RICE UNIVERSITY

The Effects of Structure and Metacognitive Prompts on Training Outcomes

by

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

Master of Arts

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HOUSTON, TEXAS
February 2015

ABSTRACT

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This study investigates the use of metacognitive prompts and training structure for a computer-based training intervention. It is framed in resource allocation theory (Kanfer & Ackerman, 1989) and includes a fully-crossed 2 (low vs. high structure) x 2 (no prompts vs. metacognitive prompts) experimental design to examine how different training methods affect training outcomes – performance and self-efficacy – via metacognitive activity. Individual differences such as cognitive ability, motivation, and goal orientation were also anticipated to affect trainee performance on a test of immediate and delayed performance. Results from this research indicate that structure affected scores on a delayed performance test but not immediate performance or self-efficacy. Furthermore, metacognitive prompts did not produce any predicted effects on performance. Future research should carefully consider the viability of metacognitive prompts for affecting training outcomes.

Acknowledgments

I would like to thank my advisor, Dr. Margaret Beier, for her constant guidance and support throughout the duration of this project. I would also like to thank my committee members, Dr. Mikki Hebl and Dr. Anton Villado, for their helpful insight and feedback, which have greatly improved this project and paper. Furthermore, I am grateful to members of the Beier lab for their assistance with data collection, and the psychology department staff, Lanita Martin and Jennifer Gucwa, for their help in coordinating the administrative portion of the thesis proposal and defense. Finally, I would like to thank my family for their support.

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The Effects of Structure and Metacognitive Prompts on Learning Outcomes in Training Environments

Companies invest significant resources in training their workers. In 2013, organizations in the U.S. spent an average of $1,208 on training and development per employee for the entire year (Miller, 2014). This large financial expenditure for employee training demonstrates that organizations value training and understand that developing highly-skilled workers is advantageous in today's competitive marketplace. The demand for training is also expected to increase into the near future as technological developments in the workplace increase the value of employees with up-to-date skillsets.

Training presents people with job-relevant information and is designed to produce relatively permanent changes in their knowledge, skills, and/or attitudes in the hopes that the job-related information they learn in training will be used in the future (Cascio & Aguinis, 2011). Training can affect organizational performance, so programs have to be carefully designed and implemented to teach employees job-relevant information effectively; a poorly designed program will waste valuable organizational resources and employee time with limited positive impact for the organization.

The present study manipulated two training elements (structure and metacognitive prompts) in a computer-based training program to examine effects on training outcomes – performance and post-training self-efficacy for retention – and identify mediators of those effects. In the context of resource allocation theory (Kanfer & Ackerman, 1989), structure and metacognitive prompts served as external influences on the distal and proximal predictors of training outcomes. Participants were taught a series of conceptually different tasks and then allowed to practice each one. Afterwards, trainees

were reported the amount of metacognitive activity they engaged in during training. They were also evaluated for performance on immediate and delayed performance tasks and self-efficacy for retention of training material. Study results inform researchers on the viability of each training design manipulation as an effective method of increasing post-training performance and trainee self-efficacy for retention of training material.

This thesis is organized in three parts. First, I will address the theory related to the skill acquisition process, addressing both determinants and outcomes of this process. Second, I will frame the study in the context of resource allocation theory (Kanfer & Ackerman, 1989), presenting the expected relationships between the experimental manipulations and individual difference variables, along with their expected interactions to affect training outcomes. Last, I will provide an overview of the research design and obtained results, along with implications for the training literature.

Skill Acquisition Process

The process of learning new skills is called skill acquisition. According to Anderson's ACT theory (1982), skill acquisition consists of three distinct, sequential stages: declarative knowledge, knowledge compilation, and procedural knowledge. The declarative knowledge stage of training consists of trainees learning novel information related to the skill being taught. This skill acquisition stage presents trainees with task specifications for the training program along with the facts they need to learn to achieve training objectives. Tasks presented to people during the declarative knowledge stage require trainees to focus attentional resources, particularly working memory, to learn and perform the task. The declarative knowledge stage is succeeded by a second stage called knowledge compilation. In this stage, trainees begin putting together the knowledge

obtained during the declarative knowledge stage, and start to develop expertise through extensive skill practice. The final stage of skill acquisition is procedural knowledge, where the skill that was taught can be performed automatically without conscious attention. In this stage, task performance is not as dependent on attentional resources and tasks can be carried out quickly with minimal cognitive effort or attention (Kanfer & Ackerman, 1989); continual practice is typically needed to reach this stage of skill acquisition.

As the purpose of training is to produce a positive change in job performance, both determinants of training performance and measurements of training outcomes are important variables of interest. The following sections will review determinants of training performance during the skill acquisition process and training outcomes indicative of learning. These determinants and outcomes will then be framed in the context of the present study.

Determinants of performance. During each stage of skill acquisition, trainees perform different functions that ultimately help them acquire a skill. Each of these different functions calls for different determinants as one progresses through the skill acquisition process. Ackerman (1988) asserts that three abilities –general ability, perceptual speed, and psychomotor ability – determine one's success during the declarative knowledge, knowledge compilation, and procedural knowledge stages respectively. General ability, also known as cognitive ability, is the product of processes that people use to obtain information, store and retrieve it within memory, and use information in novel situations (Humphreys, 1979). This ability aligns with the processes people must engage in to acquire new declarative knowledge. Perceptual speed addresses

how quickly people can cognitively process information, such as letters or numbers. For the knowledge compilation stage, perceptual speed is important because the faster one can make sense of the information being shown, the better performance becomes. The final determinant of skill acquisition is psychomotor ability, or how quickly and accurately one can physically react to something using motor skills, and without processing the information. In the automaticity stage, where actions are essentially automatic and are not processed, psychomotor abilities can account for increased performance. However, the task being learned can affect the importance of perceptual speed and psychomotor abilities during the skill acquisition process. For instance, learning how to drive a car will rely more heavily on psychomotor ability than learning how to solve complex math problems. Ackerman's research focused on psychomotor tasks with specific characteristics that relied on perceptual and psychomotor skills. Thus, while cognitive ability is important for learning any new skill in general, perceptual speed and psychomotor abilities may be less important for tasks with different characteristics (e.g., domain knowledge acquisition).

Even though determinants of performance are important for the overall process of skill acquisition, training implemented in the workplace is subject to constraints. Organizations may have limited time for their employees to practice their newly learned skills due to work demands, or they may want to minimize the amount of time employees spend away from their work. The result is that employees do not experience all stages of skill acquisition during a workplace training session; at the minimum, employees may only experience the declarative knowledge stage. Consequently, some determinants of performance (i.e., cognitive ability) will be more important than others when predicting

post-training performance. Due to the practical constraints of implementing training in the workplace, I will focus only on cognitive ability as a determinant of skill acquisition for the present study.

Training outcomes. Because the purpose of training is to produce changes in employees' job-related behaviors, it is important for organizations to measure the outcomes that result from training interventions. In the training literature, one of the classic models for measuring training outcomes is Kirkpatrick's (1959, 1960) four levels of training criteria. This taxonomy proposes four different outcome levels that are linked in a linear progression: reactions, learning, behavior, and results. Reactions refer to trainee's affective perceptions about the training; for instance, whether trainees liked the training program or felt the content was job-relevant. This level of training criteria does not assess how much a trainee has learned. Kirkpatrick's second level of criteria, learning, measures the degree to which trainees have achieved specified training objectives by testing the acquisition of declarative knowledge, skills, or attitudes. However, high scores on learning measures may not translate to actual on-the-job performance. Thus, job performance is measured by the third level of training criteria, behavior. Lastly, the results level of training criteria addresses how training results fit within organizational objectives and produce measureable outcomes such as absenteeism or turnover.

Though this taxonomy is used in many organizations, Kraiger, Ford, and Salas (1993) proposed a hierarchical classification of learning outcomes, arguing that Kirkpatrick's (1959, 1960) classification was oversimplified and did not sufficiently capture the breadth of training outcomes. Specifically, Kirkpatrick's taxonomy did not

clearly delineate the changes that should occur to indicate trainee learning, and there was no distinction between the usage of different measurement tools for assessing different learning situations (e.g., learning skills vs. learning facts). Accordingly, Kraiger and colleagues proposed a classification scheme that conceptualizes learning outcomes as composed of three separate types: cognitive outcomes, skill-based outcomes, and affective outcomes. Cognitive outcomes refer to the quantity, types, and organization of knowledge that a trainee acquires. This type of learning outcome is typically assessed through verbal knowledge, knowledge organization, and the cognitive strategies (e.g., thinking about one's own thinking, also known as metacognition) trainees use during training. Skill-based outcomes address technical or motor skill development, and follow stages of the skill acquisition process outlined by Anderson's (1982) ACT theory. Thus, measurement of skill-based outcomes target the declarative knowledge a trainee obtains, along with the proficiency and speed at which he/she can perform given tasks. Affective outcomes are the final type of learning outcome and encompass the resulting attitudes and motivational tendencies that arise from exposure to training. This particular type of learning outcome was overlooked in Kirkpatrick's (1959, 1960) taxonomy and is especially relevant to training because attitudes and motivation can dictate whether or not a person decides to use their newly-trained skills on the job.

Another training outcome that has gained interest is the transference of trained skills to on-the-job situations. Employees often have to use their newly trained skills in a variety of contexts; during training, the different contexts that employees can be trained on are limited by organizational constraints (e.g., deadlines or financial resources). Consequently, researchers have focused on performance in near transfer and far transfer

situations. Near transfer refers to people applying what was learned during training to a similar context, where context can refer to dimensions such as (but not limited to) time, physical location, or knowledge domains (Barnett & Ceci, 2002). For instance, someone who learns how to operate a boat and is assessed on performance the same day he/she is trained would be evaluated on near transfer of skills for the temporal dimension of transfer. Far transfer refers to people applying trained skills to dissimilar contexts (Barnett & Ceci, 2002). For example, if someone learns how to operate a boat and is assessed on performance one year later, he/she would be evaluated on far transfer of skills for the temporal dimension of transfer. Transfer situations can also be similar or dissimilar along multiple dimensions (e.g., time and physical location). In reality, employees may not learn the skills they were trained on right away or use them in contexts similar to how they were presented in practice, so it is important that they can also retain trained information well. To address this issue, training outcomes in the present study will be assessed in both near transfer and far transfer situations. These outcomes will be measured with questions containing content slightly different from practice items both immediately after training and one week after training has concluded.

The present study focuses primarily on task-related and affective training outcomes. Task-related outcomes refer to performance after the conclusion of training, both immediately and after a short temporal delay. As the purpose of training is to positively impact job performance, I am particularly interested in how people will perform on a task using their newly learned trained material and skills. In relation to Kraiger's classification scheme, performance is best represented by skill-based outcomes

as these outcomes indicate the proficiency at which people can process newly learned information to complete a task.

The affective training outcome was assessed with self-efficacy for information retention. Self-efficacy is a person's assessment of his or her capabilities to perform a specific task and/or to produce certain results. According to Bandura (1977), expectations of self-efficacy dictate the type of behavior a person will engage in (e.g., coping behavior), how much effort a person will expend, and how long someone will persist at a task when approached with difficulties. Levels of task-specific self-efficacy can be affected by several different sources: performance accomplishments (e.g., whether the person succeeds or fails at a task), vicarious experience (e.g., modeling), verbal persuasion (e.g., feedback, suggestions), and physiological responses (e.g., emotional arousal) (Bandura, 1977). In computer-based training programs, self-efficacy can fluctuate as trainees receive feedback from the software program about the accuracy of their actions and upon completion of (or failure to complete) a practice task. In fact, the psychological literature has consistently demonstrated a strong, positive relationship between self-efficacy and work-related performance (Stajkovic & Luthans, 1998). As such, trainees' post-training self-efficacy measured post-training for retention of the newly learned material can provide insights on whether or not a trainee will use his/her newly trained skills on this job.

In sum, I am interested in examining both determinants (i.e., cognitive ability) and outcomes (i.e., performance and self-efficacy) of skill acquisition within a training context, and the relationships between these variables. Next, I will review the theoretical

framework I expect these variables to operate within, and how they will be affected by individual differences such as motivation and goal orientation.

Resource Allocation Theory

The theoretical basis of the presented study lies in resource allocation theory (Kanfer & Ackerman, 1989). This theory is concerned with how individual differences and task demands affect how people perform on tasks; specifically, it incorporates motivational factors into the skill acquisition process described above. One of the key principles of resource allocation theory is that maximal amount of cognitive resources a person has at his/her disposal is dictated by cognitive ability; the higher one is in ability, the more cognitive resources are available. Resource allocation theory also posits different determinants of performance in skill acquisition situations: distal motivational influences that dictate the amount of cognitive/attentional resources a learner will allocate for use during skill acquisition, and proximal motivational influences that affect the distribution of these cognitive resources into self-regulatory, off-task, and on-task activities during actual task engagement (Kanfer & Ackerman, 1989).

Distal motivational processes help a person decide on a goal before engaging in proximal motivational processes. Goal choice is a result of a person's evaluation of perceived usefulness of using the trained skill on the job. The learner uses perceived relationships between his/her expected performance, effort, and utility, or usefulness, of the task to make the decision and subsequently set a goal for task engagement. However, in the workplace, employees may not have the opportunity to choose a goal (e.g., mandatory training), thus participants were given a goal in the present study. Once the learner begins the skill acquisition process and strives toward the goal by working on the

task, proximal motivational processes are used to allocate cognitive resources towards on-task behaviors, off-task behaviors, and self-regulation.

Self-regulation activities refer to the related activities people engage in to evaluate whether or not the amount of resources dedicated to the task are appropriate during skill acquisition. In training contexts, self-regulation can be represented by constructs such as metacognition. Metacognition is a form of cognitive self-regulation that involves higher-order executive mental processes. Metacognitive activities typically consist of monitoring and evaluating one's progress on a task, being sensitive to various forms of feedback, planning strategies for approaching a task, and allocating resources that affect performance (Schraw & Moshman, 1995). Metacognitive skills have been found to correlate with skill development and expertise, with experts having more metacognitive skill than novices (Larkin, 1983). Thus, metacognitive activity that trainees engage in during training can serve as an indicator of learning engagement and potentially mediate performance as a proximal process during goal striving.

The Present Study

I conducted an experiment examining the effects of two training design features – structure and metacognitive prompts – on training outcomes. Structure refers to the degree of instruction a trainee receives during training when acquiring a new skill, and metacognitive prompts are statements or cues designed to make people think about their own thinking. The purpose of the present study was to identify *how* structure and metacognitive prompt manipulations affect the following training outcomes: self-efficacy for retention and performance. Experimental manipulations were introduced during skill acquisition to affect the proximal processes that produce variations in training outcomes.

Due to the multidimensional nature of training outcomes, self-efficacy for retention and performance were expected to be positively related to one another.

The training literature has examined these manipulations as ways to increase performance post-training. However, the underlying theoretical mechanisms driving these effects are still unclear. The present study focused on whether or not metacognitive activity is a mechanism through which both metacognitive prompts and training structure operate to affect transfer performance. I expected training structure and metacognitive prompts to affect performance and self-efficacy by acting on proximal determinants (as dictated by resource allocation theory) of these two training outcomes. I also expected individual differences such as cognitive ability, motivation, and goal orientation to yield additional effects on these outcomes. Figure 1 provides the hypothesized interactions that will be covered in the following sections; main effects have been omitted as the focus of the study lies with the interaction effects.

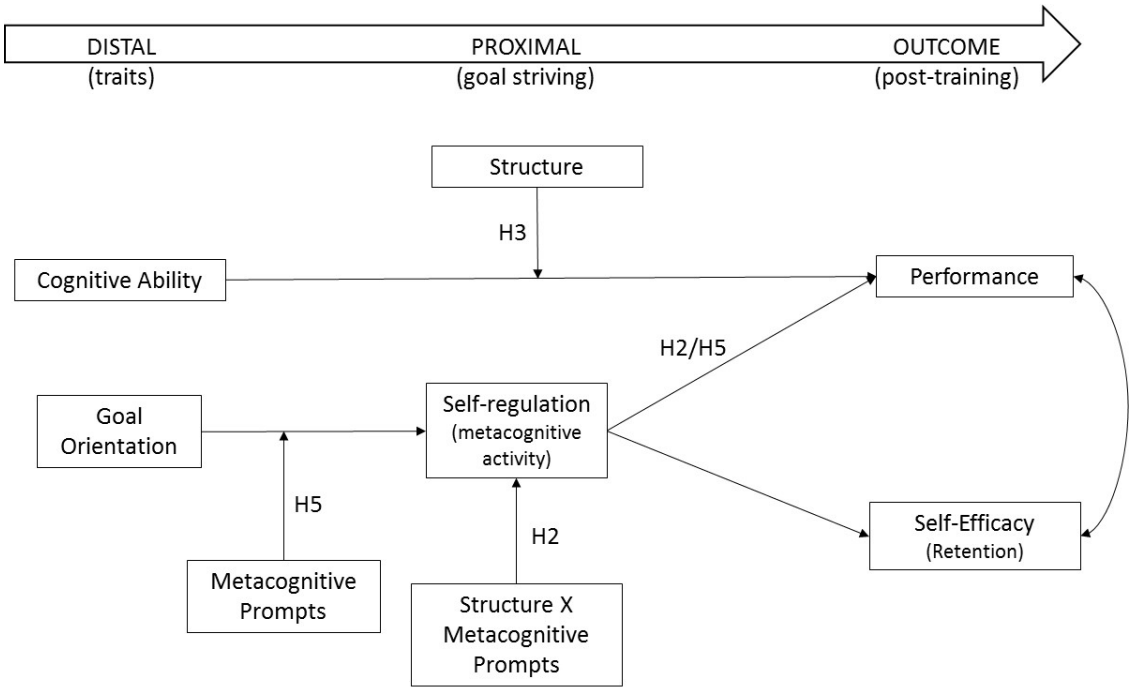

Figure 1. Hypothesized interactions. Hypotheses 1 (main effect of structure on performance), 4 (main effect of motivation on performance), and 6 (main effect of structure on self-efficacy) are excluded.

Training structure. Structure is a training design feature that can be used to create an active/exploratory learning environment (low structure) or a passive learning environment (high structure). Active learning environments are learning situations defined by two key features: learner control and an inductive learning process (Bell & Kozlowski, 2008).

Learner control is where a trainee is given responsibility for monitoring their learning development and making instructional decisions, such as when to progress to the next section of training content (DeRouin, Fritsche, & Salas, 2004). Training approaches that limit learner control and make the instructional system responsible for learning decisions are called passive approaches, whereas training approaches that let learners have primary control over training decisions are called active approaches (Bell &

Kozlowski, 2008). Thus, in passive learning situations (high structure), learning is regulated externally by the program, as opposed to active learning situations where learning is regulated internally by the trainee.

The inductive learning process refers to how trainees obtain the information they need to learn; specifically, inductive learning requires trainees to explore and experiment within the environment to infer relevant rules and strategies needed to effectively perform the given task (Smith et al., 1997). Active learning (low structure) situations make learners engage the inductive learning process whereas passive learning (high structure) situations do not, because in passive learning situations the relevant training information is given to the trainee.

High structure environments create a passive learning approach by giving trainees detailed instructions, generally through an instructor or in print format, for how to accomplish tasks in training. Compared to trainees who learn in low structure, trainees who learn in high structure use relatively less cognitive processes to infer and construct relationships between different concepts; this is because they are guided by the instructions to learn only about the information needed to successfully complete training tasks. The non-inductive nature of learning relevant material can lead to a restricted knowledge base; this is expected to impede performance when trainees are presented with tasks that are not similar to those presented during practice and require additional knowledge of the learning environment. An example of a high-structure task would be assembling furniture using the illustrated step-by-step instruction booklet provided with the product.

Conversely, low structure training creates active learning environments for

learners by giving trainees limited or minimal instruction for completing a task. In training, the lack of instruction forces learners to discover the information they need to complete practice tasks and develop their understanding of the training material through direct experience (Bell & Kozlowski, 2008). This can lead to trainees learning about information that may be tangential or completely unrelated to the actual task. However, exposure to such information can assist in the development of a broad and deep understanding of the training material that extends beyond step-by-step instructions provided in high structure training. This may benefit trainees when they are evaluated on performance items that are dissimilar to those presented during practice. An example of a low structure or active learning task would be assembling furniture only using a picture of the completed product as a reference. Rather than being provided the exact, accurate steps needed to build the piece of furniture, the person assembling the furniture must explore and experiment to match up building components in order to successfully produce the final product.

When applied to the context of resource allocation theory, the key differences between high and low structure training can affect training outcomes. Specifically, low structure training will be more cognitively taxing, especially in the declarative knowledge phase, leaving trainees with less resources for off-task thought. In response to this training demand, trainees may redirect their resources to on-task activities. The increased allocation of cognitive resources towards training can be beneficial, as more resources are available for the trainee to use when learning and performing training tasks. Furthermore, past research has found low structure training to be advantageous over high structure training for producing transfer performance (Keith, Richter, & Naumann, 2010). Thus, I

expect:

H1: There will be a main effect of structure on performance such that participants in low structure conditions will perform better on the immediate and delayed performance tests than participants in high structure conditions.

Metacognitive prompts. The second training design manipulation – metacognitive prompts – is expected to cue metacognition. Trainees who learn in exploratory, low structure environments with minimal instruction have to engage in metacognitive activity to successfully complete the task presented to them (Brown, Bransford, Ferrara, & Campione, 1983). By contrast, trainees in high structure environments are guided through tasks correctly with every step and do not need to re-evaluate their behavior and engage in metacognition to successfully complete the trained task.

The use of metacognitive processes can promote correct evaluations of how much training material people know, leading them to assess their learning accurately. Research has shown that people's metacognitive judgments about their learning are predictive of future recall and recognition of information (Koriat, Ma'ayan, & Nussinson, 2006). Metacognition is also related to outcomes such as academic performance and performance on problem-solving tasks (Berardi-Coletta, Buyer, Cominowski, & Rellinger, 1995; Pintrich & De Groot, 1990). Furthermore, engagement in metacognitive activity yields higher test scores, higher rates of declarative knowledge acquisition during training, and better performance on skill-based assessments (Schmidt & Ford, 2003; Vrugt & Oort, 2008).

Metacognitive activity can be incited through external sources, such as cues embedded in dialogue (Osman & Hannafin, 1992). These metacognitive prompts, statements or cues that remind people to reflect on what they are learning, have also been found to positively affect student performance (Davis, 2003). In this study, metacognitive prompts are expected to positively affect trainee performance by cuing metacognition in trainees.

Furthermore, the training literature has already established that exploratory, low structure training requires metacognitive activity for trainees to process feedback and complete training tasks. However, trainees in highly structured training will receive only positive feedback; this is because they have been guided through every step of the task, producing errorless performance. Thus, they are not compelled to think about what material they know or do not know. Therefore, I expected the following interaction with structure and metacognitive prompting:

H2a: There will be an interaction between structure and metacognitive prompting such that participants exposed to high structure and metacognitive prompting will perform better on the performance tests than high structure participants who do not receive metacognitive prompting. Low structure participants will perform better on the performance tests than high structure participants, regardless of whether or not they received metacognitive prompts.

I also expected that the amount of metacognitive activity participants engage in would influence performance on the performance tests. Exposure to metacognitive prompts does not guarantee that all participants will actually perform the self-regulatory behavior; when prompted, some people may decide to engage in a little or a lot of

metacognitive activity. Research by Keith and Frese (2005) has shown that metacognitive activity fully mediates the relationships between active learning training on transfer performance. Given the anticipated significant interaction of structure and metacognitive prompting on performance, I expected metacognitive activity to fully mediate this relationship.

H2b: There will be a mediated moderation where metacognitive activity fully mediates the relationship between the interaction of structure with metacognitive prompts and performance on the immediate and delayed performance tests.

Individual differences. For complex tasks (e.g., learning computer-based software functions), task demands, individual differences, and self-regulatory processes play key roles in determining how well someone will perform (Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994). Under resource allocation theory, these elements are expected to interact with the experimental manipulations and affect training outcomes.

***Cognitive ability*.** Resource allocation theory asserts that performance is dependent upon the cognitive resources available for allocation towards performance. High ability people have a greater availability of cognitive resources than low ability people (Kanfer & Ackerman, 1989). As such, people lower in ability will have relatively less attentional resources available compared to people higher in ability. Consequently, people lower in ability will need to allocate a larger share of their cognitive resources to obtain the same level of performance on a task as people higher in ability (Ackerman, 1988; Kanfer, Ackerman, Murtha, Dugdale, & Nelson, 1994). Cognitive ability has been repeatedly shown in the literature to be one of the strongest predictors of job and training

performance (Schmidt & Hunter, 1998). Thus in line with previous research findings, I anticipated a positive relationship between cognitive ability and performance on the immediate and delayed performance tests distributed post-training.

Within the resource allocation framework, the structure of a training program is an external influence that can impose different task demands on trainees and ultimately affect performance on a task. The interactions between individual differences and training manipulations are called aptitude-treatment interactions (ATIs). ATIs acknowledge that not all people are alike and some within-person individual differences can affect training success (Campbell & Kuncel, 2001). One well-known ATI is between cognitive ability and training structure (Snow, 1989).

Higher learner control in low structure will require more attentional resources to handle learning decisions in comparison with high structure situations, where learner control is minimal. Thus, people relatively lower in ability should perform better when a task relatively less cognitively demanding (e.g., high structure training) as opposed to relatively more cognitively demanding (e.g., low structure training). Conversely, people relatively higher in ability who engage in low structure training should have the attentional resources necessary to develop the broad knowledge base beneficial for use in performance situations. Some researchers have also asserted that a low structure, exploratory training approach may only be effective for higher cognitive ability people (Kirschner, Sweller, & Clark, 2006). As such, lower ability people benefit from high structure training situations (Snow, 1989; Sternberg, Grigorenko, Ferrari, & Clinkenbeard, 1999) because cognitive demands are lessened by the guidance instructions, freeing up more cognitive resources for lower ability people to dedicate

towards performance. Past research has also shown that people higher in cognitive ability benefit from low structure relative to people lower in cognitive ability (Carter & Beier, 2010; DeRouin, Fritzsche, & Salas, 2004), likely because they have more cognitive resources available for learning novel tasks.

Amongst relatively high ability people, participants in low structure training should construct broader training knowledge (due to the exploratory nature of training) than participants in high structure, and score higher than them on a performance test. Therefore, I anticipated an ATI where relatively higher ability trainees should be better at learning the training content for both performance tests when exposed to low structure training (which is more cognitively taxing) compared to high structure training. Relatively high ability people are also expected to outperform relatively low ability people on average. By contrast, relatively low ability people should perform better in high structure training (which is less cognitively taxing) compared to low structure training.

H3: There will be an interaction between cognitive ability and structure such that performance on post-training tests will be rank ordered by condition (from highest to lowest): high ability people trained in low structure, high ability people trained in high structure, low ability people trained in high structure, and low ability people trained in low structure.

Motivation. One of the key components of resource allocation theory is motivation. Motivational processes can affect the quantity of cognitive resources people will allocate towards training tasks before the intervention begins and during task engagement. Meta-analytic results in the training literature have shown that training

motivation accounts for incremental variance in performance above and beyond cognitive ability (Colquitt, LePine, & Noe, 2000). Thus, if two people have the same level of cognitive ability, the person who is more motivated for training can outperform the less motivated individual, presumably by dedicating more cognitive resources towards the task. When a goal is assigned, motivation can also serve as a measure of goal strength that informs the distal and proximal processes, which help a trainee arrive at their resource allocation decisions prior to and during task engagement. In line with previous literature, I expect:

H4: There will be a main effect of motivation on post-training performance.

***Goal orientation*.** Goal orientation is defined as the mindset people have when they pursue goals (Dweck, 1986). It is derived through a person's belief about the malleability of cognitive ability. Specifically, people who believe in the incremental theory of ability believer that ability is fluid and changeable through learning and practice. These people typically adopt a mastery goal orientation that focuses on developing competence. People high in mastery orientation believe that effort leads to success and aspire to develop themselves by improving competence and mastering new skills (Dweck, 1986). By contrast, people who endorse the entity theory of ability believe that ability is fixed and cannot be altered with effort. This mindset produces two types of performance goal orientation: performance-approach goal orientation and performance-avoid goal orientation. Both types of performance goal orientation focus on demonstrating competence in one of two forms. People high in performance-approach goal orientation try to show that they are competent against a normative comparison/standard to gain favorable judgments from others; people high in

performance-avoid goal orientation avoid displays of incompetence and others' negative judgments (VandeWalle, 1997). In sum, mastery goal orientation focuses on developing skills and learning whereas performance goal orientations focus on demonstrating competence.

Individual differences in goal orientation can produce variation in training performance. During the skill acquisition process, trainees may encounter difficulties or be presented with negative feedback that can be discouraging. Individual differences in goal orientation have been shown to influence how people respond to such information, particularly whether they persist at a task or avoid such negative information altogether (Vrugt & Oort, 2008). For instance, people high in mastery orientation seek challenges that can build their competency and thus will persist in the face of difficulty and negative feedback (Button, Mathieu, & Zajac, 1996; VandeWalle, Cron, & Slocum, 2001). Meanwhile, people high in performance orientation are typically seen as less adaptive and persistent in the face of difficulties (Ames, 1992; Dweck & Leggett, 1988). Due to the exploratory nature of low structure, trainees are more prone to facing difficulties and receiving negative feedback when completing tasks in low structure conditions. In these conditions, people high in mastery orientation may see difficulties as challenging and perform better on tasks than people high in performance orientation, who may see difficulties as discouraging and cease working on the task altogether. Within the context of resource allocation theory, goal orientation provides a lens through which trainees will interpret feedback to inform self-regulation behaviors.

Metacognition can also interact with goal orientation to mediate performance. Individual differences in goal orientation are expected to serve as a distal influence on

metacognition, affecting a person's engagement in metacognitive behavior and subsequently, performance. Past literature has found interactive effects between goal orientation and metacognitive instruction, such that people high on performance-avoid orientation engage in less metacognitive activity than their low performance-avoid orientation counterparts (Schmidt & Ford, 2003); this is likely due to the desire to avoid negative feedback about performance, which indicates incompetence. Researchers have also established relationships between maladaptive behaviors (e.g., avoidance of challenges, task withdrawal in the face of difficulties) and performance-avoidance goals (Barron & Harackiewicz, 2001). Thus for people high in this type of goal orientation, their metacognitive activity and subsequent performance on training tasks may be negatively affected.

For the present study, I predicted an interaction between goal orientation and metacognitive prompting. I anticipated that individual differences in goal orientation would affect the effectiveness of metacognitive prompts on participant performance. Due to their underlying beliefs about ability, people high on performance-approach or mastery orientations would likely welcome negative feedback and perform well because of it. However, people high on performance-avoid orientation do not want to receive negative feedback because they see it as a display of incompetence. Metacognition can potentially produce negative feedback so people high on performance-avoid orientation may not engage in a lot of metacognitive activity to avoid receiving such information. Therefore, I predicted an effect between the metacognitive prompts manipulation and goal orientation:

H5a: There will be an interaction between metacognitive prompts and goal orientation such that participants who receive metacognitive prompts and are

high in performance-avoid orientation will engage in less metacognitive activity than participants high in performance-avoid orientation who do not receive any metacognitive prompts. Participants who are either high in performance-approach or mastery orientations and receive metacognitive prompts will engage in more metacognitive activity than their counterparts who do not receive prompts.

In line with Keith and Frese (2005), I expected metacognitive activity to serve as a mediator again, this time between the interaction of goal orientation and metacognitive prompts, and performance on the adaptive transfer test.

H5b: There will be a mediated moderation where metacognitive activity fully mediates the relationship between the interaction of goal orientation with metacognitive prompts and performance on post-training tests.

Lastly, I will assess self-efficacy, an affective training outcome. Self-efficacy will be measured to examine trainees' confidence for retaining trained material after exposure to different training conditions. Even though self-efficacy for retention may not be the primary training outcome of interest, it plays a crucial role in determining whether trainees will use their newly acquired skills in the future. The guided nature of high-structure training sets up trainees for receiving primarily positive, errorless feedback from the computer program and thus trainees in high-structure conditions are expected to emerge with high self-efficacy post-training. Low-structure training does not provide detailed instructions so trainees are likely to receive negative feedback through mistakes made at some point during training. These mistakes can be discouraging and lower post-training self-efficacy.

H6: There will be a main effect of structure on self-efficacy such that participants in low structure training will have lower self-efficacy for retention than participants who received high structure training.

Method

Participants

Participants were undergraduate students recruited from Rice University using the psychology subject pool. A priori power analyses for a fixed effects ANCOVA indicated that a minimum total of 128 participants were needed to detect a medium effect in a 2 (structure: high and low) x 2 (metacognitive prompting: present and absent) factorial design (Cohen, 1988). Thus, a total of 219 participants were recruited to obtain power of at least .80. Participants were given course credit for participation. Three participants were eliminated due to being outliers (three standard deviations beyond the mean) on the dependent variables of interest. Eight additional participants were excluded due to an error in study implementation. Thus, a total of 208 participants (94.9% of total recruited) completed the study.

Procedure

The study was composed of three parts. See Figure 2 for the general study design.

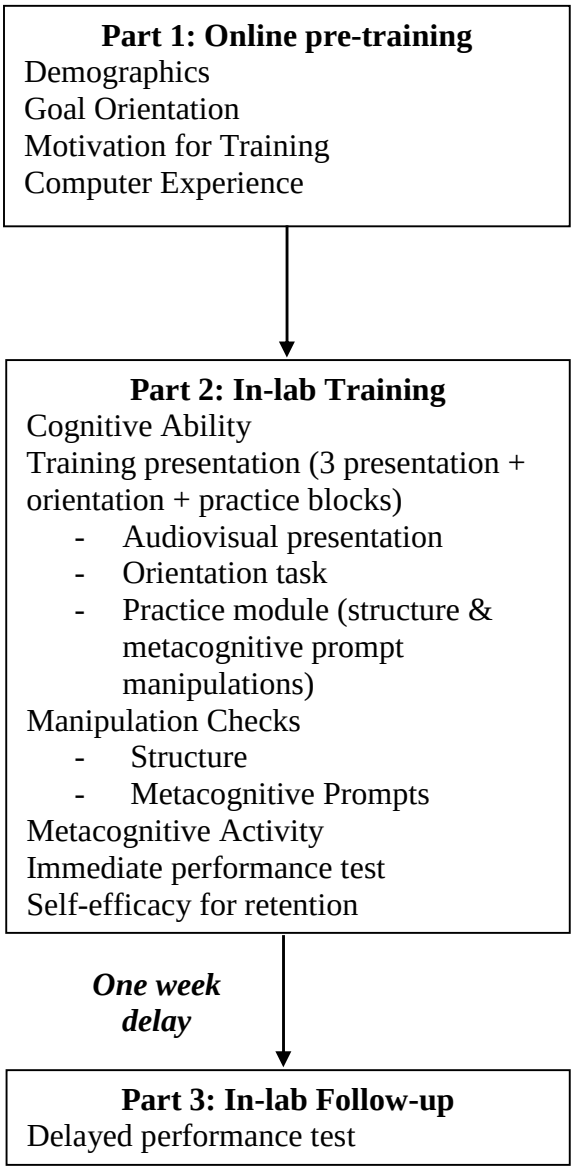

Figure 2. General Study Design

First, participants completed predictor measures through an online survey prior to their training session. These measures consisted of self-report scales for personality, goal orientation, computer experience, motivation for training, and basic demographic information (e.g., age, gender, race, etc.). Second, participants attended an in-person

laboratory session for the training and experimental manipulations. Prior to the start of each training session, cognitive ability was measured for all participants. Then each participant was randomly assigned to one of four training conditions consisting of (a) low structure and no metacognitive prompts, (b) high structure and no metacognitive prompts, (c) low structure and metacognitive prompts, or (d) high structure and metacognitive prompts. Training sessions were designed to present three Microsoft Excel training modules, which built upon one another and targeted pivot tables as the training material of interest. Participants learned Microsoft Excel tasks pertaining to creating pivot tables, organizing and filtering data, and writing formulas.

Each module consisted of three parts presented in the following order: an audiovisual tutorial, an orienting task designed to familiarize participants with the training environment by reviewing the training tutorial activity, and a practice session with new activities. The audiovisual tutorials were composed of video clips that presented the general background behind concepts covered during the module, along with information about where to find and perform the related functions in Microsoft Excel. Upon completion of the tutorials, participants were presented with semi-guided orienting activities designed to get them familiar with the training environment, functions, and activity presented during the tutorial. Instructions in these activities were provided a moderate level instruction (relative to step-by-step high structure) and visual guides to acclimate participants to the material. This moderate level of structure for orienting tasks was the same for all conditions.

After the orienting tasks, practice sessions using the most recent tutorial's concepts were presented to participants. Time spent on each practice activity was

controlled as some study conditions took longer than others. Time limits were determined through a pilot study of 50 participants that timed how long participants took for each practice session. Participants for the pilot study were recruited from Rice University undergraduate subject pool; participants who participated in the pilot study were excluded from participating in the full study. Time limits differed by question and were set at the average time taken plus one standard deviation. See Appendix A for time limits of each practice question. Any participants who finished early were instructed to sit at their workstations until time expired and were not allowed to review training materials to prevent additional practice effects or effects resulting from tasks designed to use up remaining practice time. Participants who did not complete the practice task within the given timeframe were told to proceed to the next task. If participants in any condition asked for help from research study proctors during training, they were instructed to refer to an Excel reference sheet with basic information on the training content (see Appendix B) and did not receive help from the proctor.

Study manipulations (structure and metacognitive prompts) were included only in the practice portions of the modules. After participants completed all three modules, they completed measures to evaluate their metacognitive activity during training, and two manipulation checks for both structure and metacognitive prompt manipulations. Participants then took the immediate performance test and completed a measure for self-efficacy for retention, concluding the first in-lab portion. Lastly, participants returned to the laboratory one week later to take the delayed performance test.

Structure Manipulation

Structure was manipulated within the practice period on two levels; in high

structure conditions, participants were provided with step-by-step instructions accompanied by screenshots of each step needed to complete the task. In low structure conditions, participants were told to accomplish the same tasks, but no instructions or screenshots for how to proceed through the task were provided. All participants were provided a screen capture image of what the end product should look like so they would know when they had finished each practice task. See Appendix C for examples of low structure and high structure for a practice task.

Metacognitive Prompting Manipulation

Participants in metacognitive prompting conditions were presented with a visual metacognitive prompt on a poster at their work station and an audio prompt over headphones at the beginning of the practice sessions for each module. Two different prompts were shown/heard during each practice session (see Appendix D). Participants in conditions with no metacognitive prompting did not receive any prompts during the training program.

Measures

Cognitive ability. All participants completed the paper-and-pencil Wonderlic Personnel Test (WPT; Wonderlic, 2002). The Wonderlic is a 50-item test consisting of problems that evaluate math, verbal, logic, and analogy reasoning skills. Participants were given 12 minutes to complete as many of the items as possible. Scores were obtained by summing the total number of items solved correctly within the time limit. The estimated reliability of this measure has been reported as .87 in academic settings (McKelvie, 1989).

Computer experience. Participants completed a 6-item measure to evaluate their past computer and spreadsheet program experience. Two items asked for the number of years a participant owned a computer and number of hours spent using one daily. For all remaining items, participants were instructed to rate their expertise in relation to the general population or on a specific program with an 8-point Likert scale from 1 = *never used* to 8 = *true expert*. See Appendix E.

Goal orientation. VandeWalle's (1997) 13-item measure of three dimensions of goal orientation was used to assess participants' goal orientation. Participants were instructed to evaluate themselves on these statements with a 5-point Likert scale ranging from 1 = *not at all like me* to 5 = *very much like me*. A sample item for mastery goal orientation is "I am willing to select a challenging assignment that I can learn a lot from." A performance-prove orientation item is "I prefer to work on projects where I can prove my ability to others." Lastly, a performance-avoid orientation sample item is "I would avoid taking on a new task if there was a chance that I would appear rather incompetent to others."

Motivation. Twenty items total were used to measure motivation for training. As participants were given a goal, rather than allowed to choose one, the motivation measures served as measurements of goal strength. The first 10 items were adapted from Sanchez, Truxillo, and Bauer (2000) and participants were instructed to describe their beliefs about the training on a 5-point Likert scale ranging from 1 = *strongly disagree* to 5 = *strongly agree.* A sample item is "I would like to use the Excel skills I am trained on in the future". The second set of 10-items was adapted from Tremblay et al. (2009) evaluated participants' motivation to take the training. This scale presented statements to

participants and instructed them to indicate on a 5-point Likert scale (1 = *does not correspond at all* to 5 = *corresponds exactly*) the correspondence with their reasons for taking the training program. A sample item from this scale is "I am taking this training program because I derive much pleasure from learning new things". These measures were later combined due to the strong correlations between both measures. See Appendix F.

Self-efficacy. The 10-item self-efficacy scale was adapted from Quinones (1995) to assess participants' self-efficacy for retention (after the immediate test and prior to the delayed test). Responses were completed on a 5-point Likert scale from 1 = *strongly disagree* to 5 = *strongly agree.* A sample item is "After a delay, I am sure I could remember how to use Excel effectively." See Appendix G.

Structure manipulation check. Participants completed a 6-item measure adapted from Carter and Beier (2010) to assess the degree of engagement in active, exploratory learning (i.e., if participants had to explore and infer material from the training environment). A sample item is "I was able to complete the practice tasks without having to experiment with the steps I took." The structure manipulation check asked participants to respond to items on a 5-point Likert scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. See Appendix H.

Metacognitive prompts manipulation check. A 2-item metacognition manipulation check developed for the present study assessed whether participants were aware of the metacognitive prompts presented during practice. Participants responded to the following item on a Yes/No dichotomy: "Did you see/hear the visual/audio prompts during practice?", then provided a free-response answer detailing the exact content they heard. See Appendix I.

Metacognitive activity. Participants completed a 15-item metacognitive activity measure adapted from Schmidt and Ford (2003). Participants responded to items on a 5-point scale ranging from 1 = *never* to 5 = *always*. See Appendix J.

Performance. Performance was evaluated twice during the study; participants were given a performance test immediately after training concluded and one week after completion of the training intervention. Each assessment consisted of two performance questions and required participants to perform a specific Excel task or troubleshoot a problem above and beyond the content taught in the training program. See Appendix K. Questions provided a basic work scenario and required participants to complete a task to fulfill the needs presented in the scenario. Error detection questions provided participants with a description of an error and asked participants to detail how they would remedy the issue. To simulate realistic work scenarios, no screenshots were provided to give participants an indication of when to stop working (as was available in the practice tasks). All assessment questions were scored based on how many elements each participant correctly produced or solved.

Results

Contrasts and Manipulation Checks

Orthogonal contrasts were developed for structure and metacognitive prompts; contrasts were developed such that the sum of the cross-products of contrast coefficients equaled zero. The structure contrast was: .5 (high structure + metacognitive prompts), .5 (high structure + no prompts), -.5 (low structure + metacognitive prompts), -.5 (low structure + no prompts). The metacognitive prompts contrast was .5 (high structure + metacognitive prompts), -.5 (high structure + no prompts), .5 (low structure +

metacognitive prompts), -.5 (low structure + no prompts).

Structure and manipulation checks were also examined to see if the experimental manipulations were effective. For the structure manipulation, participants perceived significant differences between high and low structure conditions ($t(201) = 2.36$, $p = .019$) such that high structure participants were more likely to rate training as structured than participants in low structure. Additionally, participants perceived significant differences in the presentation of metacognitive prompts between no prompt and metacognitive prompt conditions ($t(201) = 14.1$, $p < .01$); participants who received metacognitive prompts perceived the visual and audio prompts more than participants who received no prompts.

Preliminary Analyses

In an effort to manage the amount of time participants spent completing the study, twenty-eight of the recruited participants were given a fixed amount of time to complete the performance tests. However, this time constraint proved to be problematic; participants were unable to complete all of the training content, thus the time constraint on the performance tests was later removed. The time constraint on practice tasks was preserved for the duration of the study however. A *t*-test revealed that there was no difference in performance between participants who experienced fixed time constraints on the performance test and those who had no time limit (immediate: $t(193) = -1.27$, $p = .21$; delayed: $t(195) = -1.60$, $p = .11$). Consequently, these participants were included in the study analyses.

Scale scores for each measure were computed by summing the items contained within each scale. After examining specific item information, one item was removed

from the computer experience scale due to low item-total correlation. The specific item (i.e., “If you own a computer, please state the number of years you have owned one.”) was reviewed to identify any issues with its content. I determined that the item was not appropriate for the population I was sampling because ownership was a poor proxy for actual computer experience; due to technological advancements, many of the recruited participants grew up with computers in their households despite not using them proficiently until they were older.

Descriptive statistics were computed for all study variables by condition (see Table 1).

Table 1

Means and Standard Deviations for All Study Variables, Overall and by Condition

		Overall (N = 208)		HMC (N = 50)		HN (N = 44)		LMC (N = 55)		LN (N = 59)	
	# Items	M	SD	M	SD	M	SD	M	SD	M	SD
1. Cognitive Ability	50	29.30	5.31	30.27	5.24	29.51	5.65	28.19	4.83	29.37	5.50
2. Computer Experience	6	18.95	4.85	19.98	4.87	19.79	5.08	18.18	4.65	18.20	4.69
3. Mastery Orientation	5	19.45	2.88	19.44	2.37	19.35	3.17	19.80	3.25	19.22	2.75
4. Performance-prove Orientation	4	13.96	2.81	13.72	3.31	14.16	2.64	14.33	2.59	13.68	2.69
5. Performance-avoid Orientation	4	12.24	2.98	12.55	3.11	11.77	2.93	12.63	2.56	12.00	3.25
6. Motivation	20	70.39	9.25	67.49	8.28	70.65	9.92	71.24	8.97	71.86	9.45
7. Metacognitive Activity	14	35.73	9.47	33.53	10.57	36.98	8.68	36.37	8.49	36.09	9.86
8. Self-Efficacy Retention	10	33.34	6.92	33.27	6.06	33.95	6.51	32.84	6.98	33.39	7.95
9. Immediate Performance	2	9.86	2.84	10.11	2.63	9.98	2.68	10.09	2.89	9.37	3.08
10. Delayed Performance	2	12.57	3.37	12.33	3.27	12.12	3.28	12.96	3.35	12.74	3.56

Note: HMC = high structure + metacognitive prompts, HN = high structure + no prompts, LMC = low structure + metacognitive prompts, LN = low structure + no prompts.

Means for computer experience indicate participants assigned to high structure conditions had more computer experience than participants in low structure conditions; however, as this was a control variable, subsequent analyses should not be affected. The means for motivation indicate that people assigned to high structure conditions may have been less motivated than people assigned to low structure conditions; thus, motivation was also controlled for in subsequent analyses. Finally, means for delayed performance point towards lower performance for people in high structure conditions relative to people in low structure conditions.

Correlations and reliabilities for all study variables were also computed to provide additional information beyond descriptive statistics (see Table 2).

Table 2

Intercorrelations and Reliabilities of Study Variables

	1	2	3	4	5	6	7	8	9	10	11
1. Structure Contrast	--										
2. Metacognitive Prompts Contrast	.07	--									
3. Cognitive Ability	.09	-.01	(.81)								
4. Mastery Orientation	-.02	.01	.09	(.82)							
5. Performance-prove Orientation	-.08	.00	.01	**.22****	(.71)						
6. Performance-avoid Orientation	-.08	.11	.09	**-.34****	**.24****	(.79)					
7. Motivation	**-.15***	-.13	.00	**.26****	**.29****	-.03	(.83)				
8. Metacognitive Activity	-.07	-.12	-.13	.02	.10	-.07	**.26****	(.88)			
9. Self-efficacy Retention	.05	-.04	**.23****	**.29****	.08	**-.18***	**.24****	.09	(.89)		
10. Immediate Performance	.03	.11	**.23****	**.18***	.03	-.13	-.05	-.02	**.38****	(.88[a])	
11. Delayed Performance	-.10	.02	**.18***	.13	-.01	-.15	.03	-.05	**.35****	**.43****	(.97[a])

Note: N = 173. * Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed). Structure contrast compares high structure + metacognitive prompts (HMC) and low structure + no prompts (HN) conditions against low structure + metacognitive prompts (LMC) and low structure + no prompts (LN) conditions, coded as .5(HMC), .5(HN), -.5(LN), -.5(LE). Metacognitive prompts contrast compares HMC and LMC conditions against HN and LN conditions, coded as .5(HMC), -.5(HN), .5(LMC), -.5(LN).

All computed scales had reliabilities of at least .70, demonstrating generally acceptable internal consistency (Cronbach, 1951). Performance test items were evaluated with two different rubrics (one per test item); scores were then summed to create overall scores for separate immediate performance and delayed performance tests. Intraclass correlation coefficients for absolute agreement were computed for each performance test and demonstrated high agreement amongst raters on the immediate and delayed performance tests ($ICC_{immediate}$ = .88, $ICC_{delayed}$ = .97). These ICC values were computed using a random sample of 20 participants who completed the entire study.

As can be seen in Table 2, none of the experimental manipulation contrasts correlated with cognitive ability or goal orientation. Correlations also indicated that self-efficacy for retention had significant positive relationships with both immediate performance (r = .38, p < .01) and delayed performance (r = .35, p < .01).

Looking at the relationships between predictor and criterion variables, motivation was also shown to correlate positively with mastery orientation, (r = .26, p < .01) performance-prove orientation (r = .29, p < .01), and metacognitive activity (r = .26, p < .01). However, motivation was not correlated with any immediate performance (r = -.05, p > .05) or delayed performance outcomes (r = .03, p > .05). On the other hand, cognitive ability demonstrated significant correlations with self-efficacy for retention (r = .23, p < .01) and performance outcomes (immediate: r = .23, p < .01; delayed: r = .18, p < .05). Additionally, mastery goal orientation had significant positive correlations with self-efficacy for retention (r = .29, p < .01) and immediate performance (r = .18, p < .05), indicating that individuals higher in mastery goal orientation had higher self-efficacy for retention of training material and performed better on the immediate test. A significant

negative correlation between performance-avoid orientation and self-efficacy for retention was also found, indicating that participants relatively higher in performance-avoid orientation believed they were less capable of retaining training material than people relatively lower in performance-avoid orientation.

Hypothesized Effects

Data were analyzed with a series of regressions to accommodate categorical independent variables and continuous covariates (i.e., computer experience and motivation). Hierarchical regression analyses were used to examine the main effect of structure on performance. Computer experience and motivation were entered as covariates in Step 1, and the main effect of structure was added in Step 2. Results indicate that after controlling for computer experience and motivation, structure did not account for a significant portion of the variation in immediate test performance (β = -.02, R^2 = .04, p = .84). However, structure did account for variance in delayed test performance (β = -.14, R^2 = .07, p = .056), providing some support for Hypothesis 1 (see Table 3).

Table 3

Hierarchical Regression for Effect of Structure on Immediate and Delayed Performance

	Immediate Performance					Delayed Performance				
Variable	B	SE B	β	R^2	ΔR^2	B	SE B	β	R^2	ΔR^2
Model 1				.05					.07	
Computer Experience	.13	.04	.23			.18	.05	.26		
Motivation	-.03	.02	-.08			.00	.03	.00		
Model 2				.05	.00				.09	.02*
Computer Experience	.13	.04	.23			.20	.05	.29		
Motivation	-.03	.02	-.08			.00	.03	-.02		
Structure Contrast	-.08	.43	-.02			-.94	.49	-.14		

Note: $N = 173$. * $p < .10$

To test for the presence of a structure and metacognitive prompt interaction, immediate test performance was regressed onto covariates (Step 1), the structure and metacognitive prompt contrasts (Step 2), and finally the interaction between the structure and metacognitive prompt contrasts (Step 3). However, no significant interaction was found (β = -.05, R^2 = .03, p = .54). A regression for delayed test performance was also performed but no significant interaction was found (β = .00, R^2 = .06, p = .96). Thus, the data does not support Hypothesis 2A. Because the interaction of structure and metacognitive prompts on performance was not significant, the mediated moderation proposed in Hypothesis 2B could not be analyzed.

I then examined the cognitive ability and structure interaction on performance with hierarchical regression. Any continuous predictors (e.g., cognitive ability) were standardized to account for multicollinearity amongst study variables (see Aiken & West, 1991). Computer experience and motivation were entered as covariates in Step 1, and main effects of cognitive ability and structure were entered in Step 2. In Step 3, the two-way interaction of abilityXstructure was entered. However, this interaction was not significant for both immediate test performance (β = .01, R^2 = .08, p = .87) and delayed test performance (β = -.11, R^2 = .10, p = .11). Thus, there was no aptitude-treatment interaction of cognitive ability and structure, and Hypothesis 3 was not supported.

Motivation was also regressed onto post-training performance (with computer experience as a covariate), but no significant effects were found for both immediate test performance (β = -.08, R^2 = .04, p = .26) and delayed test performance (β = .00, R^2 = .06, p = .95). This indicates that motivation did not influence performance and Hypothesis 4

was not supported. These results are consistent with the lack of significant correlations between motivation and performance outcomes.

To analyze the interaction between metacognitive prompts and all types of goal orientation proposed in Hypothesis 5A, metacognitive activity was regressed onto the covariates of computer experience and motivation (Step 1), main effects of goal orientation scales and the metacognitive prompt contrast (Step 2), and finally the two-way interactions (Step 3; learningXmetacognitive prompts, performance-proveXmetacognitive prompts, and performance-avoidXmetacognitive prompts). Because goal orientation was a continuous predictor, the scales for each dimension were standardized before being placed in the regression. No significant interactions between metacognitive prompts and different types of goal orientation on metacognitive activity were found (learningXmetacog prompts: β = -.06, R^2 = .07, p = .43; performance-proveXmetacog prompts: β = .02, R^2 = .07, p = .77; performance-avoidXmetacog prompts: β = .07, R^2 = .07, p = .37). The mediated moderation proposed in Hypothesis 5B could not be tested because none of the interactions between types of goal orientation and metacognitive prompts were significant. Consequently, participants' goal orientation in combination with assigned structure condition did not influence the amount of metacognitive activity a person engaged in.

Lastly, no main effect of structure on self-efficacy for retention was found (β = .00, R^2 = .23, p = .95) after regressing self-efficacy for retention onto the covariates (Step 1) and structure contrast (Step 2). Furthermore, structure did not have a significant correlation with self-efficacy for retention, providing evidence that structure conditions did not affect participants' beliefs that they could retain the training material. Therefore,

Hypothesis 6 was not supported.

Discussion

The present study sought to examine the effects of structure and metacognitive prompts on training outcomes, and identify the psychological mechanisms through which these training manipulations work. This is important for both scientists and practitioners as it provides a better understanding of the psychological variables at work and how to best target those variables that produce improved training outcomes. In this study, I manipulated structure and metacognitive prompts to target proximal variables in the skill acquisition process and examined their effects on training outcomes (i.e., performance and self-efficacy).

Preliminary results from this study provide evidence of effective study manipulations, with participants engaging in activity indicative of their assigned structure conditions and detecting the metacognitive prompt stimuli only when they were provided. However, descriptive information for the data did not indicate general tendencies in the same direction of the hypothesized expected effects. Analyses to test the hypothesized effects provided more interesting information, as many anticipated effects were not present.

The one significant hypothesized effect in this study was the main effect of structure on delayed performance, such that participants in low structure conditions outperformed participants in high structure conditions. Even though there was no effect of structure on immediate performance, the significant main effect on delayed performance aligns with previous empirical work by Schmidt and Bjork (1992). These authors demonstrated that training manipulations for motor tasks and verbal learning,

which yield poorer performance during training, are actually beneficial and produce better performance after a temporal delay. Thus, though there may not be a difference in immediate performance after participants are exposed to low structure training, this training design feature has the potential to benefit trainees long after training has concluded because increased performance will occur while they are on-the-job.

This result also provides support for the theoretical mechanism underlying exploratory training; specifically that exploratory, low structure training situations facilitate a broader base of knowledge acquisition than guided, high structure training. Furthermore, the result aligns with the resource allocation theory perspective that low structure training uses more cognitive resources than high structure training, facilitating poorer performance post-training. Structure does not seem to impact participant affect however, as no significant main effect of structure on self-efficacy for retention of training material was found. Furthermore, when structure was combined with metacognitive prompts, participants' post-training performance was not affected. These two findings may be a function of the population sampled; Rice undergraduate students are on average more efficacious as a product of their life experiences (e.g., gaining admission into a top-tier university) and may engage in metacognitive activity as part of their typical behavior.

No significant correlations, main effects, or hypothesized interactions (i.e., interactions between structure and metacognitive prompts, and goal orientation and metacognitive prompts) with metacognitive prompting were observed, despite participants noticing the actual prompts during training. These non-significant results collectively imply that metacognitive prompts do not affect performance and people

naturally engage in an average level of metacognitive activity regardless of prompts, structure, or goal orientation. Even though study results do not support the theoretical underpinnings for these predictions, preliminary analyses indicate that there may be additional variables affecting participants' engagement in self-regulatory activity.

The strong positive correlation between motivation and metacognitive activity suggests that the more motivated people are for training, the more resources they will allocate towards self-regulation (i.e., metacognitive activity). However, this relationship may be due to assigning participants a goal for training, rather than allowing them to establish one themselves. The assigned goal during this study may have also affected motivation and performance as well, because no significant correlation between the two variables was found despite multiple studies in the literature indicating that motivation affects training performance (Colquitt, LePine, & Noe, 2000).

In relation to resource allocation theory, these results yield several implications. First, structure affects training outcomes, specifically performance. This lends support to the idea that structure affects performance by increasing or decreasing cognitive load on participants in skill acquisition situations. Second, metacognitive activity did not mediate any training outcomes despite being a proximal process that trainees do report engaging in. This may be due to the effectiveness of metacognitive prompts at triggering metacognitive activity. However, participants do appear to self-regulate as a function of how much they are motivated (or how strong their goals are) for training. And third, though structure appears to affect proximal processes enough to influence performance, this is not the case for self-efficacy for retention of training materials. This lack of an effect may be due to the laboratory nature of the study. The population of participants I

sampled from use technology (i.e., computers) regularly as part of their occupation as undergraduate university students. Thus, they have multiple life experiences affirming that they are capable of using computers and related software. The negative feedback that they received as part of the training program may not have exceeded a threshold before they will truly reconsider how efficacious they are at something. Furthermore, participants knew they were taking the training for research credit and would not receive academic grades dependent on their post-training test scores.

The lack of significant hypothesized results may raise questions about the validity of this study. However, the statistical results that were not the focal point of the hypotheses provide some evidence for validity. For example, study results indicate that the strongest, consistent predictor of both immediate and delayed training performance is cognitive ability. This effect has been repeatedly demonstrated in the literature and aligns with established empirical evidence that cognitive ability is one of the best predictors of performance (Colquitt, LePine, & Noe, 2000). Additionally, the interrater reliability of both post-training performance tests demonstrated high levels of agreement, indicating that the rubric grading system used to evaluate performance test items was a consistent criterion measure. Further evidence of validity was demonstrated with a significant positive relationship between performance and self-efficacy for retention, a result that coincides with previous literature on multi-dimensional training outcomes (Kozlowski et al., 2001).

Limitations

Despite having manipulations that were detected or cued appropriate participant activity, there are some areas for improvement and further investigation for this study.

The metacognitive prompt manipulation could benefit from improvement; specifically, increased sensitivity in measuring whether metacognitive activity is a product of the experimental manipulation or due to participants' typical learning process. This would help identify the cause of the metacognitive activity. Additionally, the sensitivity of the performance tests as dependent variables could be examined. Though these measures were consistent, a lot of the original content proposed for use in the training program and subsequent performance tests was reduced to fit all relevant content within time limitations. Thus, while the performance test items were complex, the number of items may need to be increased to improve sensitivity for measuring performance.

Future Directions

Though past research has provided evidence of metacognitive instructions being effective, the effects are small (Schmidt & Ford, 2003). In this study, I was unable to find evidence for hypothesized effects related to metacognitive prompting, or any preliminary statistical evidence indicating a potential effect of metacognitive prompts, regardless of the direction of the effect. Future research work can focus whether metacognitive prompts effectively activate metacognitive activity like researchers theorize in the literature. However, one should also carefully evaluate whether metacognitive activity produces a meaningful increase in performance (given the small effect size indicated by the literature) and consider whether future work in this specific research stream should be pursued.

Conclusion

The present study sought to examine the effectiveness of structure and metacognitive prompts on training outcomes while framed in a resource allocation

framework. Study results indicate that structure (i.e., high vs low) produces a main effect on performance, where participants in low structure benefit. Additionally, the non-supported effects pose critical questions for psychologists. Particularly, researchers should consider whether or not metacognitive prompts are a useful avenue to pursue in training design and how to disentangle the complicated role metacognitive activity may play in the skill acquisition process. Follow-up research that addresses such topics will provide psychologists with a clearer perspective on metacognition when used within skill acquisition environments and the validity of resource allocation theory in different contexts.

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Appendix A

Practice Item Time Limits

Module 1 Practice
M = 5.36
SD = 2.71
Time limit = 8 minutes

Module 2 Practice
M = 3.34
SD = 1.54
Time limit = 5 minutes

Module 3 Practice
M = 6.52
SD = 3.67
Time limit = 9.25 minutes

Appendix B

Excel 2010 Reference Sheet

Pivot Tables

- Specialized table used to organize information
- Accessible via right clicking on pivot tables, Pivot Table Field List pane, and Options tab
- Access points for different functions
    - Insert tab
        - Create pivot table
    - Pivot Table Field List pane
        - Summarize field values
        - Pivot a report
        - Filter
    - Pivot Table Options tab
        - Pivot table-based calculations/formulas
        - Sort
        - Filter
        - Group

Macros

- Automates repetitive tasks
    - Can record screen activity or use Visual Basic code
- Access points for different functions
    - Developer Tab
        - Create macros
        - Reference different cell locations
        - Run macros

VLOOKUP

- Search function for list-based information
    - Can find exact or approximate values with a reference
- Not constrained to same worksheet
- Access points
    - Formulas tab
    - Typewritten formula
- Type of information needed
    - Reference cell
    - Target information location
    - Type of information match desired

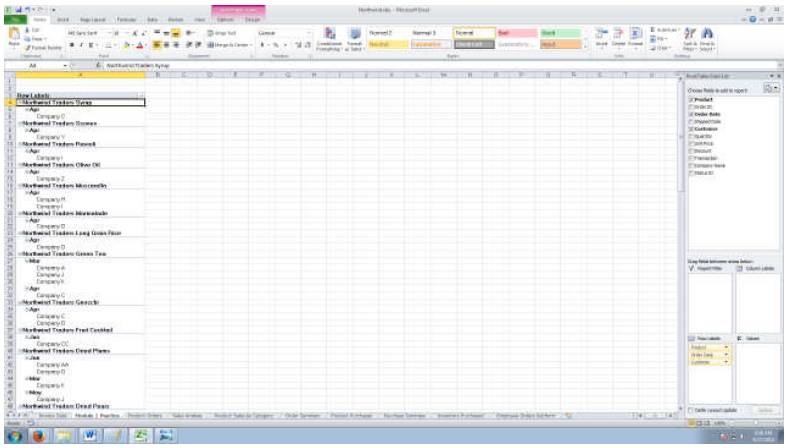
Appendix C

Practice Task Example

Task:
Open Northwind.xlsx workbook and select the "Product Orders" spreadsheet. Using this spreadsheet as your source data, create a pivot table that organizes the data with the following fields as Row Labels: Product, Order Date, and Customers. Group the Order Date by months. Place this pivot table in a new spreadsheet called "Module 1 Practice". Sort the Product Names in reverse alphabetical order from Z to A.

Low Structure

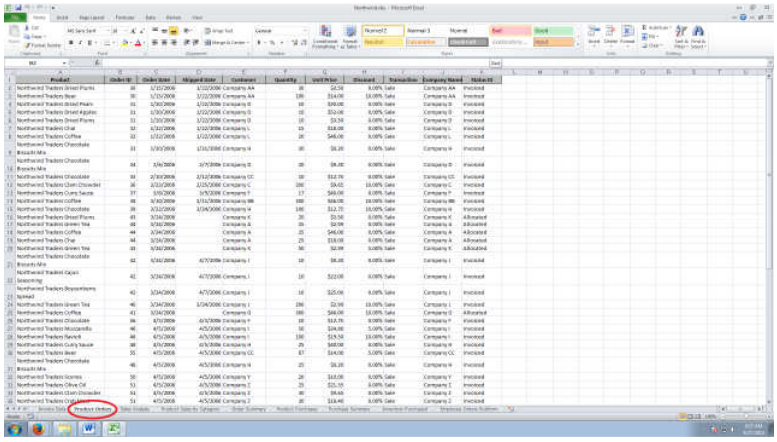
The screenshot below will show how your final product should look like.



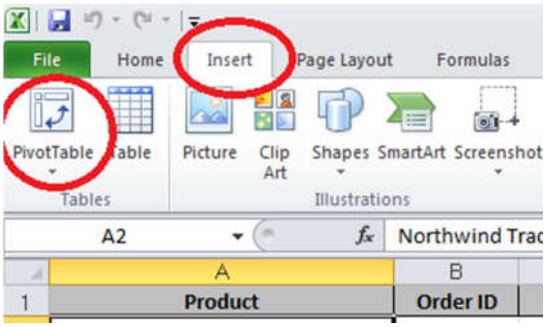
High Structure

1. Go to File, then Open.

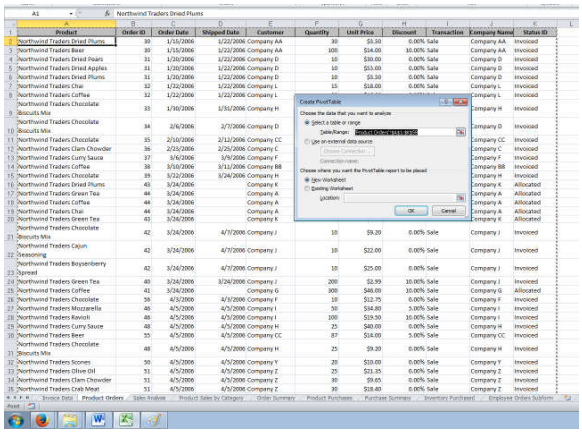
2. Select the Northwind.xlsx database. Once it is open, select the “Product Orders” spreadsheet.



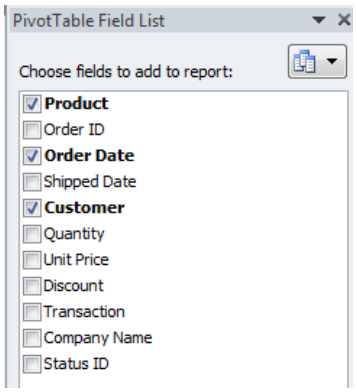
3. Click on “Insert” and select “PivotTable”



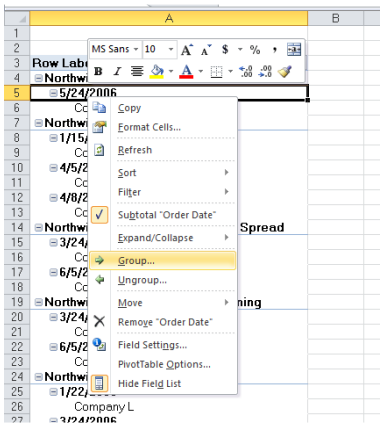
4. Make sure all the data is selected. Select “New Worksheet” for “Choose where you want the PivotTable to be placed.” Click “OK.”



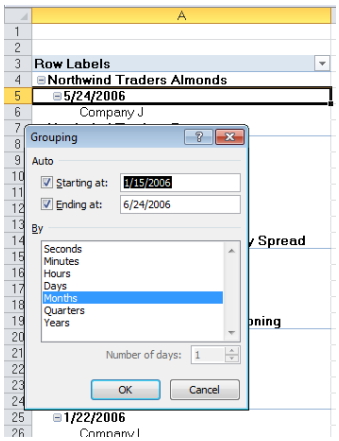
5. Select “Product” “Order Date” and “Customer” from the PivotTable Field List on the right.



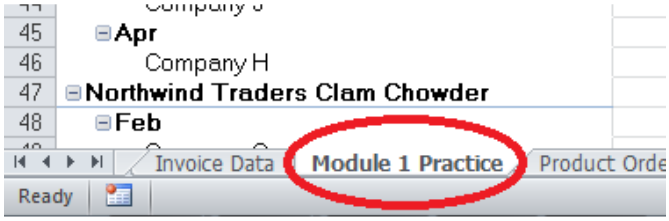
6. To group Order Date by months, right click on a date and select “Group”.



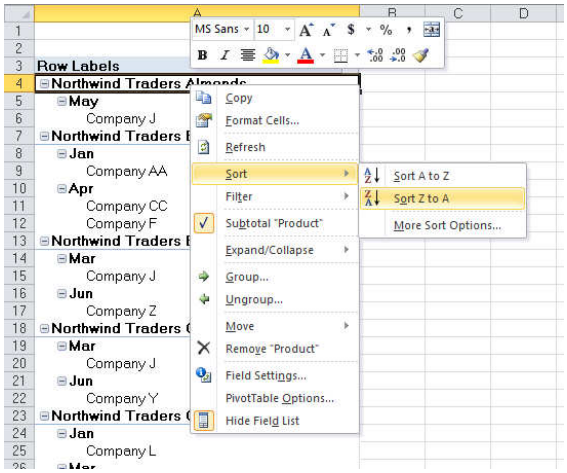
7. Then select “Months” and click “OK.”



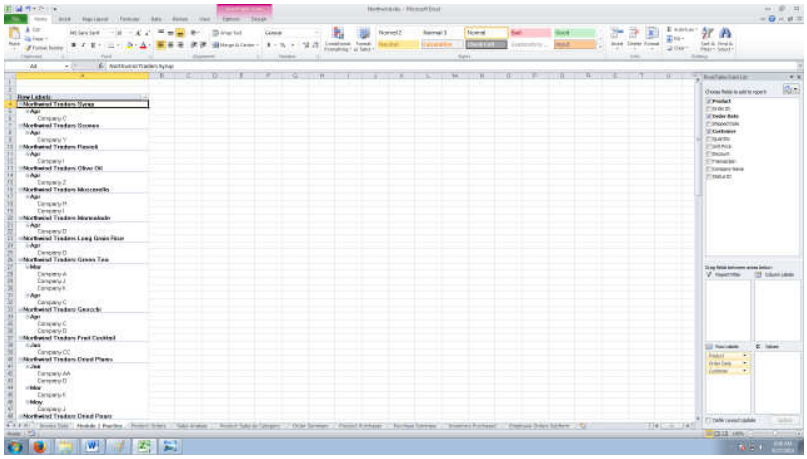
8. Rename “Sheet 1” as “Module 1 Practice”.



9. Right click on “Northwind Traders Almonds”, select “Sort”, and “Sort Z to A”.



10. The screenshot below will show you how your final product should look like.



Appendix D

Metacognitive Prompts

Prompts presented before practice:
"Before you start practice…"

1. …think about what the main concepts of this training module are.
2. …think about what steps may be needed to successfully complete the task.
3. …think about what portions of the task should be addressed first.
4. …think about checking and evaluating your progress throughout the activity.
5. …think about what needs to be accomplished for this task.

Prompts presented on posters:

1. Think about how you're progressing toward the task.
2. Think about what portions of the training concepts you find confusing.
3. Think about the feedback you are getting from Microsoft Excel and how this may affect your current task strategy.
4. Think about the different ways you can approach the task and if one of these ways may be more efficient than your current method.
5. Think about what you can do better to accomplish the task more quickly and accurately.

Appendix E

Past Computer and Spreadsheet Software Experience

1. If you own a computer, please state the number of years that you have owned one. _____

2. Please estimate the number of hours you spend using a computer during an average day where you would typically use a computer (e.g., average workday):
   a. None
   b. 0 – 1 hour
   c. 2 – 4 hours
   d. 4 – 7 hours
   e. 7 hours or more

3. On a scale of 1 (true beginner) to 8 (true expert), estimate your general level of expertise with computers, compared to the general population: _____

4. On a scale of 1 (never used) to 8 (true expert), please rate your level of expertise with the following programs:

   _____ Microsoft Excel
   _____ Lotus 1-2-3
   _____ OpenOffice Calc
   _____ Google Spreadsheets (within Google Docs/Drive)

5. List any additional spreadsheet programs you have had experience with. For each program you list, rate your level of expertise with the program on a scale of 1 (true beginner) to 8 (true expert).

6. On a scale of 1 (never used) to 8 (true expert), please rate your level of expertise with the following features in Microsoft Excel:

Tables
_____ Basic
_____ Logical (e.g., IF, AND)

Formulas & Functions
_____ Financial
_____ Logical (e.g., IF, AND)
_____ Text
_____ Statistical
_____ Mathematical & Trigonometry
_____ Lookup & Reference
_____ Engineering

Macros
_____ Recording-based (no programming or code needed)
_____ Programming/code-based (e.g., Visual Basic)

Other
_____ Charts/Graphs
_____ Sparklines
_____ Formula Auditing
_____ Keyboard Shortcuts

Appendix F

Training Motivation

Set 1 (adapted from Sanchez et al., 2000)

1. If I try my best during the Excel training program, I can do well on the performance test.
2. If I concentrate and try hard, I can master the Excel training content.
3. I can master the skills taught during the Excel training program if I put in effort during training.
4. If I do well during this Excel training program, I have a good chance of using the skills I learned in the future.
5. I think I will use the Excel skills in the future if I master them.
6. Whether I can master the Excel skills will affect whether I will use them in the future.
7. The better I master the Excel skills, the better my chance of using them in the future.
8. I would like to use the Excel skills I am trained on in the future.
9. It would be good to use the Excel skills in the future.
10. I want to use the Excel skills in the future.

Set 2 (adapted from Tremblay et al., 2009)

11. I believe the Excel skills taught during training will be useful in obtaining certain goals in the future.
12. I am taking this training program because of a course requirement.
13. I am taking this training program because I derive much pleasure from learning new things.
14. I chose to participate in this training program because it will move me closer towards my career goals.
15. I am participating in this training program for the satisfaction I experience from taking on interesting challenges.
16. I believe this training program will provide me with marketable/useful skills.
17. Participation in this training program will help me attain the grade I want in class(es).
18. I am participating in this Excel training because I find the topic interesting.
19. I am taking this training for the satisfaction I experience when I am successful at doing difficult tasks.
20. I am doing this training because I receive course/extra credit in return.

Appendix G

Self-efficacy for Retention (adapted from Quinones, 1995)

1. I feel confident in my ability to use Excel in the future.
2. I think I can retain much of my Excel knowledge.
3. After a delay, I am sure I could remember how to use Excel effectively.
4. I don’t feel that I am as capable of retaining my Excel knowledge as other people.
5. On average, other people are probably much more capable of retaining their Excel knowledge than I am.
6. I am a good at remembering how to use computer spreadsheet programs, in comparison to other people.
7. I don't think I could ever remember much of my Excel training, no matter how much practice and training I got.
8. It would take me a long time to re-learn how to use Excel effectively.
9. I am not confident that I can retain my Excel knowledge successfully.
10. After a delay, I doubt that my performance would be very adequate on an Excel test.

Appendix H

Structure Manipulation Check (adapted from Carter & Beier, 2010)

1. I made some errors during the practice tasks.
2. After looking at the results of an action, I needed to go back and make corrections.
3. I tried several different options when trying to complete a practice task.
4. I was able to complete the practice tasks on the first try without making any mistakes.
5. I needed to make changes to the steps I took to successfully complete a task.
6. I was able to complete the practice tasks without having to experiment with the steps I took.

Appendix I

Metacognitive Prompt Manipulation Check

1. Did you see/hear the visual/audio prompts during practice?
    - Yes
    - No
2. What types of prompts did you see/hear? (free response)

Appendix J

Metacognitive Activity (adapted from Schmidt & Ford, 2003)

"During this training program…."

1. …I thought about how well my tactics for learning were working.
2. …I thought carefully about how well I had learned material I had previously studied.
3. …I thought about what skills needed the most practice.
4. …I tried to monitor closely the areas where I needed the most improvement.
5. …I thought about what things I needed to do to learn.
6. …I asked myself questions to make sure I understood the things I had been trying to learn.
7. …I tried to think through each topic and decide what I was supposed to learn from it, rather than just jumping in without thinking.
8. …I monitored how well I was learning its requirements.
9. …I carefully selected what to focus on to improve on weaknesses I identified.
10. …I tried to change the way I learned in order to fit the demands of the situation or topic.
11. …I made up questions to help focus on my learning.
12. …I set goals for myself in order to direct my activities.
13. …if I got confused, I made sure I sorted it out as soon as I could before moving on.
14. …I noticed where I made mistakes and focused on improving those areas.
15. …I tried to determine which things I didn’t understand well and adjusted my learning strategies accordingly.

Appendix K

Assessment Questions

Immediate Test

1. John has been assigned to examine Northwind Traders' sales analysis data and prepare a report which will be publicly displayed in the break room for employees to track their sales progress. Using the Sales Analysis spreadsheet,
    a. Make a pivot table which reports the sum of monthly sales (in dollars) for each salesperson.
    b. Use Employee IDs as identifiers so employees can track their progress confidentially. Put these in numerical order across the top row of the pivot table.

2. You are trying to create a calculated item function but you keep getting a #NAME error. Part of the issue seems to stem from having the same name for different items. Specifically, two items have the same name but are in two different fields within a single report. How do you fix this issue and get rid of the #NAME error?

Delayed Test

1. Northwind Traders has implemented a new surcharge policy due to rising shipping costs. Each order placed at Northwind Traders, regardless of order amount, will now have a $5 surcharge.
    a. Using the Order Summary spreadsheet, create a pivot table containing all order numbers with their total order amounts, shipping fees, and order dates.
    b. Then incorporate a pivot table field that determines the grand total amount the customer will be charged, including the new $5 surcharge and shipping costs.

2. You have created a pivot table containing data for order date (as indicated by MM/DD/YYYY), product name, and order amount fields. The data is sorted in reverse alphabetical order by product name. Now you want to group the order date by months. However, the following error is produced:
   "Cannot Group that Selection"

   What is an aspect of a data set that may produce this error?

Appendix L

Practice Questions

Module 1: Pivot Table Basics
Open Northwind.xlsx workbook and select the "Product Orders" spreadsheet. Using this spreadsheet as your source data, create a pivot table that organizes the data with the following fields as Row Labels: Product, Order Date, and Customers. Group the Order Date by months. Place this pivot table in a new spreadsheet called "Module 1 Practice". Sort the Product Names in reverse alphabetical order from Z to A.

Module 2: Filtering Data
Open Northwind.xlsx workbook and select the "Sales Analysis" spreadsheet. Create a pivot table that displays the employee who made the sale, Customer Name, and Sales amount. Filter the data so that only information from companies J to Y appear.

Module 3: Calculating Data in Pivot Tables
Open Northwind.xlsx workbook and select the "Order Summary" spreadsheet. Make a pivot table that shows orders for all companies grouped by month. Create a calculated field showing Order Total, which consists of the Sub Total and Shipping Fee combined. Columns from left to right should read “Sum of Sub Total, Sum of Shipping Fee, and Sum of Order Total.”