MAKING ERRORS AND VISUALIZING SUCCESS: EFFECTS ON TRAINING TRANSFER

By

Nathan T. Brucher

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ABSTRACT

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Error management training and symbolic rehearsal are two training techniques that have been shown to affect training transfer. Previous studies have looked at these two techniques in isolation, however the effects have never been examined together. The current study attempts to examine the effects on training transfer. Using a software training paradigm, error management training with an added symbolic rehearsal component was hypothesized to contribute to better adaptive transfer, declarative knowledge, and mental models than an error management training alone condition. Results indicated there was no significant difference between conditions. Exploratory analyses confirmed relationships found in past research. Discussion, implications, and limitations of the current study are included.

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CHAPTER 1:

INTRODUCTION

Training is important for maintaining competency in the twenty-first century. Companies need highly skilled workers and individuals need to learn new skills to keep up with an ever-changing workplace. This study aims to examine alternative approaches to improving training effectiveness by combining two previously unpaired techniques. In order for training to work it needs to transfer. Transfer is when knowledge, skills, and abilities are able to be used when moving from training to a job setting, or from one task to another (Baldwin & Ford, 1988; Hesketh, 1997). Without transfer, training is useless. As researchers and practitioners, transfer should be the goal of any training program. This study investigates error management training (EMT) and symbolic rehearsal (SR) as well as the impact of combining the two approaches on training effectiveness.

First, I outline current and past findings focusing on SR design, history, theory, and outcomes. Next, I do a similar review of EMT literature. Finally, I integrate the two literatures and develop a research model to drive research and generate hypotheses.

Symbolic Rehearsal

Can simply imagining performing a skill increase training effectiveness? Symbolic rehearsal is a cognitive technique that has been used to increase effectiveness in learning cognitive and motor skills. Symbolic rehearsal is also a key component in behavioral modeling training. I will start first by describing symbolic rehearsal and going into the cognitive theory behind it and reviewing studies that show its effectiveness.

Symbolic rehearsal, which has been referred to as mental practice (Driskell, Copper, & Moran, 1994; Suinn, 1997), mental rehearsal (Rawlings & Rawlings, 1974), or imagining (Cooper, Tindall-ford, Chandler, & Sweller, 2001) is a cognitive technique whereby individual imagines themselves performing the skill or action which they are to learn (Bandura & Jeffrey, 1973). Studies involving symbolic rehearsal usually include a portion after learning the behavior where participants are instructed to close their eyes and imagine themselves performing the action correctly. Studies usually include comparisons to a control group which does no practice or a motor practice group. They are then assessed on some performance measure (Driskell et al., 1994).

Symbolic Rehearsal and Psychological Processes

Theories from Behavioral Modeling and Social Learning.

Symbolic rehearsal has origins in social learning theory. Two major components of social learning theory are symbolic rehearsal and symbolic coding (Bandura & Jeffrey, 1973). Symbolic coding occurs when an observed behavior is coded by an individual into mental symbols. These are usually represented as verbal or visual representations of the steps and main aspects of the trained behavior, but can take other symbolic forms (Bandura & Jeffrey, 1973). These symbols provide a way for an individual to remember the behavior beyond a simple stimulus response. Many behavioral modeling training experiments have an explicit symbolic coding component where the person is either presented or are asked to generate the learning components necessary for replication of the behavior. These symbolic coding components of behavioral modeling have been shown to be effective, especially when rules for the behavior are provided or generated rather than simple summaries or descriptions of behavior (Decker, 1980, 1982, 1984). In studies with a symbolic rehearsal component, participants are asked to use these codes as guides for mentally rehearsing the behavior. Studies in which participants generate their own symbolic coding rules have been shown to be the most effective (Decker, 1980).

Symbolic rehearsal occurs when a person consciously uses these symbols to aid in their memory of the observed event. This can take the form of internal dialogue, mental imagery, verbalizations or other ways of invoking the symbolic codes.

Symbolic rehearsal has shown effectiveness above and beyond motor rehearsal in behavioral modeling studies (Decker 1980, 1982, 1984; Jeffery, 1976). A meta-analysis indicated that including symbolic rehearsal in behavioral modeling training has a positive effect on training effectiveness *(d* = .27; Taylor, Russ-eft, & Chan, 2005). Behavioral modeling and symbolic rehearsal has been shown to be useful in simple maze tracing studies (Sacket, 1934) , interpersonal skill training (Decker, 1984), computer skill training (Davis & Yi, 2004), and surgical training (Arora et al., 2011; Mick et al., 2016). Symbolic rehearsal or mental practice has been influential in sports psychology, showing improvement in a variety of motor skills (Suinn, 1997).

Theories from Sports Psychology

While behavior modelling literature has shown benefits to outcomes of training, it has not elaborated on the processes leading to those outcomes. Symbolic rehearsal has long been studied in sports psychology as a way to enhance training effectiveness. Several theories have been proposed to account for the efficacy of symbolic rehearsal in sports training.

Activation of Neurological Pathways.

One theory is that the symbolic rehearsal evokes a similar neuromuscular motor pattern that is needed to perform the act (Suinn, 1997). A number of studies have found small neuromuscular activity during symbolic rehearsal, and many studies have found similar EMG activity during symbolic rehearsal and the performance of the motor movement (Bird, 1984; Harris & Robinson, 1986; Jowdy & Harris, 1990). However, many studies have casted doubt on this neuromuscular theory of symbolic rehearsal. A meta-analysis by Feltz and Landers (1983) suggests that the effects of symbolic rehearsal are not likely produced by these neuromuscular patterns, suggesting that symbolic learning and cognitive explanations are better explanations.

Motivation.

Another line of thinking proposes that symbolic rehearsal increases motivation and self-efficacy as the person imagines themselves succeeding at the task. (Paivio 1985). Evidence for increased motivation has been argued for in behaviors of athletes. These include engaging in longer practice, more practice, or enduring more physical exhaustion (Suinn, 1997). However, contradictory results suggest that self-efficacy is not affected by symbolic rehearsal. Other studies argue that the symbolic rehearsal vision of success has to be task specific rather than general visions of success (Lee, 1990). Finally, the meta-analysis of symbolic rehearsal showed a low effect size when comparing motivational and nonmotivational control groups (Feltz & Landers, 1983). The motivational theory of symbolic rehearsal does not have strong support among the field.

Arousal.

Arousal theories posit that the symbolic rehearsal process evokes arousal that lead to priming of the muscles and lower the threshold required to activate the motor skill (Suinn, 1997). There is not much empirical support of this theory. Emotional aspects of symbolic rehearsal have not been found to relate to performance and in some cases negative relationships were found (Murphy, Woolfolk, & Budney, 1988).

Symbolic Learning.

The most empirically supported theories of symbolic rehearsal in sports psychology are symbolic learning theories. These state that the effectiveness of symbolic rehearsal is due to the fact that people are practicing the symbolic components of the motor task rather than the actual motor actions. These are the more cognitive elements of the task rather than the motions. These can include temporal, spatial, or plans of action (Suinn, 1997). Support for symbolic learning theory is seen by the fact that tasks that contain more cognitive elements benefit more from symbolic rehearsal or mental practice (Feltz & Landers, 1983).

Schema Automation and Cognitive Load Theories.

One view of symbolic rehearsal states that it facilitates automation of schema (Cooper et al., 2001). Schemas allow for the categorization of new information. Automation occurs when a task moves from high conscious processing to minimal conscious attention. In the initial stages of learning, individuals develop schemas to organize information in their mind. These initial schemas are effortful and require conscious working memory to be used. With practice, these schemas become automatic and less effortful working memory is dedicated to enacting the schemas. For example, novice drivers have to consciously think about pushing the gas pedal and changing gears, but as time goes on this process becomes automatized and requires less attention. A study using a computer spreadsheet application showed that SR, aids in the automation of schema, but only if a proper schema has been formed beforehand (Cooper et al., 2001).

Automation of schema relates to cognitive load theories of learning. According to cognitive load theory there is a limited amount of cognitive resources that can be devoted to novel information (Paas, Renkl, & Sweller, 2004). Working memory process new information and is limited in the amount of information it can take in (Cowan, 2000; Miller, 1956). However, working memory does not have the same limitations when working with information that has previously been organized and taken from long term memory (Ericcson & Kintsch, 1995; Paas et al., 2004). To this end anything that facilitates the transfer of memory from working memory to long term memory should result in reduced cognitive load, freeing cognitive resources for other tasks. Schemas normally take up working memory capacity when they are being constructed, however automation of schemas does not. This schema acquisition and automation is important for learning (Kotovsky, Hayes, & Simon, 1985). SR processes schemas in working memory which facilitates long term memory construction and automation of schemas (Leahy & Sweller, 2007). This creates superior schemas in long-term memory that can be drawn upon when recalling information and performing skills.

Research indicates that using SR with higher element interactivity material and large cognitive load is most beneficial for this schema construction and automation (Leahy & Sweller, 2007). Therefore, high complexity tasks such as steps for interacting with a computer software are well suited to SR.

In a nutshell, SR aids in schema construction and automation and transferring that to long term memory. The schema can be drawn upon from working memory without using up resources which frees resources for future more novel information.

Conclusion

In conclusion, theories of symbolic rehearsal are varied and there is debate to which accurately describes the process by which it enhances training. However, the majority of support has been in favor of more cognitive theories. These theories posit that symbolic rehearsal is useful for practicing the symbolic codes or cognitive aspects behind the skill being learned. Although these theories do not explicitly mention metacognition, the processes they are describing fit with how metacognition is conceptualized. Metacognition is conceptualized as "knowledge about one's own cognitions rather than the cognitions themselves" (Brown, 1978 p. 4). This definition of metacognition fits with cognitive theories behind symbolic rehearsal. People using symbolic rehearsal are rehearsing the cognitive aspects of the task and in doing so, become aware of them. Therefore, I argue that symbolic rehearsal fits with metacognition and that the process of undergoing symbolic rehearsal will increase metacognition.

Additionally, there is evidence and theory that SR can aid in the construction and automation of schema. It is thought that the schema is automated and transferred to long term memory. This frees working memory to tackle new situations without having to effortfully recall the information already learned. Using SR in a training program can aid learning and transfer by aiding in organizing and automating schema.

Error Management Training

Frese and Altmann (1989) state that “errors produce the non-attainment of a goal.” (p. 67). EMT is focused on encouraging active errors which are defined as “unintended deviations from plans, goals, or adequate feedback processing, as well as incorrect actions resulting from lack of knowledge.” (Frese & Keith, 2015, p. 663). These are distinguished from inefficient strategies where a non-optimal strategy results in delayed goal attainment, as well as violations where people actively attempt to break rules (Frese & Keith, 2015). The errors we look at in this review are errors of action.

A Brief History of Errors in Training and Learning

Training and learning have a deep history in psychology, however the early emphasis on training was based on rewarding positive behaviors. Thorndike first developed his law of effect which stated that favorable outcomes will increase behavior and negative outcomes will decrease behavior (Thorndike, 1927). This focus on positive reinforcement was further refined in behaviorist views of operant conditioning. Skinner took these ideas and popularized behaviorist views of learning, focusing on reinforcement of behaviors (Skinner, 1953). Theory moved on from purely behavioral learning to involving cognitive processes, but the emphasis on positive outcomes remained. Bandura’s (1986) social learning theory influenced behavioral modeling training where correct behaviors are presented and learners are intended to mimic behaviors. Errors are seen as nuisances that get in the way of learning and can actually result in interference effects or negative behaviors.

Cognitive theories began to appreciate that difficulty during learning can serve as a positive influence of learning. The desirable difficulties outlined by Robert Bjork (1994) showed that even frustrating experiences where learners are struggling during the learning phase are often times the best for facilitating long term transfer and retention, not necessarily for initial learning.

The history of what is now referred to as EMT can be dated back to Frese's (1991) study of error management using word processing software. His paradigm of framing errors positively as a learning opportunity has been investigated in number of studies. Many other studies were done to explore the psychological mechanisms behind EMT. Studies explored the metacognition (Bell & Kozlowski, 2008; Keith & Frese, 2005), motivational(Bell & Kozlowski, 2008; Chillarege, Nordstrom, & Williams, 2003; Wood, Kakebeeke, Debowski, & Frese, 2000) and emotional processes (Keith & Frese, 2005a) involved. Other studies have looked at individual differences and the limitations of EMT (Gully, Payne, Koles, & Whiteman, 2002; Kluge, Ritzmann, Burkolter, & Sauer, 2011). Recently research has turned to a more macro perspective of looking at error management culture or climate where the organization's toleration and response to errors are examined (Bell & Kozlowski, 2010; Frese & Keith, 2015).

EMT Design

EMT is an active learning approach that focuses on the idea that learners should appreciate errors as learning opportunities. Typical EMT involves an instruction phase where material is taught, as well as an active exploration phase where participants are encouraged to apply what they had just learned. The exploration phase is unguided and difficult to ensure that participants inevitably make errors. In this way, EMT is not much different from exploratory learning approaches which allow participants to explore their new skill in an unstructured setting. However, EMT training generally places trainees in more difficult situations where errors are likely to occur. Where EMT differs from pure exploration training is through the framing of the errors. In contrast to other forms of training that urge trainees to avoid errors or punish errors, EMT frames them as a positive experience that can be learned from (Keith & Frese, 2008). Many studies include adapted versions of Frese and colleagues' (1991) original instructions which include statements like "I have made an error. Great!" or "There is a way to leave the error situation." Statements like these are either repeated by an instructor when a trainee makes an error or are prominently displayed in the training environment and emphasized to the participant beforehand. Thus, the framing of the error shapes trainee's expectations so they do not see the error as a failure, but as a positive aspect that will help them achieve success in the future.

In experimental design, EMT is often contrasted with other forms of training. One of these is what is often referred to as "error avoidant" training. Error avoidant training is a traditional way of training where positive models or procedures are shown. These are generally highly structured trainings where exploration is minimized and errors are discouraged and quickly corrected (Keith & Frese, 2008). Error avoidant training was often seen as the preferable form of training according to behaviorist and social cognitive theories, because negative models could lead to poor learning (Bandura, 1986; Skinner 1953).

The majority of error management studies have been done within the context of teaching computer software skills. A meta-analysis conducted in 2008 found that 21 of the 24 studies were all computer skill based trainings and the others were decision making tasks conducted on the computer (Keith & Frese, 2008). Recently, EMT has been applied to domains outside computer software. The medical field has started to implement EMT in their studies. Studies have found the effectiveness of EMT in training surgeon trainees in surgical simulations (Darosa

& Pugh, 2012; Gardner & Rich, 2014), radiology (Gardner, Abdelfattah, Wiersch, Ahmed, & Willis, 2014), and ultrasound skills (Dyre, Tabor, Ringsted, & Tolsgaard, 2017). This focus on learning from errors is due to the severity of error consequences in the medical field. There is little research on interpersonal or other soft skills, however one study did find support for the effectiveness of EMT on learning and transfer of a negotiation skill task (Cullen, Muros, Rasch, & Sackett, 2013). Behavioral modeling training has traditionally been used to teach these interpersonal "soft skills" (Taylor et al., 2005).

Effectiveness of EMT

The effects EMT might not be obvious to the trainee or trainer during the actual learning session. The effectiveness of EMT depends on the time performance is examined. If you look at within training performance, performance during the learning context is often worse than error avoidant methods. Meta-analytic results found a small negative effect on within training performance (d = -.15) However, a large benefit of EMT on post training performance was found (d =*.56*; Keith & Frese, 2008) This is an important distinction because many training programs are effective at teaching within the program, but the teaching does not extend to a time after the training. The goal of training is not just to impart knowledge, but to have an impact after the training is completed. If things are going easy during training, trainees are likely to overestimate their learning. (Bjork, 1994). With EMT, trainees might not feel like they are learning, but post training results show otherwise.

In order to examine effectiveness of training, you have to look at transfer of knowledge and/or skill. Adaptive transfer is the transfer of the skills to new or more difficult problems than the ones encountered during the training (Ivancic & Hesketh, 1995). Analogical transfer is the transfer of skills to similar situations to the one presented in training. Adaptive transfer is significantly more important for on the job performance. In a job, individuals encounter a number of unpredictable and tough situations that require quick adaptation to new situations. It would be much more advantageous to have a worker that can adapt what they have learned to new situations, instead only being able to do tasks that closely resemble the training. Meta-analytic results found a small effect of EMT on analogical transfer (d = .20), and a very large effect on adaptive transfer (d = .80; Keith & Frese, 2008). Therefore, EMT results in trainees who are better equipped to handle the more rigorous and variable challenges. These harder challenges are more similar to what one might encounter on the job.

EMT and Psychological Processes

The effectiveness of EMT interventions is consistent with the principles of active learning theories. The design elements of EMT are in line with the elements of active learning and self-regulatory strategies espoused by Bell and Kozlowki's (2008) model. These are exploratory learning, error framing, and emotion-control strategies. These design elements exert effects through metacognition, motivation, and emotion process pathways. The next section will go over these different processes and how they increase training effectiveness.

Metacognition.

EMT is seen as promoting increased metacognition and fostering deeper mental models (Bell & Kozlowski, 2008; Keith & Frese, 2005a). Metacognition is a process where learners monitor, are aware of, and check their own cognition process (Flavell, 1979). Metacognitive processes during training have been linked to greater knowledge acquisition and performance (Ford, Smith, & Weissbein, 1998). Error management involves a large amount of exploration which promotes metacognitive thinking (Bell & Kozlowski, 2008; Keith & Frese, 2005a). Instead of restricting the learning to simple mimicking of the trained behavior, EMT involves the active exploration of the skill being learned (Frese et al., 1991). Learners are allowed to explore the task, trying out new ways of looking at the problem and discovering the strategies that work. According to control theory, errors give feedback that increases attention until the error can be resolved (Keith & Frese, 2005a). Learners determine what worked in that situation, as well as what did not work. This enhances the mental model of the learner in terms of creating stronger understanding of relationships among the task elements and thus invokes deeper and richer learning (Frese et al., 1991; Frese & Altmann, 1989; Keith & Frese, 2005).

Action and control theories are thought to be important contributors to EMT processes. An action theory view of EMT suggests that errors disrupt the premature automation of process, which requires learners to rethink their strategy and try new approaches. A control theory view proposes that errors cause a discrepancy between the current state and the end goal state that results in more attention being paid attention to one's performance on the task and causes an adjustment in strategies and performance (Keith & Frese, 2005a). Recent research has shown that participants undergoing EMT had more on task thoughts than participants in an error avoidant condition (Dimitrova, van Dyck, van Hooft, & Groenewegen, 2015). This suggests that EMT does devote more attentional resources to the task. According to Craik and Lockheart (1972), engagement with a topic on a deeper level of cognition results in increased long-term learning and memory retention.

Metacognition has been shown to be a mediator of the relationship between EMT and adaptive transfer by a multitude of studies (Bell & Kozlowski, 2008; Keith & Frese, 2005a;

Steele-Johnson & Kalinoski, 2014). In Frese's original study (1991), he found that participants in the EMT condition performed better on a free recall test of computer commands. He claimed this suggested a more organized mental model. Additionally, individuals undergoing EMT exhibited a higher level of metacognitive processes based on the analysis of verbal, think aloud procedures (Frese et al., 1991). Keith and Frese (2005) found that the relationship between EMT and adaptive performance was fully mediated by increased metacognition and emotional control. Emotional control in their study is the mitigation of the effects of negative emotions that arise when errors occur. EMT resulted in enhanced declarative knowledge which researchers have argued suggests a richer mental model (Chillarege et al., 2003; Frese et al., 1991).

In conclusion, the metacognitive psychological processes relevant to EMT are well supported. There is strong evidence that metacognition mediates the relationship between EMT and adaptive performance. The metacognitive processes result in a more concrete mental models which prepares learners to tackle novel situations.

Motivation.

Another aspect of EMT that is hypothesized to contribute to its effectiveness is through its impact on motivational processes. One avenue that has been suggested is that EMT promotes higher intrinsic motivation (Bell & Kozlowski, 2008; Frese & Altmann, 1989). The empirical support for this hypothesis is strong. Most studies have found increases in intrinsic motivation due to EMT (Bell & Kozlowski, 2008; Nordstrom, Wendland, & Williams, 1998; Wood et al., 2000). While most studies indicate that EMT increases intrinsic motivation, it has not been determined whether changes in intrinsic motivation relate to positive training outcomes. While some studies found a benefit of increased intrinsic motivation training outcomes such as performance and transfer (Bell & Kozlowski, 2008) others have not (Debowski, Wood, & Bandura, 2001; Wood et al., 2000). This difference may be as a result of the task that participants are trained on. The Debowski et. al (2001) and Wood et. al (2000) studies utilized an electronic search task which may not rely or engage motivational aspects.

Goal orientation shapes how people interpret challenges. Goal orientation can be a trait that differs between individuals or a state that is induced by a situation. Goal orientation can be split into learning and performance-prove, and performance avoid goal orientation. Learning goal oriented individuals are motivated to developing competency in their work, while performance goal oriented individuals are motivated to prove their competency to others (performance-prove) or avoid criticism from others (performance-avoid). (Kanfer, Frese, & Johnson, 2017). People who are learning oriented are more likely to see challenges as a chance to learn and improve. In contrast, people with a performance-prove orientation are more motivated by success and comparing oneself to others which can lead to demotivation when performance is not satisfactory. Similarly, people with a performance-avoid goal orientation are motivated to prevent failure and embarrassment and get discouraged by errors and failure. The positive framing of errors central to EMT is thought to promote state learning goal orientation. Since performance is not emphasized and errors are treated as learning events, people tend to take a learning orientation towards the training and move away from performance goal orientation. In EMT, individuals are not discouraged by the errors, but see them as a part of the learning process that will help them grow. Learning goal orientation typically is associated with improved performance and learning, whereas performance-prove goal orientation is uncorrelated, and performance-avoid goal orientation has detrimental effects (Payne, Youngcourt, & Beaubien, 2007).

Studies have been supportive of the hypothesis that EMT instates learning goal or mastery orientation. One study examined the interaction between a trait goal orientation and EMT. No interaction was found between trait goal orientation and EMT. They attributed this to the fact that the EMT manipulation was strong enough to override the effects that trait goal orientation had (Heimbeck, Frese, Sonnentag, & Keith, 2003). Empirical results have since confirmed that EMT interacts with trait goal orientation such that it compensates for low trait learning goal orientation and instates a high state learning orientation in these individuals, but there is no direct effect of error framing on motivational state (Bell & Kozlowski, 2008).

Self-efficacy is an important measure of training effectiveness and is associated with mastery goal orientation (Ford et al., 1998).. It has been theoretically argued that promoting mastery orientation in EMT could promote self-efficacy (Keith & Frese, 2005).Self-efficacy in active learning tasks was found to be associated with both analogical and adaptive transfer as well as post training performance (Bell & Kozlowski, 2008; Kozlowski et al., 2001). It has been found to be related to transfer performance, goal orientation, knowledge acquisition, and metacognition(Ford et al., 1998). Because EMT promotes mastery orientation in trainees it should additionally boost task specific self-efficacy.

Emotional Control

Making errors when attempting to gain new knowledge or improve a skill can be seen by the trainee as a negative event. Such reactions can result in negative emotions such as anxiety, frustration, and negative self-evaluations. Errors require resources and regulation to keep negative emotions in check. Theories posit that the positive error framing present in EMT invoke emotional control in participants (Bell & Kozlowski, 2008; Keith & Frese, 2005, 2008). The error framing instructions (e.g., "I have made an error. Great!") cause the learner to cognitively reevaluate the learning situation in a way that eliminates the negative aspects and focuses their attention on finding a new solution (Heimbeck et al., 2003). If errors are encouraged, then negative emotions associated with them will be eliminated (Frese & Altmann, 1989). Emotional control is a self-regulatory skill that limits performance anxiety and other negative emotional reactions during the task while learning. Negative emotions use cognitive resources that could be more productively used on the task and can direct attention away from the task (Frese & Altmann, 1989). Early support had been found for emotion control as a mediator of increased adaptive transfer in EMT(Keith & Frese, 2005). However, a more robust study examining this relationship in conjunction with the exploratory learning, and error framing aspects of training found no significant relationships between emotion control strategy and training performance, adaptive transfer, or analogical transfer (Bell & Kozlowski, 2008). Another study focusing on error framing effects in a computerized scheduling task found support for cognitive and motivational processes of error framing, but weaker support for an emotion control process (Steele-Johnson & Kalinoski, 2014). For this reason, emotional control was not included in the current study as an observed variable.

Conclusion

EMT is a technique that can enhance the adaptive transfer of training. It does so primarily through metacognitive and motivational pathways. In line with these results, EMT should be a boost to training effectiveness when added to trainings with a SR component.

Integration of the Two Training Techniques

Research Model and Hypotheses

The current study is novel in integrating SR and EMT components into one training program for computer skills. The study seeks to examine how adaptive transfer is affected by this unique training and how processes of the training affect adaptive transfer.

EMT works mainly through promotion of metacognition and motivational pathways. EMT motivates and increases knowledge through encouragement of errors and increased experience while exploring the new skill.

SR increases metacognition but also facilitates the important process of automating schemas or mental models. Automation is when a set of actions requires minimal cognitive effort. An example is a golf swing, at first it takes a lot of effort to think about how to hold it, focus on the ball, how far to bring your backswing and a multitude of other features that go into a spring. For a novice this is a deliberate procedure that requires cognitive resources for each aspect that must be controlled. However, with repeated practice and experience this becomes "automatic" for expert golfers. Research has indicated that schemas or mental models that are committed to long term memory do not use up cognitive resources (Davis & Yi, 2004). This frees up cognitive resources for the golfer to focus on other aspects such as the length of the green, spin, and other advanced aspects needed for successful golfing. I am proposing that SR aids in this automation process. This in turn will free up cognitive resources which allow for more advanced skill acquisition and demonstration.

Error management is a great tool for learning topics. It encourages people to explore and to learn from mistakes. This active learning strategy leads to an increase in mastery orientation, metacognition, and self-efficacy. Adding in SR at the end of training can help the learner consolidate the knowledge gained in an organized way that that allows more cognitive resources to be focused on novel information during the transfer task. This will help with adaptive transfer because more resources are available to take on new information and less are spent processing the schema. It will also help with procedural knowledge of steps to take to complete actions.

Learning requires several stages before mastery is gained. An important theory of learning is Anderson's ACT model (Anderson, 1987, 1996). It separates learning into several stages: declarative, knowledge compilation, and proceduralization. Learners focus first on learning facts and instructions, then turning "what" knowledge into "how" knowledge by turning declarative knowledge into proceduralized knowledge. Finally, the knowledge is fully proceduralized and automated, requiring little to no attention to use.

Other models, including those based on cognitive load theory, have different amount of stages or names for stages, but all focus on the difference between initial effortful learning and its progression towards more integrate and automatic knowledge of skills. According to cognitive load theory, learning is a process that includes schema creation and schema automation (Van Merriënboer & Paas, 1990). In order to learn new learners must construct schemas or mental models which relate the concepts to one another. Learners with appropriate background knowledge likely have these relationships consolidated into schemas. SR helps schema automation (Cooper et. al., 2001). Working memory is limited in capacity. There are no limitations for dealing with previously stored information in long term memory (Davis & Yi, 2004). Studies have found that SR shows the greatest improvement when participants have more background knowledge. Therefore, SR should have its largest effects after material is properly learned (such as after undergoing EMT). People must be familiarized or study with the material before to get the enhanced effects.

Based on the discussion above, I expect that the following hypotheses will be found between the EMT alone condition and combined EMT + SR condition. The addition of SR to EMT will provide benefits above and beyond traditional EMT alone.

H1: *The combined SR and EMT experimental condition will perform better than the EMT alone condition on adaptive transfer tasks.*

The process by which this occurs is that the addition of SR will result in a more integrated schema (more similar to experts), as well as better performance on procedural knowledge (and similar/no difference in performance on declarative/basic knowledge).

H2: *Participants in the SR and EMT experimental condition will perform better on a procedural knowledge task than participants in the EMT alone condition*

H3: *Participants in the SR and EMT experimental condition will have a more similar mental model to experts than participants in the EMT alone condition*

CHAPTER 2

METHODS

Participants

The sample was taken from an undergraduate population of a large midwestern public university. 135 participants had an average age of 19.31(SD = 1.93). The sample was majority female (65%) and majority White (58%) followed by Asian (26%) and Black (10%). Participants enrolled in the experiment in exchange for credit in psychology undergraduate courses. Participants had a mean familiarity of 1.86 out of five, indicating that the majority of the participants were slightly familiar or not familiar at all with photo editing software, indicating that the majority were novices. Participants were tested in groups of 1-5.

Design

Experimental Manipulations.

The study had a between-subjects design with a EMT only group and an EMT + SR group. In both groups, participants were presented with the EMT instructions and all the materials. In the EMT group, after learning the material and before being tested, participants were given a distractor task (Tetris) for three minutes. In the SR group, after learning the material, they were asked to imagine themselves performing the task for three minutes (full instructions can be seen in Appendix B).

EMT.

An EMT environment was created learning module by providing sheets with statements encouraging errors (e.g. You made an error, great! You can learn from that). Additionally, experimenters conducting the training emphasized the positive nature of errors by repeating those phrases. Experimenters were instructed only to help in the case of technical errors, such as a computer crashing, and only to provide encouragement after participants made an error (examples of the EMT instructions can be found in Appendix E).

SR.

SR was added to the experimental condition after learning the material, and before undergoing the adaptive transfer task. Participants were presented with the adaptive transfer task sheet and asked to imagine themselves performing the actions necessary to create the card shown in the task (see Appendix B for exact SR instructions). After hearing the instructions, the participants were asked to practice SR for three minutes. The time frame was chosen because previous results from a meta-analysis indicated that large effect size was found for cognitive tasks with small trials and relatively short periods of practice time (M= 3.17 mins). Additionally, cognitive tasks were found to require less time and trials than motor tasks (Feltz & Landers, 1983).

Materials

Photo Editing Software.

The training was focused on using Photopea. Photopea is an image editing software that is very similar to Photoshop which is popular among photographers and graphic designers. Photopea is a free alternative to Photoshop and contains an almost identical interface. Photopea was chosen because it is a complex program that the majority of people are not technically proficient on, and because it was thought to be intrinsically motivating as a practical skill. It was thought that using Photopea would keep participants engaged more than an arbitrary task.

Similar studies using EMT and SR have been conducted on computer software (e.g., Davis & Yi, 2004; Keith & Frese, 2005).

Learning Videos.

Training videos were taken from the Adobe website. Video times differed ranging from 2-5 minutes. Videos were divided into two different groups: introductory and task focused. The introductory videos focus on basic skills required to navigate the program such as learning the toolbars, functions, layers, and selections. Introductory training videos include: Work area (3:58), Undo (4:53), Understand Layers (4:44), and Selections (4:18). The work area video focuses on navigating the interface of photoshop including the menu bar, options bar, tools panel, panels, and document window. The undo video focuses on how to undo an operation using commands and the user interface. The understand layers video teaches participants use layers, a crucial concept for using photoshop. The selection video focuses on how to select certain elements within the document.

Task-focused videos focused on specific skills that participants will practice and will be tested on. Adding an image (3:06), Inserting text into an image (4:57), Adding shapes (4:15), and Brush tool and Color Selection (3:41). Each video focuses on a specific task you can do in photoshop. Each learning module includes a narrator walking the viewer through the precise steps needed to complete the task. Screenshots and links to the videos can be found in Appendix K.

Learning Sheets.

Each learning module was accompanied by a paper sheet outlining the key steps. These included steps on how to perform the particular action, as well as icons and keyboard shortcuts that are useful in completing the actions. Learning sheets can be found in Appendix F. The training tasks were directly related to the task-focused video modules. Tasks were related to adding images, inserting text, inserting shapes, and brush tool use and color selection. Details of these tasks can be found in Appendix F.

Distractor Task.

A distractor task was given to participants in the EMT condition in between the training phase and the adaptive transfer test. Participants were directed to the webpage “freetetris.org” and started a game of the popular brick stacking game. Participants played for three minutes. No measurements were taken, nor scores recorded. The task was purely meant to keep them from practicing or thinking about the training they underwent.

Measures

Demographics.

Gender, age, race, ethnicity information from participants. A sheet can be found in Appendix C.

Metacognition.

Following the last trial, participants completed a 12-item measure of metacognitive activity adapted from Ford et al. (1998). Items asked about self-monitoring and planning behaviors. Reliability was high ($\alpha = .82$) See appendix H for items.

Trait Goal Orientation.

Vandewalle (1997)’s measure of trait goal orientation was used to assess trait goal orientation. Response options ranged from 1 = strongly disagree to 5 = strongly agree. An example item for trait mastery orientation is “I am willing to take on challenges that I can learn a lot from." An example item for trait prove orientation is "I'm concerned with showing that I can perform better than my peers." An example item for trait avoid orientation is "I prefer to avoid situations where I might perform poorly." Trait mastery ($\alpha = .85$), prove ($\alpha = .70$), and avoid ($\alpha = .78$) goal orientations all had high reliabilities. Trait goal orientation was be measured only once, before the familiarization phase. See Appendix D for items.

State Goal Orientation.

Following the last trial, participants filled out a fifteen-item questionnaire measuring goal orientation (Hovarth, Scheau, & Deshon, 2001). The scale has subscales for three goal orientations: learning, prove, and avoidance. Questions focus on the motivation for how they feel about the training. E.g, "On this task, my goal is to learn the task as well as I can". Reliability for the learning ($\alpha = .90$), prove ($\alpha = .81$), and avoid orientation ($\alpha = .81$) were all high. See appendix G for items.

Task self-efficacy.

A measure of task self-efficacy was adapted from Ford et. al. (1998) and made specific to the photo editing training. Items asked about the extent to which participants felt confident in their abilities and potential to learn photoshop skills. Participants were asked both before undergoing training and after the adaptive transfer task. Reliability was high for both pre-test (α =. 82) and post-test measures ($\alpha = .87$). See Appendix I for items.

Knowledge quiz.

A knowledge quiz was created to test the knowledge of photoshop skills learned in the training. The quiz included measures of basic knowledge such as what certain icons are, as well as procedural knowledge questions about the processes of completing certain tasks within the software. This was a self-made measure. The basic knowledge test was 17 items (α = .64) and the procedural knowledge test was 11 items (α = .61). Because of high correlation between the measures (r = .53) they were combined for the exploratory path modeling (α = .75) . See Appendices M and N for the items.

Adaptive transfer performance.

Adaptive transfer performance was be measured using a task that is harder to implement than the previously learned skills from the training. No direct directions were given, they were instructed to recreate a birthday invitation to the best of their ability. The task was to design a birthday invitation with the following elements: a picture of the person provided, text, a background image, and more. Participants received a score based on how many elements they complete correctly. See Table 5 for task instructions. The task was scored by two independent raters by awarding points for correct elements. The average of the two raters was used. The correlation between raters was $r = .98$. A two-way random effects intraclass correlation coefficient (ICC) for multiple raters using consistency was calculated according to guidelines found in Koo et. al (2016). The ICC = .99 which indicated a high level of interrater reliability. See Table 5 for the scoring rubric used.

Usefulness.

Participants were asked if they found the training useful. This was a self-made measure consisting of three items related to the perceived usefulness of the training (α = .88). See appendix J for items.

Concept Relatedness Task and Concept Map Representation.

Schemas and mental models were measured using a rating procedure to generate a network of relationships among topics which were then used to create a concept map using Pathfinder analysis. A list of 16 topics was created to represent the main concepts of the training. The list of topics was given to an expert in photoshop. The photoshop expert is a designer and owner at an advertising firm and uses the app extensively in his day to day work. He has 17 years using the app to create artistic and commercial projects. The expert was asked the relatedness of two of the concepts, one pair at a time (1 not related at all, 7 completely related). This was used to create an expert mental model using the PATHFINDER analysis (Schvaneveldt, Durso, & Dearholt, 1989).

` Participants in both experimental conditions then filled out the same relatedness ratings on the 16 concepts. Each experimental group had their ratings averaged; these average ratings were then input into the JPathfinder software to calculate the pathfinder networks for each experimental group. The models were compared using the pathfinder analysis (Schvaneveldt, 1989). Models more similar to the expert model were judged to be better organized mental models and thus indicative of commitment of the mental model/schema to long term memory. See appendix N for an example of the rating task.

For both the expert and experimental groups Pathfinder concept maps were created using JPathfinder software (Schvaneveldt, 2017). Ratings data were used to create the maps according to the guidelines set out in Schvaneveldt et. al (1989) for ordinal data. The r parameter of infinity was used. The p parameter was set to (n-1) in this case 15. This resulted in the most parsimonious model with only the strongest links shown.

Experimental Flow

The experiment had five phases, the pre-study phase, introductory phase, the training phase, the test phase, and the adaptive transfer phase. The study was focused on the outcome of adaptive transfer. In order to best detect this effect, it was crucial that the SR immediately preceded the adaptive transfer task. For this reason, the survey measures were completed after the adaptive transfer task. The focus of the study was on the addition of SR to aid adaptive transfer, not on the general mechanisms which have been covered in other research. Appendix A has a summary of the experimental flow.

Pre-study phase.

Participants filled out an online form including demographics, and measures of goal orientation and state mastery orientation.

Introductory Phase.

Participants entered the testing room and sat at computers with the familiarization video loaded. The videos taught basic aspects of navigating the software.

Training Phase.

The training phase consisted of four learning modules based on each video. Participants were informed that they were watching a training video and to pay close attention. Participants then watched the video.

After this, the participants were instructed to complete tasks based on what they learned in the video (see Appendix F). Participants received the error framing instructions (e.g., "Errors are good for learning) before attempting the tasks (see appendix E for instructions). These were repeated for each learning module.

Post Training/Test Phase.

After all video and practice, the participants were shown the final task sheet (see Figure 5). They were given 30 seconds to look it over. After looking at the sheet, the participants were instructed to do SR for three minutes and imagine themselves recreating the card (see appendix B for instructions). Participants in the EMT condition worked on the distractor task (Tetris) for the same amount of time as the combined EMT + SR condition. Both conditions were three minutes long. Participants then did the adaptive transfer task. They were given fifteen minutes to recreate the birthday card on the sheet. A post survey was taken. Measures of state mastery orientation, metacognition, and task self-efficacy were taken. Participants then completed the basic knowledge and procedural knowledge tests.

Pilot Study

Pilot studies were conducted to ensure the experiment is working as described. SR manipulations were checked in order to determine if instructions are adequate to be followed by participants and if participants engage in SR. The overall time of the study was examined to see if it runs too long and whether adjustments need to be made. Overall aspects of the study such as the script, ordering of the manipulations, and time allowed were examined. After running an initial twenty participants it was determined that the materials and the study design were adequate to move into the final study with minor changes. The largest change from pilot to full study, was the experimental manipulations. Originally, in the EMT condition, participants were given a break and not instructed to do anything during this break other than relax. This was changed in the final study to a distractor task (playing Tetris) in order to prevent them in engaging in symbolic rehearsal on their own or reviewing the material or skills they learned.

Additionally, the SR instructions were altered to include an explanation for why they were doing the SR exercise and its benefits for learning.

Analytic Strategy

Hypotheses 1 and 2 were tested using between subjects t-tests to test for significant mean differences in outcomes. Hypothesis 3 was tested using Pathfinder analysis and the Jpathfinder software to generate concept maps. Concept relatedness ratings were correlated between experimental conditions. The number of links shared in common between the concept map of the expert, and both experimental groups was compared. The similarity between models was also calculated according to guidelines found in Schvaneveldt et al. (1989).

Post hoc analyses were conducted based on the significant findings in the correlation table and past research on the subject. An illustration of the tested model and paths can be found in Figure 4.

CHAPTER 3

RESULTS

Means, standard deviations can be found in table 1 and bivariate correlations between variables are provided in table 2. Means and standard deviations for the variables separated by experimental conditions are presented in table 3. A high correlation was found between the procedural and basic knowledge test ($r = .53$), so, a combined measure was created by summing the scores of the two tasks together ($\alpha = .75$). All reliabilities were acceptable with the exception of the basic ($\alpha = .64$) and procedural knowledge tests ($\alpha = .61$) which were lower.

Examining the bivariate correlations, several relationships were found that match with previous research (e.g., Bell and Kozlowski, 2008). Significant relationships were found between the adaptive transfer measure and the knowledge measure ($r = .42$), the state prove measure ($r = .30$) and the state learning measure ($r =.27$), as well as a change in self efficacy ($r =.41$). The combined knowledge test was related to self efficacy ($r= .23$), state learning orientation ($r= .27$) and negatively related to a trait performance prove orientation ($r = -.19$). State learning orientation was positively related to metacognition ($r=.56$) and trait learning orientation ($r = .34$). No significant correlations were found between the experimental conditions, and any of the variables in the experiment. In order to test the main effect of the experimental manipulation on outcome variables, between subjects t-tests were conducted between the two conditions (SR and SR + EMT). Results of these tests can be found in Table 3. None of the tests revealed significant differences between conditions. The addition of SR did not show a significant effect on any of the observed outcome variables.

Hypothesis 1

Hypothesis 1 stated that experimental condition adding together SR and EMT will perform better than the condition that has EMT alone on adaptive transfer tasks. This was not found to be the case. There was no significant difference between the EMT condition (M = 12.2, SD = 4.9) and the SR + EMT condition (M = 12.7, SD = 5.6) in performance on the adaptive transfer task ($t = .51$, $p = .61$, $d = .09$,). Hypothesis 1 was not supported.

Hypothesis 2

Hypothesis 2 stated that participants in the experimental condition adding together SR and EMT would perform better on a procedural knowledge task than participants in the condition that has EMT alone. This was not found to be the case. There were no significant differences between the EMT + SR (M = 7.58, SD = 2.29) and EMT conditions (M = 7.74, SD = 2.05) in performance on the procedural knowledge task ($t = .44$, $p = .66$, $d = .08$). The addition of SR to EMT did not result in increased procedural knowledge. Hypothesis 2 was not supported.

Hypothesis 3

Hypothesis 3 stated that participants in the experimental condition adding together SR and EMT will have a more similar mental model to experts than participants in the condition that has EMT alone. In order to test this hypothesis, pathfinder concept maps were created using JPathfinder software (Schvaneveldt, 2017). Ratings data were used to create the maps according to the guidelines set out in Schvaneveldt et. al (1989) for ordinal data. The r parameter of infinity was used. The p parameter was set to (n-1), in this case 15. This resulted in the most parsimonious model with only the strongest links shown. The average ratings were calculated for each experimental group; and input into the Jpathfinder software to calculate the pathfinder networks, and generate the concept maps.

The expert model had 19 links between the nodes, compared to 15 links in the EMT condition and 16 links in the EMT + SR condition. The expert concept model can be seen in figure 1, the EMT group can be seen in figure 2, and the EMT + SR group model can be seen in figure 3.

This demonstrated that the expert had a more interconnected mental model than the novices in this sample. Tools, color, and layers emerge as central nodes in this model with the number of links to other nodes of 5, 5, and 4 respectively. This indicates that these are central concepts of the photoshop software.

Pathfinder analysis can be analyzed in terms of similarity of the links between the expert and learner models. The similarity between pathfinder networks is the number of links in common divided by the total number of unique links in the two networks Two identical networks will yield a similarity of 1 and two networks that share no links will yield similarity of 0. (Schvaneveldt et al., 1989) The measure is the proportion of all the links in the two networks that are in both networks. From this formula, the similarity between the expert network and the two conditions was calculated. The EMT condition had a similarity of .36 ($p < .01$) when compared to the expert network, and the EMT + SR condition had a similarity of .30 ($p < .01$). The similarity between the two networks derived from novices in the different conditions was .55 ($p < .01$).

When examining correlations between the ratings of groups the correlation between the EMT group and the EMT + SR group was $r = .94$, between the expert rater and EMT of .65, and between the expert rater and EMT + SR group was r = .71. A Fisher r to z transformation was used to test for a significant difference between these correlations. No significant difference was found. z(135) = .64, p = .52. Hypothesis 3 was not supported.

Looking at the structure of the models, both of the novice derived networks were more linear than the highly interconnected expert model. Many of the nodes only have one or two links and there were not a lot of nodes that were heavily interconnected with others. For example, in the expert node, layers is connected to 5 other nodes, while in the EMT group network it is connected to 3 nodes and in the EMT + SR group it is connected to only 2. Between the EMT group and EMT + SR group, the tools concept was more connected in the EMT (4 links) than in the EMT + SR group (2 links).

Exploratory Analyses

After testing the main hypotheses, exploratory analyses were conducted using the information collected. These were modeled based on the findings in previous research. These analyses looked at the relationships among variables independent of the experimental condition. Previous training research indicated state learning orientation was predictive of change in self-efficacy, declarative knowledge, and metacognition activity (Ford et. al., 1998; Keith & Frese, 2005; Bell & Kozlowski, 2008). Previous training research indicated that self-efficacy has predictive relationships with declarative knowledge and adaptive transfer (Bell & Kozlowski, 2008, Kozlowski et. al., 2001). Meta-analytic results also indicated a significant relationship between declarative knowledge and adaptive transfer (Blume, Ford, & Baldwin). A path model was created to model these relationships. The model can be seen in figure 4. The model tested has trait mastery predicting state learning which then predicts score on the knowledge quiz, change in self-efficacy and the measure of metacognition. The score on the knowledge quiz, metacognition, and change in self-efficacy then predict the score on the adaptive transfer task.

The model fit well (Chi-square (7) = 7.77, $p = .35$, CFI = .99, RMSEA = .03, SRMR = .06). Significant path coefficients were found with trait mastery orientation predicting state learning orientation ($b = .5$, $p <.01$). State learning orientation predicted metacognition ($b = .57$, $p <.01$), change in self-efficacy ($b= .36$, $p < .01$) and declarative knowledge ($b = .22$, $p = .01$). Change in self-efficacy also predicted declarative knowledge ($b = .18$ $p = .03$) declarative knowledge ($b = .43$, $p <.01$) and change in self-efficacy ($b = .35$, $p <.01$) were both predictors of adaptive transfer performance. The only nonsignificant path was metacognition predicting declarative knowledge ($b = -.03$, $p = .82$).

An alternate model was tested removing the nonsignificant path between metacognition and declarative Knowledge. Model fit indicated an increase in fit (chi-square (8) = 7.79, $p = .46$, CFI = 1.00, RMSEA = .00, SRMR = .05). A chi-square difference test was not significant (chi-square (1) = .01 $p = .91$), indicating that the two models did not fit significantly differently. The alternative model provided better explanation without decreasing model fit and was thus adopted. Path estimates, standard errors, and p-values of the path model can be found in Table 4.

CHAPTER 4

DISCUSSION

The purpose of this study was to examine whether an integration of SR and EMT methods of training would result in increased training effectiveness. Using theories from active learning and both the EMT and SR training literature, I predicted that by integrating EMT and SR adaptive transfer would be enhanced by increased procedural knowledge and more expert-like mental models. Results suggest that this was not the case. A specific discussion of the results of each hypothesis follows.

Hypotheses 1 and 2 examined effects on the outcomes of adaptive transfer and procedural knowledge respectively. These were both not supported by the data of this study. Adding SR to EMT did not produce a significant difference in these outcomes.

Hypothesis 3 proposed that the mechanism by which SR could enhance EMT is though the organization of better mental models. Hypothesis 3 was not supported; the experimental group's mental model was not closer to experts as predicted. The EMT group had a slightly more similar mental model to the experts than the EMT + SR group. However, the correlation of .94 between EMT and EMT + SR group concept ratings indicates that the two groups rated concepts extremely similarly. The hypothesis that adding SR would help to create a better mental model that was related to experts was not supported in this experiment.

The lack of significant differences between groups in several key indicators could suggest a variety of explanations. One of which is that SR and EMT are both techniques that encourage similar mechanisms in learning. Both are forms of deliberate practice, although with different emphases and tangibility. In EMT metacognition is encouraged through the exploration and monitoring of learning throughout. During EMT here is considerable planning, rehearsing, and practice that takes place when trying new things or imagining yourself completing a task. When approaching new situations in EMT people are navigating an unfamiliar environment that causes them to be constantly evaluating their own knowledge and testing new things. In SR the person has to come up with a way of achieving some goal by practicing learned behaviors in their mind. in the same way they are navigating the environment in their mind and testing out ways to do things in a way they think will work. They draw on prior knowledge and their experience working with the program. In actuality the cognitive mechanisms used in the two techniques might not be different at all. Both highlight metacognitive processes and highlight gaps in knowledge. It might be the case that since they both have similar mechanisms and are effective for enhancing training effectiveness, that adding them together doesn't add additional benefit to training transfer. However, the lack of a control group between EMT and SR limits what the process behind this similarity might be. Future studies should compare and contrast the mechanisms responsible for enhancing training transfer in both.

Exploratory analyses confirmed several relationships found in previous studies. State Learning orientation was found to be predictive of change in Self-Efficacy, Declarative Knowledge, and Metacognition activity. This is in line with previous training research (Ford et. al., 1998; Keith & Frese, 2005; Bell & Kozlowski, 2008). Change in Self-efficacy was found to predict Declarative Knowledge and Adaptive Transfer. Once again, this was in line with previous research studies including these two variables. (Bell & Kozlowski, 2008, Kozlowski et. al., 2001). Declarative Knowledge predicted Adaptive Transfer. Meta-analytic results are in line with this relationship (Blume, Ford, & Baldwin, 2010).

Limitations and Future Directions

There are several limitations to this study that can be addressed in future research. The first of which is the fact that this is a an experimental study with no results over time. Knowledge and training transfer were taken at the same time the training occurred. For EMT, the effectiveness of training is seen largely in posttraining contexts and there is actually a decrement in performance within training (Keith & Frese, 2008). A separation between the time of the training and the time of the transfer task might yield different results for training transfer and knowledge acquisition. Additionally, with a longitudinal study design there could be an examination of trajectories such as skill/knowledge decay, mental model stability, and other outcomes that show how EMT and SR could have differential effects over time. Additionally, constructs such as self-efficacy, metacognition, and state goal orientation were taken after the adaptive transfer task. These were used as predictors of adaptive transfer in the exploratory analysis, but did not precede the adaptive transfer measure.

The concepts were chosen based on relevance to the training program. However, these concepts were not created using subject matter experts. Future studies should use the knowledge of subject matter experts or people who teach photoshop to create the most relevant and useful concepts for assessing a conceptual model of the photoshop software.

Second, there was no control group and comparison between SR and EMT. There was only an EMT group and the combined EMT and SR group. This did not allow for direct comparison of the techniques, it only allowed for comparing EMT and the combination of EMT and SR. A future study could employ a 2x2 design with EMT and no EMT instructions on one axis, and SR and no SR on the other axis. This would include a true control group and would allow for the comparison of the addition of either technique to a training with each other. Do they both improve training effectiveness equally, or is one better than the other? Which areas do they affect the most? It would also allow for the comparison of the psychological mechanisms such as self-efficacy, metacognition, mental models, and more. It would reveal whether the techniques invoke similar or different mechanisms. A larger study would allow for answering these questions and would better illustrate the interaction of the two training techniques.

The symbolic rehearsal manipulation might not have been strong enough to evoke a difference in any of the outcome variables. There was only one three-minute period where participants were asked to participate in SR. A future study with more opportunities for SR maybe after each learning module, might produce stronger differences that could be detected. The manipulation was not checked with a measure to ensure participants were actually engaging in SR. Pilot studies were not focused on the content of SR that participants were engaging in. Future studies should monitor this to determine the correct amount of SR and whether it is effective for training.

The measure of posttraining self-efficacy was taken after the adaptive transfer test. This ties self-efficacy directly to performance which makes it hard to state whether self-efficacy predicted performance or whether high performance predicted self-efficacy. Future studies should counterbalance the timing of this measure to examine this relationship.

Metacognition was self-reported after learning and the adaptive transfer task. It was not taken while undergoing the training. Other studies could look at this measure as the experiment goes on through think aloud procedures, or to take more frequent samples of self-report metacognitive activity throughout the task.

The experiment did not provide much task feedback to participants. A meta-analysis of EMT has indicated that task feedback is important for training transfer (Keith & Frese, 2008). In future studies, task feedback could be given after each trial to help cement learning and the correct techniques. This could be done by having experimenters look at the work and give feedback.

Another limitation is that of external validity. This experiment was done in a laboratory environment with college undergraduate students. No samples were taken in the workplace. Workers in training situations have different motivations. They might be more motivated to complete the training and transfer it if it is required by their job. SR might be a more effective tactic to use in a workplace setting.

APPENDICES

Appendix A

Experimental Flow

Pre Survey
Fill out consent form, trait goal orientation, intrinsic motivation, self-efficacy
Subtotal: 10 minutes
Introductory Phase
Work area (3:58)
Understand Layers (4:44)
Selections (4:18)
Subtotal: Videos (13:00)
Training/Manipulation Phase
Add image (4:25)
Add text (4:57)
Create Shape (4:32)
Use color /the brush tool (4:44)

Watch training video (3-7 min)
Symbolic rehearsal/break (3 min)
Instructions/error framing (1 min)
Exploration/practice task (5 min)
Subtotal – 16 mins X 4 = 64 minutes
Posttraining Test Phase
Knowledge Test (15 min)
Adaptive Transfer (15 min)
Post survey/Knowledge Quiz (20 min)
Subtotal (50 min)

Total: 127 minutes

Appendix B

Script

Pass out sign in sheet, ask them to put down their full name. Make sure you fill in the date.

Introduction:

Hello, thank you for participating in this experiment. For this experiment you will be learning various skills in Photopea. Photopea is a photo editing software very similar to photoshop. Please review and then sign the consent sheet when you are ready.

Consent sheet is included on the first page of the Qualtrics survey.

1. **Pre-Survey Phase:**
   Now we will be filling out a survey. Please answer honestly and how you feel. When you reach a page that says minimize the response, please contact the experimenter and wait until the next phase of the experiment.
   (*direct all participants to the Qualtrics survey page)*
2. **Familiarization Phase**
   Thank you. Now you will be watching videos on various photoshop elements to help get you familiar with the software. At this point nothing is required other than viewing the videos. Please put on the headphones provided and watch the videos. I will load the videos for you to watch.

(*Put on the familiarization video* 1.IntroVideo.mp4, ***subsequent times*** *follow the order* 2.AddingText.mp4, 3.AddingShapes.mp4, 4.colors.mp4 *)*

3. **After video:**
   ***(Only after the first video**)*
   Pass out the error management instruction sheet and the learning sheet.
   Here is a sheet that has some phrases I would like you to think about during the instruction today. Please read over these phrases and use them during the training today.
   Give 30 seconds or so to allow people to read the sheets

SAY THIS THE FIRST TIME

During today's training, do not hesitate to make errors as you explore and learn Photopea. Errors are a natural part of any training experience! When you make errors, you create opportunities to learn from your mistakes. By making errors, you can develop a better understanding of the task. When you make an error during the task, view it as a chance to learn something new! Remember that you should make errors in the training simulation today.

SAY THIS SUBSEQUENT TIMES

Please do not hesitate to make errors as you explore and learn Photopea. Errors will help you learn. Consult the helpful phrase sheet for things to think and say when you make an error.

Say this every time

Now you will be asked to complete the tasks indicated on the learning sheet and the video you just watched *(direct them towards the proper number on the learning sheet).* You will have five minutes to complete the task and explore as you wish. Please use Photopea to complete the tasks.
(Set timer for 5 minutes, allow them to explore and work)

Don't answer any questions or actually help them beyond critical failures (e.g. browser closing, computer shutdown). Respond positively to any questions saying that they are supposed to make errors and explore. If they really press you, you can say that you are not there to help them, just let them try to fix the problem on their own.

AFTER
Thank you. Now I will be putting on another video for you to learn.

REPEAT Step 2 and 3 for each module changing videos each time. *You don't need to pass out the sheets again.*

4. **After all videos have been shown and practiced**
   Pass out skill test sheet with birthday card on it

You will be asked to recreate this birthday card using Photopea. Please view the card. Please do not start working.
(Wait 30 seconds, don't let them work on it)

Administer the following instructions to the attendees.
NO SR condition:
Now you will be doing something different this time. Please play the game Tetris for the next three minutes.
(Open up freetetris.org in a new tab and start a game, set timer for 3 minutes)

SR condition:

Now we will be doing visualization. Research has shown that by doing a visualization exercise, you can enhance learning and performance. It has been used in sports psychology to help enhance training and performance of Olympic athletes.

For the next three minutes please close your eyes and imagine yourself performing the actions necessary to create this birthday card. Draw on your experience with the software and the learning videos to help you imagine. Visualize yourself interacting with the software and the

computer in order to accomplish the task. Try to use as detailed imagery as you can when imagining the task.
(Set timer for three minutes and wait)

After SR or Tetris
Now you will be tested on your skills. You will be asked to create a birthday card identical to the one shown in the picture on the sheet. Pay attention to the color and position of the text, shapes, images and background. Try your best. You will have 15 minutes to complete this test.
(*Open up a new document in photopea, Use default settings 1280 x 720 pixels, 72 dpi, background white give it the name* give it the name *XXXXcard (XXXX = ID number))*
(*Set timer for 15 minutes, update participants by announcing time left at 10, 5, and 1 minutes left Do not help them except for technical problems such as exiting the webpage, or other critical errors, don't help with content or skills.)*

5. **Post Survey**

Now you will be completing the survey. *Direct everyone back to the Qualtrics survey in the other page.*

First, you will be doing concept ratings. Please answer how related each of these concepts are to each other. Use 1 for not related at all and 7 for extremely related. Please respond to each pair.

After this, there will be some questions asking you to reflect on the training.

Finally, there is a knowledge test. Please answer all the questions and select the correct answer to the best of your ability.

After you have completed all of these elements, please let the experimenter know.

Participants may leave after completing the survey

Appendix C

Demographics/Information

Demographics Questionnaire

Please provide as much of the following information as is applicable. It is important to understand that these scores will be kept confidential and used only for research purposes. If you do not remember your exam scores, please put a zero in that space.

Gender: _____ (M / F / Other: please list)
Age: _____
Race: ___________________

What operating system is your main computer?
Windows ___
Macintosh OS ___
Linux ___
Other ___
Do you have experience with image editing software (e.g., photoshop, GIMP, MS paint, etc.)
I have no experience __
I have used it once __
I occasionally use it __
I use it every day __
It is part of my job __

Appendix D

Trait Goal Orientation Measure (Vandewalle, 1997)

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

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

Goal Orientation Learning

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

Goal Orientation Prove:

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

Goal Orientation Avoidance:

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

Appendix E

Error Management Training Manipulations

EMT Instructions.
During today's training, do not hesitate to make errors as you explore and learn Photoshop. Errors are a natural part of any training experience! When you make errors, you create opportunities to learn from your mistakes. By making errors, you can develop a better understanding of the task. When you make an error during the task, view it as a chance to learn something new! Remember that you should make errors in the training simulation today.

EMT Quick Reference Document
Read and recite these phrases to yourself when participating in the simulation.

I have made an error. Great!
There is always a way to leave the error situation!
Look at the screen to find out what happened and when an error was made.
Watch what is on the screen and what is changing.
It is good to make mistakes.
You can learn from errors.
Errors are a natural part of any training experience.
Errors inform you about what you can still learn!
The more errors you make, the more you learn!
Remember you can always come back from an error, use "control + z" to undo an action

Appendix F

Learning Sheets

1. What you learned: To add images to a design

1. Choose File > Open and Place, navigate to the any image (This PC > Pictures >Photoshop>) file in File Explorer (Windows) and click Open.
2. Hold the Shift key to avoid distorting the image and drag the corners of the image border to resize the added image.
3. Drag inside the border to position the added image where you want it.
4. Click the check mark in the options bar to finalize the placement. This automatically creates a new layer containing the added image.
5. Try adding and rearranging multiple images on the canvas

2. What you learned: To add text

1. In the *Tools* panel, select the *Horizontal Type* tool.
2. In the options bar, choose a font, font size, color, and other options for your text. You can edit any of these settings later.
3. Click on the canvas and enter a single line of text. You can also create a paragraph of text by dragging out a text box and then typing inside the box.
4. Click the check mark in the options bar to accept the text and exit text mode. This automatically creates a new, editable type layer in the *Layers* panel.
5. Use the *Move* tool to move your text into position in the image.

3. What you learned: To create a shape

1. In the *Tools* panel, click and hold the *Rectangle* tool (or whichever Shape tool is showing in your Tools panel at the moment) to view all the shape tools. Select a tool for the shape you want to draw.
2. In the options bar, choose a Fill color and other options for your shape. These can be changed later.
3. Hold the Shift key to avoid distorting the shape as you drag in an image to create an editable shape. This automatically creates a new shape layer in the Layers panel.
4. Use the *Move* tool to move the shape into position in the image.
5. Scale, transform, or rotate a shape without harming its image quality by choosing Edit > Free Transform or pressing Control+T (Windows) or Command+T (macOS).

4. What you learned: To use tools that have brush tips

1. In the Tools panel, select the Brush tool.
2. In the options bar, change the size and hardness of the brush. You can also select a different brush tip to change how the brush strokes look.
3. An alternative way to increase brush size is to press the right bracket key several times.
4. To decrease brush size, press the left bracket key several times

What you learned

1. The Brush tool, the Shape tools, the Type tool, and other features that apply color use the color in the Foreground Color box at the bottom of the Tools panel.
2. There are multiple ways to set the foreground color. You can select the Eyedropper tool and sample a color from the image, or use the Color Picker, Color panel, or Swatches panel.
3. Behind the Foreground Color box is a Background Color box, where you can store another color.
4. To switch the Foreground and Background color boxes to quickly access either color, click the double-pointed arrow just above the two color boxes or press the X key.

Appendix G

State Mastery Orientation Measure (Horvath et al., 2001)

For each of the following statements, please indicate how true it is for you with regard to how your approach this task on the scale provided below.

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

Goal Orientation Learning
1. I prefer to work on aspects of this task that force me to learn new things.
2. I am willing to work on challenging aspects of this task that I can learn a lot from.
3. The opportunity to learn new things about this task is important to me.
4. The opportunity to work on challenging aspects of this task is important to me.
5. On this task, my goal is to learn the task as well as I can.

Goal Orientation Prove:
1. It is important to me to perform better than others in this task.
2. It is important to me to impress others by doing a good job on this task.
3. I was the experimenters and other students to recognize that I am one of the best on this task.
4. I want to show myself how good I am on this task.
5. On this task, my goal is to perform well.

Goal Orientation Avoidance:
1. On this task, I would like to hide from others that they are better than me.
2. On this task, I would like to avoid situations where I might demonstrate poor performance to myself.
3. On this task, I would like to avoid discovering that others are better than me.
4. I am reluctant to ask questions about this task because others may think I'm incompetent.
5. On this task, my goal is to avoid performing poorly.

Appendix H

Metacognition Measure

Metacognition (Ford et al., 1998).

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

1. While practicing a module, I monitored how well I was learning its requirements.
2. As I practiced the modules, I evaluated how well I was learning the skills of the simulation.
3. When my methods were not successful, I experimented with different procedures for performing the task.
4. I tried to monitor closely the areas where I needed the most practice.
5. I noticed where I made the most mistakes during practice and focused on improving those areas.
6. I used my performance on the previous module to revise how I would approach the task on the next scenario.

Appendix I

Self-efficacy Measure (adapted from Ford et al., 1998)

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

1. I can meet the challenges of this training
2. I am confident in my understanding of photoshop
3. I know how to navigate the photoshop software
4. I am certain that I can manage the requirements of using photoshop
5. I believe I can learn photoshop
6. I am confident that I can learn more difficult elements of photoshop

Appendix J

Usefulness Measure

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

I found this training to be useful for learning photoshop.
I enjoyed this training
I would recommend this training to others wishing to learn photoshop.

Appendix K

Video Links

Get familiar with the work area & Undo a Command
https://helpx.adobe.com/photoshop/how-to/ps basicsfundamentals.html?playlist=/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-1/collection.ccx.js

Selections

https://helpx.adobe.com/photoshop/how-to/selection-tools-basics.html?playlist=/content/help/en/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-1/collection.ccx.js

Understand Layers

https://helpx.adobe.com/photoshop/how-to/ps-layers-basics.html?playlist=/content/help/en/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-1/collection.ccx.js

Adding text and Shapes
https://helpx.adobe.com/photoshop/how-to/adding-text-shapes-basics.html?playlist=/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-2/collection.ccx.js&ref=helpx.adobe.com

Work with Layers and Add Images
https://helpx.adobe.com/photoshop/how-to/ps-layers-basics.html?playlist=/content/help/en/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-1/collection.ccx.js

Using Color
https://helpx.adobe.com/photoshop/how-to/color-management-basics.html?playlist=/ccx/v1/collection/product/photoshop/segment/designer/explevel/beginner/applaunch/ccl-get-started-2/collection.ccx.js&ref=helpx.adobe.com

Appendix L

Basic Knowledge Test

The following is a knowledge test about the simulation. Please select the response that best answers the question.

1. Where is the selection tool located?
    a. Tools
    b. Properties
    c. Options
    d. Party

2. What option changes the edge of a brush?
    a. Hardness
    b. Opacity
    c. Hue
    d. Transparency

3. What is the best tool for creating rectangular or elliptical selections?
    a. Magnetic lassos
    b. Lasso
    c. Shape
    d. Marquee

4. The ________ tool allows you to select a rectangular or circular area of an layer to change or delete.
    a. Shape
    b. Marquee
    c. Crop
    d. Spot healing

5. If you want to change the foreground color selection to one present on the campus what tool should you use?
    a. Paint bucket
    b. Gradient
    c. Brush
    d. Eyedropper

6. The "eye" icon in the layer panel does what when clicked?

    a. Deletes the layer
    b. Merges layers together
    c. Hides the layer
    d. Applies a filter to the layer

7. Which key/keys do you hold down to prevent distortion when resizing an image
    a. Option
    b. Control
    c. Control + D
    d. Shift

8. If I want to create a rectangle in the most efficient way what tool should I use?
    a. Marquee
    b. Shape
    c. Pen
    d. Brush

9. If you want to remove small blemishes from a picture of someone's face, what tool is best for the job?
    a. Crop tool
    b. Paintbrush
    c. Spot Healing Brush
    d. Selection

10. What keys do you use to **deselect** a selection you made?
    a. Control + D
    b. Control + U
    c. Option + D
    d. Option + U
11. These are the separate pieces for an overall image
    a. Files
    b. Groups
    c. Layers
    d. Filters
12. Which is not included in the **menu** bar
    a. File
    b. Edit
    c. Image
    d. Crop
13. What key do you hit to increase the size of a paintbrush
    a. "/"
    b. "]"
    c. "b"

    d. “m”

14. What is the name of this tool?
    a. Paint brush
    b. Eyedropper
    c. Spot healing brush
    d. Marquee tool

15. Clicking and holding the mouse button on a toolbar icon does what?
    a. Jncreases the size or strength of that tool
    b. Locks that tool as the default option
    c. Reveals help text for that tool
    d. Shows additional tools related to that tool
16. Singular transparent sheets which hold a particular part of an image are called:
    a. Pixel aspect ratio sheets
    b. Layers
    c. Fill filters
    d. Stylize filters
17. Photoshop keeps track of all of your edits in the _____ palette
    a. Help
    b. Gallery
    c. History
    d. Clipboard

Appendix M

Procedural Knowledge Test

1. If you accidentally delete an image what is the BEST way you can get it back?
    a. Click on edit > undo
    b. Search in trash on the desktop of the computer
    c. You cannot retrieve a deleted image
    d. Download a new image and reinsert it
2. You have two existing images on your canvas on separate layers. The images overlap such that one occludes the other. You want to change the position of these images such that one is in the foreground and one is in the background. What is the best way to go about changing this?
    a. There is nothing you can do, start a new document and insert images in the proper order
    b. Switch the image positions in the layers panel
    c. Drag and drop the image you want in front
    d. Delete both images and then reinsert them
3. You want to change the color of some text such that it is has a white fill and black outline like this: SAMPLE TEXT What would be the best way to do this?
    a. Use the color swatch to change the foreground to white and the background to black
    b. Use the paintbrush tool to fill in the text with white and outline that in black
    c. Use the paint bucket tool to fill the text
    d. Use word art to find similar looking text
4. If you use the selection tool and then use the paintbrush what will happen?
    a. The paintbrush will only be applied in the area of the selection where you click
    b. The entire selection will be filled with paint color selected
    c. The paintbrush strokes will be applied to a new layer within the selection
    d. The paintbrush will not apply any strokes within the selection
5. What is the MOST efficient and accurate way to match a color you see in part of an image?
    a. Look up the color online to find its hexadecimal value and then select that in the colors panel
    b. Use the color wheel picker to see and match the color
    c. Use the eyedropper tool and click on the part of the image with the color you wish to match
    d. Adjust the hue of the current color selected until it matches that color
6. What function does the Magic Wand tool, the Lasso tool, and the Rectangular Marquee tool have in common?
    a. A. Feathering
    b. Selecting
    c. Pasting

    d. Previewing
7. What is the BEST way to create a perfect circle in photoshop?
    a. Select the shape tool and hold down to select the ellipse tool, drag to create a circle
    b. Use the brush tool to draw a circle
    c. Use the pencil tool to draw a circle, fill in with the paintbucket tool
    d. Use the pen tool to draw a circle, dragging to create curves
8. What tool will NOT allow you to make a selection on the image?
    a. Lasso
    b. Marquee
    c. Eyedropper
    d. Magic Wand
9. How do you access tools not directly displayed on the toolbar?
    a. Go to options> tools
    b. Go to the properties menu and change the tools
    c. Click and hold the tool icon to see other options
    d. Hit CTRL + T
10. What happens when the eraser tool is used?
    a. Everything on the layer gets deleted
    b. Everything on the document gets deleted
    c. Parts that are clicked on are erased on the layer
    d. The background layer becomes transparent
11. A square shape is in front of (occluding) a circle shape. You want to want to rearrange this so that the circle shape is now in front and the square is behind? What is the BEST way to do this?
    a. Double click the circle
    b. Double click the square
    c. Elevate the circle layer above the square layer
    d. Lower the circle layer below the square layer

Appendix N

Mental Model Concept Rating

How related is each concept to each other? (e.g., 1 – related to no extent to 9 = related to a large extent)

Tools panel
Crop
Layers
Selection
Marquee
Undo
History panel
Add image
Text
Font
Save
Color
Opacity
Hue
Shape
Brush

Appendix O

Tables

Table 1.
Descriptive Statistics of Variables

Variable	M	SD	Range	Reliability
Age	19.31	1.93	18-36	--
Familiarity	1.86	.84	1-5	--
Self-Efficacy Before	20.76	4.34	8-30	.82
Trait Mastery	20.02	2.60	10-25	.85
Trait Prove	17.49	3.36	9-25	.70
Trait Avoid	11.43	3.24	4-20	.78
Metacognition	23.22	4.00	11-30	.82
Self-Efficacy After	21.53	5.03	7-30	.87
Usefulness	11.74	2.80	3-15	.88
State Learning	19.63	3.91	10-25	.90
State Prove	14.27	4.36	5-25	.81
State Avoid	12.66	4.51	5-25	.81
Basic Knowledge	12.28	2.58	5-17	.64
Procedural Knowledge	7.66	2.16	1-11	.61
Combined Knowledge	19.94	4.16	8-28	.75
Adaptive Transfer Skill Test	12.50	5.20	0-21	--
Change SelfEff	.78	4.85	-12 - +15	--

Table 2.
Correlation Table of Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.SR	--															
2.SE T1	.01	--														
3.Trait Mastery	.00	.40*	--													
4.Trait Prove	-.06	.25*	.19*	--												
5.Trait Avoid	-.01	-.09	.13	.17*	--											
6.Metacognition	-.02	.26*	.30*	.03	-.12	--										
7.SE T2	.00	.47*	.25*	.10	-.09	.30*	--									
8.Usefulness	.00	.21*	.15	-.02	-.14	.49*	.49*	--								
9.State Learn	-.05	.34*	.34*	.08	-.22*	.59*	.54*	.56*	--							
10.State Prove	-.10	.28*	.05	.35*	.07	.27*	.44*	.16	.35*	--						
11.State Avoid	.02	-.06	-.12	.21*	.36*	-.10	-.12	-.10	-.15	.25*	--					
12.Basic Knowl	.01	.16	.18*	-.14	-.01	.12	.28*	.06	.17	.03	-.05	--				
13.Procedural Knowl	-.03	.09	.03	-.20*	-.25*	.15	.33*	.19*	.33*	.19*	-.12	.53*	--			
14.Combined Knowl	-.01	.14	.13	-.19*	-.14	.15	.34*	.14	.27*	.11	-.09	.90*	.85*	--		
15. Adaptive Transfer	-.11	.07	.08	.10	.14	.15	.44*	.24*	.27*	.30*	-.12	.41*	.32*	.42*	--	
16.Change SE	-.01	-.41*	-.10	-.12	-.01	.08	.61*	.32*	.25*	.20*	-.07	.14	.26*	.23*	.41*	--

* = $p < .05$
SR = Symbolic Rehearsal 1= EMT + SR, 0 = EMT; SE = Self-Efficacy, T1 = pretest, T2 = posttest, Knowl = Knowledge Test

Table 3.
Descriptive statistics of EMT vs EMT + SR groups and results of t-tests.

Variable	EMT M(SD)	EMT + SR M(SD)	*t*	*d*
Self-Efficacy T1	20.7 (4.62)	20.8 (4.06)	.08 (p =.93)	.01
Self-Efficacy T2	21.6 (4.62)	21.5 (4.06)	.04 (p = .97)	.01
Basic Knowledge	12.3 (2.73)	12.3 (2.44)	.09 (p = .93)	.02
Procedural Knowledge	7.74 (2.05)	7.58 (2.29)	.44 (p = .66)	.08
Combined Knowledge	20 (4.25)	19.9 (4.09)	.17 (p = .87)	.03
Useful	11.74 (2.68)	11.74 (2.95)	.01 (p =.99)	.00
Metacognition	23.31 (3.80)	23.13 (4.21)	.26 (p =.79)	.05
State Learning Orientation	19.81 (3.59)	19.45 (4.24)	.53 (p =.60)	.09
Adaptive Transfer task	12.7 (5.55)	12.2 (4.86)	.51 (p = .61)	.09

Table 4.
Path estimates, standard errors, and p-values of path-model linking goal orientation to adaptive transfer.

Path	Estimate	SE	P-Value
State Learning Orientation as Predicted By:			
Trait Mastery Orientation	0.50	0.12	0
Metacognition as Predicted By:			
State Learning Orientation	0.57	0.08	0
Declarative Knowledge as Predicted By:			
State Learning Orientation	0.22	0.07	0
Metacognition*	-0.01	.12	0.06
Change in Self-Efficacy	0.18	0.08	0.03
Change in Self-Efficacy as Predicted By:			
State Learning Orientation	0.36	0.11	0
Adaptive Transfer as Predicted By:			
Change in Self-Efficacy	0.43	0.10	0
Declarative Knowledge	0.35	0.09	0

* = removed in final model

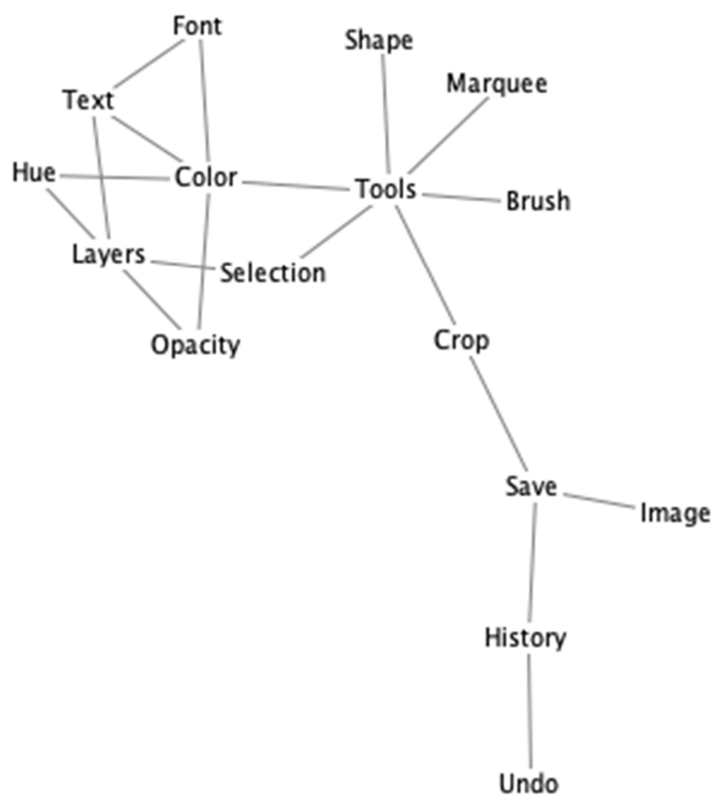
Table 5.
Adaptive Transfer Scoring Sheet

Category	Criteria	Points	Points Received
Background	Is it blue?	1	
Images	Balloon Image Present Second Balloon Image Present	1 1	
	Todd Image Present	1	
Text	"Surprise Party for Todd!" Present - Text is white	1 1	
	Address Present - Text is Black	1 1	
	Date Present - Text is Black	1 1	
	Don't Tell Todd! Present - Text is Red	1 1	
Shapes	Left is present - Left star is yellow	1 1	
	Right star is present - Right star is red	1 1	
Layout	"Surprise Party for Todd!" is in front of the two balloons	1	
	"Don't Tell Todd!" is on top of the Todd photo	1	
	The address is on top of the left star	1	
	The date is on top of the right star	1	
Misc.	Balloon Background is Transparent - Only on one (give .5)	1	
Total		**21**	

Appendix P

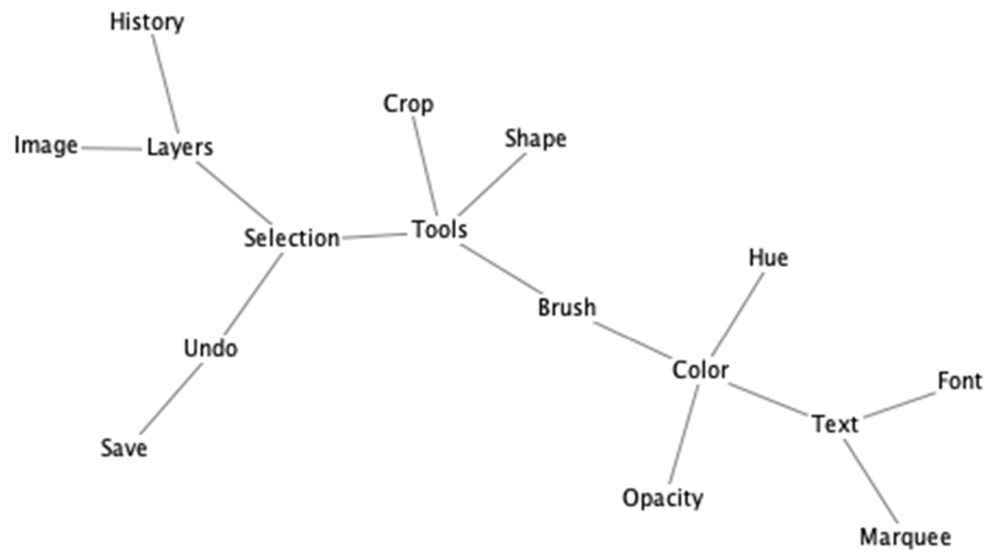
Figures

Figure 1.
Pathfinder network of photoshop expert



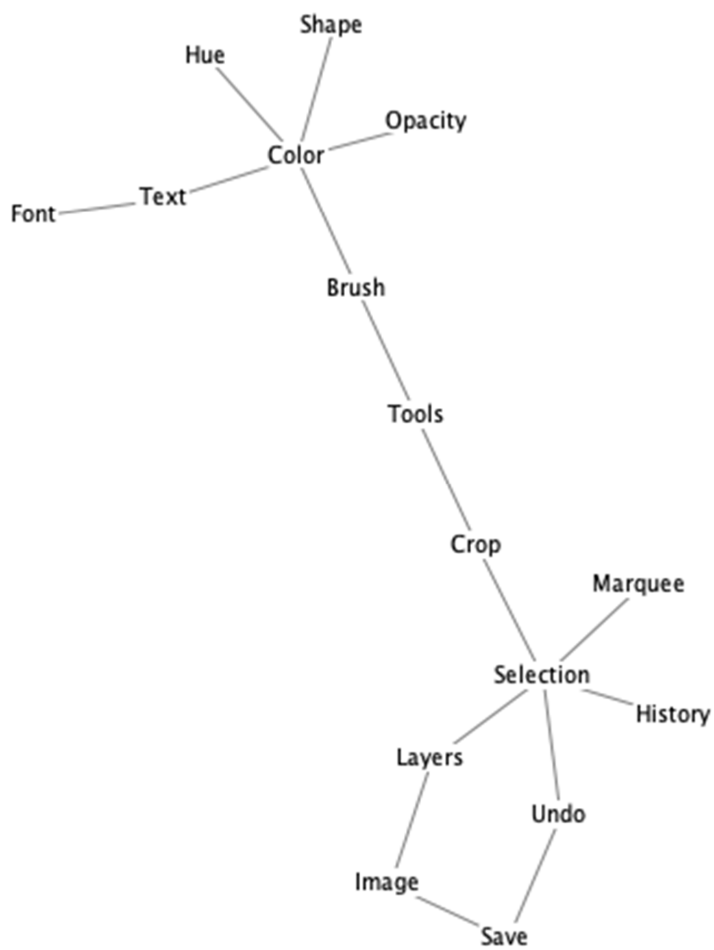
19 links between nodes. q = 15, r = infinity

Figure 2.
Pathfinder network derived from the EMT group.



15 links between nodes. q = 15, r = infinity

Figure 3.
Pathfinder network derived from the experimental group



16 links between nodes. q = 15, r = infinity

Figure 4.
Tested Path Model

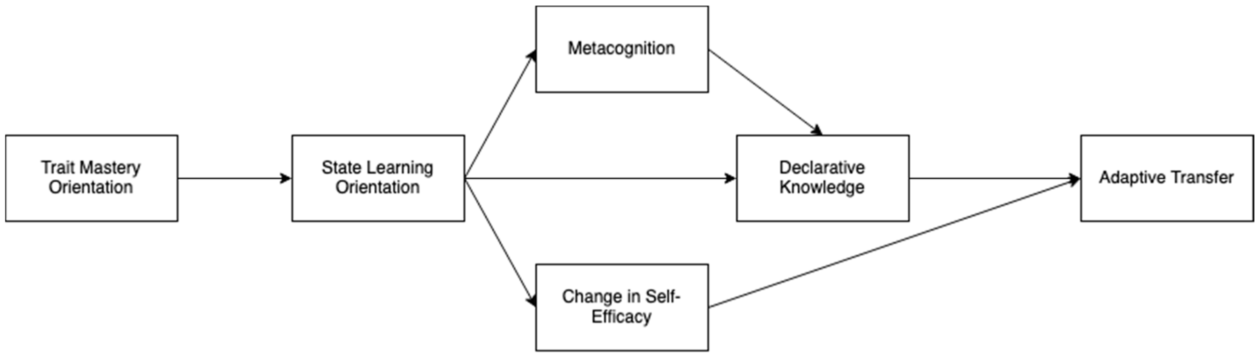


Figure 5.
Adaptive Transfer Task Sheet

Recreate this birthday card, match the text, colors, shapes, images, background, etc. as closely as possible. You will receive a score based on your ability to recreate this.

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