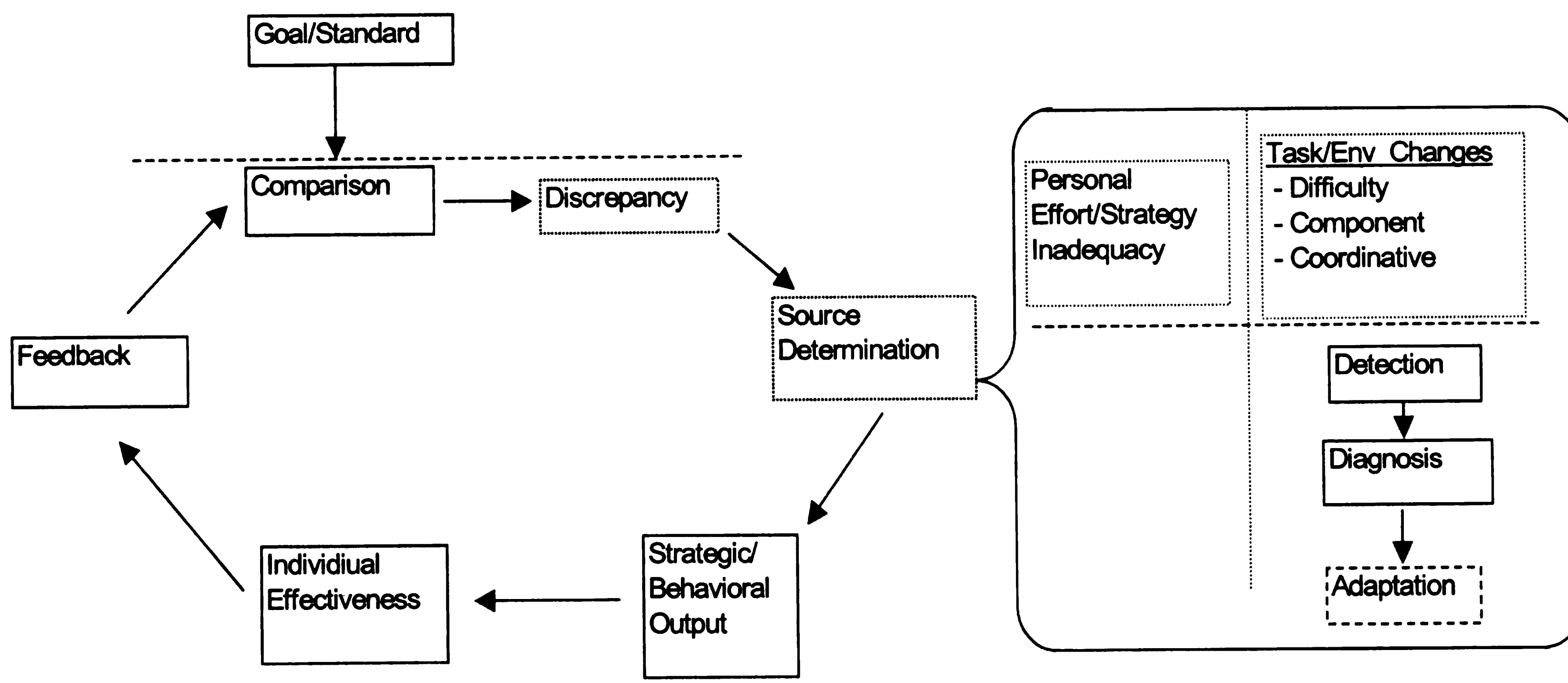


Figure 3

A General Model of the Adaptive Performance Process

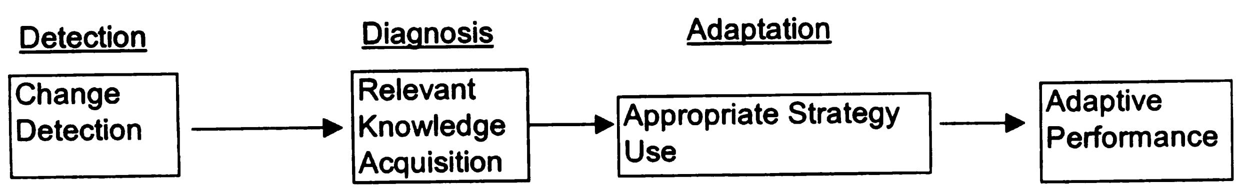


Figure 4

A Task Change Specific Model of the Adaptive Performance Process

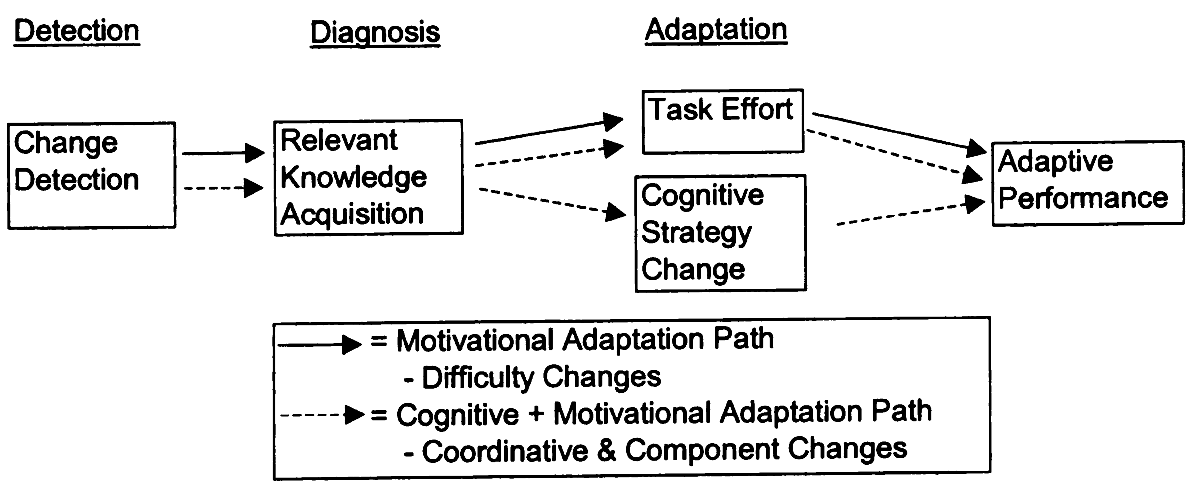
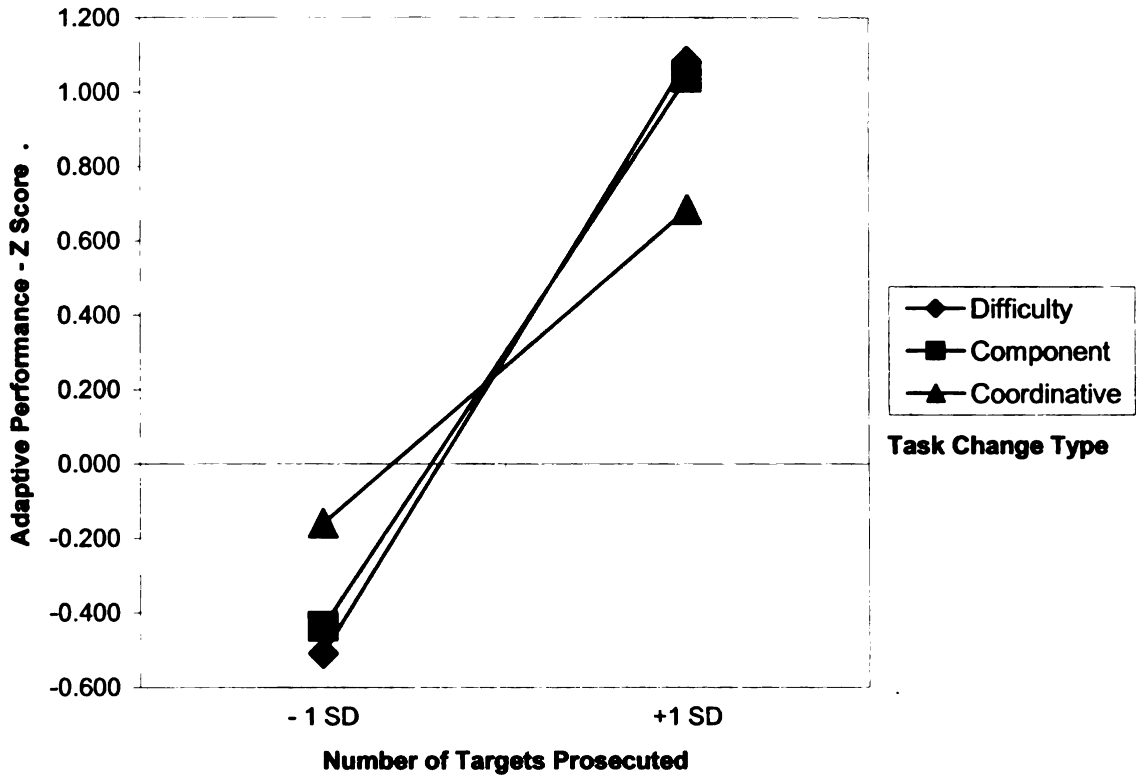


Figure 5

The Interactive Effect of Task Related Effort and Task Change Type on Levels of Adaptive Performance Effectiveness



REFERENCES

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

Aguinis, H. (1995). Statistical power problems with moderated multiple regression in management research. *Journal of Management, 21*, 1141-1158.

Aguinis, H., Boik, R. J., & Pierce, C. A. (2001). A generalized solution for approximating the power to detect effects of categorical moderator variables using multiple regression. *Organizational Research Methods, 4*, 291-323.

Aguinis, H., & Stone-Romero, E. F. (1997). Methodological artifacts in moderated multiple regression and their effects on statistical power. *Journal of Applied Psychology, 82*, 192-206.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage

Amabile, T. M. (1983). The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology, 45*, 357-376.

Ames, C. (1992). Classrooms: Goal, structures, and student motivation. *Journal of Educational Psychology, 84*, 261-271.

Anderson, C. A., Lindsay, A. J., & Bushman, B. J. (1999). Research in the psychological laboratory: Truth or triviality? *Current Directions in Psychological Science, 8*, 3-9.

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

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist, 48*, 35-44.

Aronson, E. & Carlsmith, J. M. (1968). Experimentation in social psychology. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol 2, pp. 1-79). Reading, MA: Adddison-Wesley.

Aronson, E., Wilson, T.D. & Akert, R. M. (1994). *Social psychology* (3rd ed.). New York: Addison-Wesley

Ashton, M. C. (1998). Personality and job performance: the importance of narrow traits. *Journal of Organizational Behavior, 19*, 289-303.

Baron, R. M, & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.

Barrick, M. R., & Mount, M. K. (1991). The big five personality dimensions and job performance: A meta-analysis. *Personnel Psychology, 44*, 1-26.

Bell, B. S., & Kozlowski, S. W. J. (2002). Adaptive guidance: Enhancing self-regulation, knowledge, and performance in technology-based training. *Personnel Psychology, 55*, 267-306.

Bell, B. S., & Kozlowski, S. W. J. (2008). Active learning: Effects of core training design elements on self-regulatory processes, learning, and adaptability. *Journal of Applied Psychology, 93*, 296-316.

Berardi-Coletta, B., Buyer, L. S., Dominowski, R. L., & Rellinger, E. R. (1995). Metacognition and problem solving: A process-oriented approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 205-223.

Blickle, G. (1986). Personality traits, learning strategies, and performance. *European Journal of Personality, 10*, 337-352.

Borman, W. C., Motowidlo, S. J. (1997). Task performance and contextual performance: The meaning for personnel selection research. *Human Performance, 10*, 99-109.

Brown, A. L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, New Jersey: Erlbaum.

Brown, A. L. Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In J. H. Flavell & E. M. Markman (Eds.), *Handbook of child psychology* (Vol. 3, pp. 77-166). New York: Wiley.

Brown, A. L., & Palincsar, A. S. (1982). Inducing strategic learning from texts by means of informed, self-control training. *Topics in Learning and Learning disabilities, 2*, 1-17.

Brown, A. L., & Palincsar, A. S. (1985). Reciprocal teaching of comprehension strategies: A natural history of one program for enhancing learning. In Garner, R., & Alexander, P. A. (1989). Metacognition: Answered and unanswered questions. *Educational Psychologist, 24*, 143-158.

Busato, C. C., Prins, F. J., Elshout, J. J., & Hamaker, C. (1999). The relation between learning styles, the Big Five personality traits, and achievement motivation in higher education. *Personality and Individual differences, 26*, 129-140.

Campbell, J. P. (1990). Modeling the performance prediction problem in industrial and organizational psychology. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of industrial and organizational psychology* (Vol. 1., 2nd ed.; pp. 687-732. Pala Alto, CA: Consulting Psychologists Press.

Campbell, J. P., McCloy, R. A., Oppler, S. H., & Sager, C. E. (1993). A theory of performance. In N. Schmitt & W. Borman (Eds.), *Personnel selection in organizations* (pp. 35-70). San Francisco: Jossey-Bass.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor analytic studies*. New York: Cambridge University Press.

Carver, C. S, & Scheier, M. F. (1981). *Attention and self-regulation: A control theory approach to human behavior*. New York: Springer-Verlag.

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

Carver, C. S, & Scheier, M. F. (2001). *On the self-regulation of behavior*. Cambridge, England: Cambridge University Press.

Cascio, W. F. (2003). Change in workers, work, and organizations. In: R. J. Klimoski, W. C. Borman, & D. R. Ilgen (Eds.), *Handbook of psychology* (Vol. 12, pp. 401-422). Wiley: Hoboken, NJ.

Chen, G., Thomas, B., & Wallace, J. C. (2005). A multilevel examination of the relationships among training outcomes, mediating regulatory processes, and adaptive performance. *Journal of Applied Psychology, 90*, 827-841.

Clause, C. S., Delbridge, K., Schmitt, N., Chan, D., & Jennings, D. (2001). Test preparation activities and employment tests performance. *Human Performance, 14*, 149-167.

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences: 1st edition*. New York: Academic Press.

Colquitt, J. A. (2008). Publishing laboratory research in AMJ: A question of when, not if. *Academy of Management Journal, 51*, 616-620.

Colquitt, J. A., & Simmering, M. J. (1998). Conscientiousness, goal orientation, and motivation to learn during the learning process: A longitudinal study. *Journal of Applied Psychology, 83*, 654-665.

Costa, P. T. Jr., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO-FFI) Professional Manual.* Odessa, FL: Psychological Assessment Resources, Inc.

Cronshaw, S. F., & Jethmalani, S (2005). The structure of workplace adaptive skill in a career inexperienced group. *Journal of Vocational Behavior, 66*, 45-65.

Delclos, V. R., & Harrington, C. (1991). Effects of strategy monitoring and proactive instruction on children's problem-solving performance. *Journal of Educational Psychology, 83*, 35-42.

Dweck, C. S. (1986). Mental processes affecting learning. *American Psychologist, 41*, 1040–1048.

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

Dwyer, D. J., Hall, J. K., Volpe, C., Cannon-Bowers, J. A., & Salas, E. (1992, September). *A performance assessment task for examining tactical decision making under stress* (Spec. Rep. No. 92-002). Orlando, FL: Naval Training Systems Center, Human Factors Division.

Earley, P. C., Connolly, T., & Ekegren, G. (1989). Goals, strategy development, and task performance: Some limits on the efficacy of goal setting. *Journal of Applied Psychology, 74*, 24-33.

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*, 218-232.

Ertmer, P. A., & Newby, T. J. (1996). The expert learner: Strategic, self-regulated, and reflective. *Instructional Science, 24,* 1-24.

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

Fine, S. A., & Cronshaw, S. F. (1999). *Functional job analysis: A foundation for human resources management.* Mahwah, NJ: Erlbaum.

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

Frese, M., Albrecht, K., Altmann, A., Lang, J., Papstein, P. V., Peyerl, R., et al. (1988). The effects of an active development of the mental model in the training process:

Experimental results in a work processing system. *Behaviour and Information Technology, 7*, 295-304.

Frese, M. and Altmann, A. (1989). The treatment of errors in learning and training. In L. Bainbridge and S. A. R. Quintanilla (Eds), *Developing skills with new technology* (pp. 65-86). Chichester: Wiley.

Garner, R., & Alexander, P. A. (1989). Metacognition: Answered and unanswered questions. *Educational Psychologist, 24*, 143-158.

Gellatly, I. R. (1996). Conscientiousness and task performance: Test of cognitive process model. *Journal of Applied Psychology, 81*, 474-482.

Gully, S. M., Payne, S. C., Kiechel, K. L., & Whiteman, J. K. (1999). *Affective reactions and performance outcomes of error-based training*. Paper presented at the 14th annual conference of the Society for Industrial and Organizational Psychology, Atlanta, GA.

Hesketh, B., & Neal, A. (1999). Technology and performance. In: D. R. Ilgen & E. D. Pulakos (Eds.), *The changing nature of performance: implications for staffing, motivation, and development* (pp. 21-55). San Francisco, CA: Jossey-Bass.

Hunter, J. E. (1986). Cognitive ability, cognitive aptitudes, job knowledge, and job performance. *Journal of Vocational Behavior, 29*, 340-362.

Hunter, J. E., & Hunter, R. F. (1984). Validity and utility of alternative predictors of performance. *Psychological Bulletin, 96*, 72-98.

Hyland, M. E. (1988). Motivational control theory: An integrative framework. *Journal of Personality and Social Psychology, 55*, 642-651.

Ilgen, D. R., & Pulakos, E. D. (Eds.). (1999). *The changing nature of performance: Implications for staffing, motivation and development*. San Francisco: Jossey-Bass.

Ivancic, K. & Hesketh, B. (2000). Learning from errors in a driving simulation: Effects on driving skill and self-confidence. *Ergonomics, 43*, 1966-1984.

James, L. R, & Brett, J. M. (1984). Mediators, moderators, and tests for mediation. *Journal of Applied Psychology, 69*, 307-321.

Johnson, J. W. (2003). Toward a better understanding of the relationship between personality and individual job performance. In Barrick, M. R. & A. M. Ryan (Eds.), *Personality and work* (pp. 82-120). San Francisco: Jossey-Bass.

Judge, T. A., & Ilies, R. (2002). Relationship of personality to performance motivation: A meta-analytic review. *Journal of Applied Psychology, 87*, 797-807.

Kanfer, R. (1990). Motivation theory and Industrial/Organizational psychology. In M. D. Dunnette and L. Hough (Eds.), Handbook of industrial and organizational psychology. Volume 1. *Theory in industrial and organizational psychology* (pp.75-170). Palo Alto, CA: Consulting Psychologists Press.

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

Kanfer, R., Ackerman, P. L., & Heggestad, E. (1996). Motivational skills and self-regulation for learning: A trait perspective. *Learning and Individual Differences, 8*, 185-209.

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

Keith, N., & Frese, M. (2005). Self-regulation in error management training: Emotion control and metacognition as mediators of performance effects. *Journal of Applied Psychology, 90*, 677-691.

King, A. (1989). Effects of self-questioning training on college students' comprehension of lectures. *Contemporary Educational Psychology, 14*, 366-381.

King, A. (1990). Improving lecture comprehension: Effects of a metacognitive strategy. *Applied Educational Psychology, 5*, 331-346.

King, A. (1991a). Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist, 2*, 111-126.

King, A. (1991b). Effects of training in strategic questioning on children's problem-solving performance. *Journal of Educational Psychology, 83*, 307-317.

King, A. (1992). Comparison of self-questioning, summarizing, and notetaking-review as strategies for learning from lectures. *American Educational Research Journal, 29*, 303-325.

King, A., & Rosenshine, B. (1993). Effects of guided cooperative-questioning on children's knowledge construction. *Journal of Experimental Education, 6*, 127-148.

King, L. A, Walker, L. M., & Broyles, S. J. (1996). Creativity and the five factor model. *Journal of Research in Personality, 30*, 189-203.

Klein, H. J. (1989). An integrated control theory model of work motivation. *Academy of Management Review, 1989*, 150-172.

Klein, H. J. (1991). Control theory and understanding motivated behavior: A different conclusion. *Motivation and Emotion, 15*, 29-44.

Klein, G. A. (1993). A recognition-primed (RPD) model of rapid decision making. In G. A. Klein, J. Orasanu, J. Calderwood, and D. MacGregor (Eds.), *Decision making in action: Models and methods* (pp. 138-147). Norwood, NJ: Ablex.

Kozlowski, S. W. J. (1998). Training and developing adaptive teams: Theory, principles, and research. In J. A. Cannon-Bowers & E. Salas (Eds.), *Decision making under stress: Implications for training and simulation* (pp. 115-153). Washington, DC: APA Books.

Kozlowski, S. W. J., Gully, S. M., Brown, K. G., Salas, E., Smith, E. A., & Nason, E. R. (2001). Effects of training goals and goal orientation traits on multi-dimensional training outcomes and performance adaptability. *Organizational Behavior and Human Decision Processes, 85*, 1-31.

Kozlowski, S. W. J., Gully, S. M., McHugh, P. P., Salas, E., & Cannon-Bowers, J. A. (1996b). A dynamic theory of leadership and team effectiveness: Developmental and task contingent leader roles. IN G. R. Ferris (Ed.), *Research in personnel and human resource management* (Vol. 14, pp. 253-305). Greenwich, CT: JAI Press.

Kozlowski, S. W. J., Gully, S. M., Nason, E. R., & Smith, E. M. (1999). Developing adaptive teams: A theory of compilation and performance across levels and time. In D. R. Ilgen and E. D. Pulakos (Eds.), *The changing nature of performance: Implications for staffing, motivation and development* (pp. 240-292). San Francisco: Jossey-Bass.

Kozlowski, S. W. J., Gully, S. M., Salas, E., & Cannon-Bowers, J. A. (1996a). Team leadership and development: Theory, principles, and guidelines for training leaders and teams. In M. Beyerlein, D. Johnson, & S. Beyerlein (Eds.), *Advances in interdisciplinary studies of work teams: Team leadership.* (Vol. 3, pp. 251-289). Greenwich, CT: JAI Press.

Kraiger, K., Ford, J. K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology, 78*, 311-328.

Landine, J., & Stewart, J. (1998). Relationship between metacognition, motivation, locus of control, self-efficacy, and academic achievement. *Canadian journal of counseling, 32*, 200-211.

LePine, J. A. (2003). Team adaptation and postchange performance: Effects of team composition in terms of members' cognitive ability and personality. *Journal of Applied Psychology, 88*, 27-39.

LePine, J. A., Colquitt, J. A., & Erez, A. (2000). Adaptability to changing task contexts: Effects of general cognitive ability, conscientiousness, and openness to experience. *Personnel Psychology, 53*, 563-593.

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational Behavior and Human Performance, 3*, 157-189.

Locke, E. A. (1991). Goal theory vs. Control theory: Contrasting approaches to understanding work motivation. *Motivation and Emotion, 15*, 9-28.

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

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

Louis, M. R., & Sutton, R. I. (1991). Switching cognitive gears: From habits of mind to active thinking. Human Relations, 44, 55-76.

Lovett, M. C., & Schunn, C. D. (1999). Task representations, strategy variability, and base-rate neglect. *Journal of Experimental Psychology: General, 128*, 107-130.

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review, 26*, 356-376.

McDaniel, M. A., & Schlager, M. S. (1990). Discovery learning and transfer of problem-solving skills. *Cognition and Instruction, 7*, 129–159.

Miller, G. A., Galanter, E. & Pribaum, K. H. (1960). *Plans and the structure of behavior.* New York, Holt, Rinehart, & Winston.

Minnaert, A., & Janssen, P. J. (1999). The additive effect of regulatory activities on top of intelligence in relation to academic performance in higher education. *Learning and Instruction, 9*, 77-91.

Mitchell T. R., & Daniels, D. (2003). Motivation. In W. C. Borman, D. R. Ilgen, & R. J. Klimoski (Eds.) *Handbook of psychology, vol. 12: Industrial organizational psychology* (pp. 225-254). New York: Wiley & Sons, Inc.

Mohammed, S., Hamilton, K. & Lim, A. (2008). The incorporation of time in team research: Past, current, and future. In E. Salas, G. F. Goodwin, & C. S. Burke (Eds.), *Team effectiveness in complex organizations: Cross-disciplinary perspectives and approaches* (pp. 321-348). Mahwah, NJ: LEA.

Mook, D. G. (1983). In defense of external invalidity. *American Psychologist, 38*, 379-387, Murphy, K. R. (1989). Is the relationship between cognitive ability and job performance stable over time? *Human Performance, 2*, 183–200.

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

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect". *Psychological Science, 2*, 267-270.

Newell, A., Shaw, J., & Simon, H. (1962). The process of creative thinking. IN H. Bruber, G. Terrell, & M. Wertheimer (Eds.), *Contemporary approaches to creative thinking* (pp. 63-119). New York: Atherton.

Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review, 91*, 328–346.

Osman, M. E., & Hannafin, M. J. (1992). Metacognition research and theory: Analysis and implications for instructional design. *Educational technology research and development, 40*, 83-99.

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 2,* 117-175.

Payne, S. C., Youngcourt, S. S., & Beaubien, J. M. (2007). A meta-analytic examination of the goal orientation nomological net. *Journal of Applied Psychology, 92*, 128-150.

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

Ployhart, R. E., & Bliese, P. D. (2006). Individual adaptability (I-ADAPT) theory: Conceptualizing the antecedents, consequences, and measurement of individual differences in adaptability. In S. Burke, L. Pierce, & E. Salas (Eds.), *Understanding adaptability: A prerequisite for effective performance within complex environments*, pp. 3-39. San Diego, CA: Elsevier.

Powers, W. T. (1973). *Behavior: The control of perception*. Chicago: Aldine.

Pulakos, E. D., Arad, S., Donovan, M. A., & Plamondon, K. E. (2000). Adaptability in the workplace: Development of a taxonomy of adaptive performance. *Journal of Applied Psychology, 85*, 612-624.

Pulakos, E. D., Schmitt, N., Dorsey, D. W., Arad, S., Hedge, J. W., & Borman, W. C. (2002). Predicting adaptive performance: Further tests of a model of adaptability. *Human Performance, 15*, 299-323.

Reeve, R. A., & Brown, A. L. (1985). Metacognition reconsidered: Implications for intervention research. *Journal of Abnormal Child Psychology, 13*, 343-356.

Salas, E., & Cannon-Bowers, J. A. (2001). The science of training: A decade of progress. *Annual Review of Psychology, 52*, 471-499.

Schank, R., & Abelson, R. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Erlbaum.

Schmidt, F. L. (1988). The problem of group differences ability test scores in employment selection. *Journal of Vocational Behavior, 33*, 272-292.

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

Schmidt, A., & Ford, J. K. (2003). Learning within a learner control training environment: The interactive effects of goal orientation and metacognitive instruction on learning outcomes. *Personnel Psychology, 56*, 405-429.

Schmidt, F., & Hunter, J. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin, 124*, 262-274.

Schneider, R. J., Hough, L. M., & Dunnette, M. D. (1996). Broadsided by broad traits: How to sink science in five dimensions or less. *Journal of Organizational Behavior, 17*, 639-655.

Schneider, W., & Chein, J. M. (2003). Controlled & automatic processing: Behavior, theory, and biological mechanisms. *Cognitive Science, 27*, 525-559.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*, 113-125.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*, 351-371.

Smith, E. M., Ford, J. K., & Kozlowski, S. J. (1997). Building Adaptive Expertise: Implications for Training Design Strategies. In M. Quinones (Ed.), *Training for a rapidly changing workplace* (pp. 89-118). Washington, DC: American Psychological Association Publications.

Snow, R. E., & Lohman, D. L. (1984). Toward a theory of cognitive aptitude for learning from instruction. *Journal of Educational Psychology, 76*, 347–376.

Thoresen, C. J., Bradley, J. C., Bliese, P. D., & Thoresen, J. D. (2004). The Big Five personality traits and individual job performance growth trajectories in maintenance and transitional job stages. *Journal of Applied Psychology, 89*, 835-853.

Vancouver, J. B. (2000). Self-regulation in Industrial/Organizational Psychology: A tale of two paradigms. In M. Boekaerts, P. R. Pintrich, & M. Zeidner, (Eds.), *Handbook of Self-Regulation* (pp. 303-341). San Diego, CA: Academic Press

VandeWalle, D. (1997). Development and validation of a work domain goal orientation instrument. *Educational and Psychological Measurement, 8*, 995-1015.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 4*, 548-573.

Weiner, B., Russell, D., & Lerman, D. (1979). The cognition-emotion process in achievement-related contexts. *Journal of Personality and Social Psychology, 37*, 1211-1226.

Weiner, N. (1948). *Cybernetics: Control and communication in the animal and the machine*. Cambridge, MA: MIT Press.

Winne, P. H. (1995). Inherent details in self-regulated learning. *Educational Psychologist, 30*, 173-187.

Winne, P. H. (1996). A metacognitive view of individual differences in self-regulated learning. *Learning and Individual Differences, 8*, 327-353.

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

Wood, R. E., & Locke, E. A. (1990). Goal setting and strategy effects on complex tasks. *Research in Organizational Behavior, 12*, 73-109.