THESIS

TRAINING OLDER ADULTS: THE ROLE OF STRATEGY USE AND STEREOTYPE THREAT

Submitted by

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ABSTRACT

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Older adults are becoming an increasingly important part of the workforce. Due to cognitive and emotional changes associated with aging, this population might require specially designed training programs to optimize training outcomes. Two specific changes associated with aging that need to be addressed are susceptibility to stereotype threat and the use of metacognitive strategies during learning. The purpose of this study was to investigate the effect of initiating stereotype threat in older adults, as well as the effect of encouraging older adults to use metacognitive strategies during training, on training outcomes. In a 2X2 between-subject experimental design including no stereotype threat/ stereotype threat and no metacognitive prompt/ cognitive prompt conditions, 131 older adults between the ages of 55 and 70 years old were assessed on training outcomes. Results indicated that, as hypothesized, stereotype threat had a negative effect on learning outcomes. Contrary to expectations, cognitive prompts also had a negative effect on training outcomes. Implications of the results are that further investigation of optimal training design for older adults is warranted.

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Older workers are becoming an increasingly important labor resource for American businesses. According to Schultz and Adams (2007), by 2012 more than half of all workers will be over 40 years old, and the number of workers over age 55 is projected to grow at nearly four times the rate of the overall labor force. By 2030 the elderly population will nearly double, and the U.S. will be home to more than 70 million people ages 65 and over (more than 20 percent of the population). At present, survey data suggest that by age 60, over half of all older adults have left their career jobs and are engaging in "bridge employment" (i.e., jobs that bridge careers and retirement). In addition, a quarter of heads of household reenter the workforce after retirement.

As older workers become a significantly larger portion of the workforce, American businesses will want to tap the special talents, extensive knowledge, and relevant experience of older workers in order to stay competitive. However, though older workers are some of the most knowledgeable and experienced members of the workforce, they also suffer from cognitive underperformance, such as limited working memory capacity and lack of cognitive strategy use. Because many older workers plan on finding new jobs or careers, cognitive impairment is especially relevant in regards to training.

Mayer's (2005) cognitive theory of multimedia learning (CTML) offers a promising framework upon which to base instructional design for older adults. CTML proposes that learners select relevant information from their environment, organize that information in short term memory, and then integrate that information into previous knowledge structures in long term memory. It offers suggestions for designing multimedia training presentations to optimize the selection, organization, and integration processes.

Previous research (Paas, Van Gerven & Tabbers, 2005) has studied the theory within the context of cognitive aging. This research has focused mainly on the effect of working memory, specifically how the reduction of working memory load can increase older adults' performance on learning tasks. Although this research has been useful, the current study will attempt to answer questions about cognitive aging that have not yet been researched within the CTML framework.

One focus of this study is to understand the use of cognitive strategies by older adults. Cognitive strategies are consciously-activated mental operations that facilitate the encoding and retention of new information (Richardson, 1998). For example, if a person is asked to remember the noun pair "elephant-mouse," forming a mental image of a mouse riding on the back of an elephant would constitute a cognitive strategy, as would creating a sentence, "The mouse rides the elephant." Research has shown that older adults are less likely to self-initiate cognitive strategies, even though they are capable of using strategies when encouraged to do so and this strategy use improves their performance on cognitive tasks (Dunlosky & Hertzog, 2001; Touron & Hertzog, 2004). The use of cognitive strategies has not yet been researched within the CTML model.

Another construct that can affect the performance of older adults on learning tasks is stereotype threat. Stereotype threat is the risk of confirming a negative stereotype about one's group that can lead to less than maximal performance on a stereotype-relevant task

(Steele & Aronson, 1995). For instance, women are often stereotyped as worse at math than men. When given a math test, a woman's fear of confirming that stereotype might impede her mathematical performance. This effect has been shown repeatedly with various groups and tasks, including African Americans and cognitive ability test performance (Steele & Aronson, 1995), White males and athletic performance (Stone, Lynch, Sjomeling, & Darley, 1999), and women and visual spatial tasks (Campbell & Collaer, 2009). The concept of stereotype threat has important implications for older adults, who are often stereotyped as forgetful and slow at learning new information (Lineweaver, Berger, & Hertzog, 2009). For example, older adults' performance on technology-mediated learning tasks may be impaired when stereotype threats are primed. Training scenarios may activate stereotype threat in older learners, impairing their performance. There is also evidence that cognitive strategies mediate the relationship between stereotype threat and performance (Lachman & Andreoletti, 2006). Thus, encouraging older adults to use cognitive strategies may not only increase performance, but also act as a buffer against the declines in cognitive performance often observed in older adults in stereotype threat situations.

The purpose of the current study is to examine how cognitive strategy use and stereotype threat affect the performance of older adults in a multimedia learning environment. The following sections provide an outline of cognitive deficits in older adults and how these deficits affect performance on a number of cognitively demanding tasks. Next, stereotype threat, its application to older adults, and its detrimental effect on performance are discussed. Finally, an overview of Mayer's (2005) CTML is presented, along with its specific relationship to older adults, cognitive strategy use, and stereotype threat. Hypotheses will be introduced within their relevant sections.

Age Related Declines in Cognitive Abilities

A plethora of research has shown a general cognitive decline associated with chronological age. Although there are some beneficial effects of aging on cognition, such as increased vocabulary (Park & Payer, 2006), in general, research has shown that aging is associated with impaired perception (Li & Lindenberger, 2002), slower speed of cognitive processing (Salthouse, 1996), less working memory capacity (Park & Payer, 2006), and less strategic utilization of metacognition (Hertzog & Dunlosky, 2004).

Recently, Reser (2009) offered an evolutionary explanation and argued that these declines might be the effect of formerly adaptive metabolism reduction programs. According to this argument, working memory and caloric consumption from cognitive activities represented a metabolic liability to aging hunter-gatherers. After years of experience in routinized tasks, older hunter-gatherers relied on less metabolically-demanding cognitive processes such as implicit and procedural memory for survival. Decreased cerebral metabolism, selective elimination of synapses, and the reliance on accumulated knowledge were adaptations that contributed to metabolic reduction after the youthful acquisition of necessary survival skills. Cognitive deficits observed in modern older adults are simply a maladaptive continuation of these reductions in cognitive expenditures, the consequence of an extended human life span.

Working Memory

Of the cognitive declines associated with aging, less working memory capacity has perhaps received the most attention. Working memory was conceptualized by

Baddeley (1992) as “a system for the temporary maintenance and manipulation of information, necessary for the performance of such complex cognitive activities as comprehension, learning, and reasoning” (p. 281). Hence, working memory allows an organism to perceive a complex and unpredictable, but ultimately structured, world (Baddeley, 1992). Sensory information from multiple modalities enters into, and is integrated and organized within working memory. Furthermore, information in working memory can be manipulated through cognitive processes and eventually transferred into long-term memory. Thus working memory is essential to learning new material. For instance, if a person is watching a presentation on how a bike pump works, he or she may see a picture of a valve as it is described by a narrator. The audio and visual pieces of information are integrated together in working memory (i.e., the picture of the valve with the sound of its name), organized in relation to other parts of the bike pump, and then transferred into long-term memory.

Working memory is one of the fundamental aspects of cognitive functioning, and is associated with performance on a broad range of cognitive tasks that involve memory, reasoning, judgment, and following directions (Park & Payer, 2006). Working memory is associated with higher-order cognitive processes such as the control of complex cognition, monitoring and regulating performance, and goal-directed behavior (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). Working memory is also closely related to fluid intelligence, a higher-order cognitive ability (Chen & Li, 2007). The strong relationship between working memory capacity and performance on such diverse tests as reasoning, cognitive skill acquisition, and troubleshooting led Kyllonen (1996) to hypothesize that working memory capacity was actually Spearman’s *g*, the construct synonymous with general cognitive ability. Though this point is contentious within the field of cognitive psychology (see Ackerman, Beier, & Boyle, 2005; Beier & Ackerman, 2005; Oberauer, Schulze, Wilhelm, & Süß, 2005), most researchers agree that working memory capacity is an important construct related to intelligence, and that working memory is a central cognitive processing component required for a variety of cognitive tasks.

Working memory capacity exhibits steady decline across the life span, beginning in the 20s (Park & Payer, 2006). Park et al. (2002) gave 345 participants, aged 20-92 years, reading span and computation tasks to test working memory. Results showed that age explained between 24 and 32% of the variance in working memory performance depending on the specific test. Bopp and Verhaeghan (2005) conducted a meta-analysis to explore the relationship between aging and working memory capacity. They differentiated between short term memory tasks that simply required storage of information (e.g., forward digit span) and working memory tasks that required the active manipulation of information in addition to storage (e.g., reading span). Results showed that there was a linear negative relationship between age and span task performance. Specifically, working memory tasks had a stronger relationship with age, with mean *d*s ranging from -.63 to -1.54, depending on the task. Supporting the behavioral evidence, neuroscience data show that the frontal cortex, strongly implicated in working memory performance, shrinks with age (Raz, 2000).

Park et al. (1996) provided additional evidence that working memory declines in old age. The authors administered a seven-hour cognitive battery test over three days to 301 participants aged 20-90 years. They then used structural equation modeling to explore the relationships among age, memory performance, processing speed, and working memory. Processing speed mediated substantial age-related variance in free recall, spatial, and cued memory. Working memory explained a significant amount of age-related variance in free recall and cued memory, but not in spatial memory. The authors concluded that speed of processing and working memory are fundamental constructs in explaining cognitive aging effects.

Research by Czaja, Sharit, and associates has repeatedly implicated working memory deficits in the performance of the elderly on a number of work-related tasks. For instance, one study looked at older adults' performance on computer-based tasks such as data entry, file modification, and inventory management (Czaja & Sharit, 1993). Age was significantly and negatively related to both speed and performance on these tasks, even after controlling for computer experience. Although there was no direct measure of working memory in this study, the authors hypothesized that age-related deficits in performance were most likely attributable to information-processing components such as working memory capacity.

Czaja and Sharit (1998) investigated the relationship between age and performance on a computer-based data entry task. Participants completed a battery of tasks that loaded onto three factors: computer experience, executive function and concentration, and visuomotor and memory. The visuomotor and memory factor of the battery included working memory capacity. As in previous studies, age was significantly and negatively correlated with both amount of work completed and data entry performance. The visuomotor and memory factor explained a significant amount of variance in the dependent variables beyond age, suggesting that age differences in performance can be at least partially explained by cognitive abilities such as working memory.

In another study, Sharit, Hernandez, Czaja, and Pirolli (2008) showed a direct relationship among age, working memory, and performance on an internet search task. Again, age was found to negatively relate to performance on the search task. In this case, the most significant predictor of performance was working memory. After the addition of working memory to the regression model, the relationship between age and performance was no longer significant. This line of research reveals a reliable, negative relationship between age and performance on a number of tasks similar to what would be encountered in people's jobs or day-to-day lives. The relationship between and age and task performance is at least partially attributable to the robust findings of working memory decline with age.

There is also research to suggest that older adults' limited working memory capacity affects their ability to learn new information and acquire skills. Head, Raz, Gunning-Dixon, Williamson, and Acker (2002) investigated the extent to which working memory was responsible for age-related differences in skill acquisition on two tasks: the Tower of Hanoi and the Wisconsin Card Sorting. Computation span and listening span tasks were used as measures of working memory. Results revealed that in the early stages of learning, age and working memory were associated with speed and efficiency, but not during later stages. The authors attributed these findings to the proposition that early learning relies heavily on executive functioning, and is therefore affected by working memory capacity. Thus their ability to learn is inhibited. Later, when the skill has been transferred to procedural memory, working memory deficits no longer affect performance. Thus, even though working memory deficits may not affect the performance of a previously learned skill, they contribute to the difficulty in acquiring a new skill.

In support of the evidence that working memory capacity is related to skill acquisition, a study by Kennedy, Partridge, and Raz (2008) investigated the extent to which working memory mediated the relationship between age and skill acquisition in perceptual-motor tasks, namely pursuit rotor and mirror tracing. Age was correlated with both working memory capacity and skill learning. Using structural equation modeling, the authors found support for their hypothesis that working memory mediated the relationship between age and skill learning, explaining 37% of the variance. This study provides additional support that working memory affects older adults' ability to learn new skills.

In summary, working memory, a fundamental component of a number of cognitive skills, declines with age. This decline is associated with poorer performance on a variety tasks, as well as the ability of older adults to learn new information and acquire new skills.

Metacognition

Though decline in working memory is most likely a primary cause of learning and performance deficits in older adults, other factors may also contribute. For example, aging is also related to a decline in some forms of metacognition, which is defined as the awareness and self-monitoring of cognitive processes that facilitate the encoding and retrieval of new information (Hertzog & Dunlosky, 2004). Older adults exhibit declines in their use of metacognitive skills specifically on free recall and associative memory tasks (Dunlosky & Hertzog, 2001; Kausler, 1994; Zivian & Darjes, 1983) and this decline is associated with degraded performance in learning and skill acquisition. It should be noted that other aspects of metacognition, such as judging how well material has been learned, show no age-related differences (Robinson, Hertzog, & Dunlosky, 2006) and age-related differences in metacognition are not observed on certain tasks, such as working memory span tasks (Bailey, Dunlosky, & Hertzog, 2009). Still, certain aspects of metacognition do decline across the lifespan, and metacognition is important to the understanding of learning and performance deficits in older adults.

Metacognition is defined by Koriat (2007) as "the study of what people know about cognition in general, and about their own cognitive and memory processes, in particular, and how they put that knowledge to use in regulating their information processing behavior" (p.290). Metacognition is thinking about thinking, or the self-regulation of cognitive processes (Hertzog & Dunlosky, 2004). It involves the mechanisms by which people reflect on their own cognitive processes (monitoring), and how they use this information to regulate information processing and behavior (control; Koriat, 2007).

Because metacognition involves devising and implementing learning strategies, it is closely tied to the concept of cognitive strategies, which can be conceptualized as "active encoding operations that involve the manipulation or elaboration of mental representations of the information to be remembered" (Richardson, 1998, p. 597). These goal-directed strategies are conceived of as being specific to a particular task and affecting performance on that task (Hertzog & Dunlosky, 2004; Salthouse, 1991). These strategies are under strategic control and available to conscious awareness (Richardson, 1998). Strategies include such methods as paraphrasing information, rereading text, creating and answering questions concerning learning materials, and transferring strategies from previously solved analogous problems.

Strategy use has repeatedly been shown to increase memory performance (see Richardson, 1998, for a review). Cognitive strategies were discussed nearly 100 years ago by Reed (1918), who gave subjects a list of unrelated word pairs and tested their memory for the second word when cued with the first. He also asked whether or not the subject had made any mental association between the words, for example, through imagery. His results revealed that subjects performed better on word pairs for which they had created mental associations. Subsequent research has shown that the use of verbal associations, such as linking word pairs in a sentence (Bobrow & Bower, 1969), and mental imagery (Paivio, Yuille, & Smythe, 1966) reliably increases recall. Researchers attribute this increased recall, at least in part, to the possibility that cognitive strategies such as imagery engage both visual and verbal working memory processes, thereby decreasing demands on each process individually.

Though the precise reason is unknown, there is convincing evidence that older adults (often operationalized as adults aged 55 and over) are less likely to self-initiate cognitive strategies. This is true even when they are capable of utilizing these strategies and when strategy use would result in increased performance. For example, Touron and Hertzog (2004) gave younger and older adults a noun-pair look up task. Participants verified whether a centrally presented target noun-pair matched one of a set of pairs contained in a lookup table at the top of a screen. By memorizing the noun-pairs, subjects could avoid using the lookup table, minimizing their reaction times. Memorizing and subsequently retrieving the noun-pairs was referred to as a retrieval strategy. This strategy represented the retrieval of information from long term memory as opposed to the simple retention of information in short term memory.

In the study, one third of subjects were not shown the noun-pairs prior to the task, one third of the subjects learned half of the noun-pairs prior to the task, and one third of the subjects learned all of the noun-pairs prior to the task (Touron & Hertzog, 2004). Cued-recall tests were given until the subjects had memorized all of the noun-pairs they were shown (that is to say, none, half, or all of the noun-pairs). Regardless of whether or not they had memorized the noun-pairs, older adults were less likely to use the retrieval strategy (as measured through self-reports). This occurred even when they had memorized all of the noun-pairs. Though older adults who learned all of the noun-pairs were capable of using the retrieval strategy (which would have minimized reaction times and maximized performance) they failed to do so.

Touron and Hertzog (2004) showed that older adults were less likely to use cognitive strategies compared to younger adults. However, a study by Dunlosky and Hertzog (2001), showed that older adults had the ability to use cognitive strategies when they were encouraged to do so. Younger and older subjects were given an associative learning task and were either informed of possible cognitive strategies they could use to facilitate learning (informed condition), or given no information about cognitive strategies they could use (uninformed condition). Examples of suggested cognitive strategies included sentence generation, rote repetition, and interactive imagery. Results showed that in both the informed and uninformed conditions, older adults were significantly less likely than younger adults to report using cognitive strategies. However, older adults in the informed group were significantly more likely to use strategies than older adults in the uninformed group. Furthermore, there was a main effect for strategy use, such that older adults who reported using strategies recalled more of the word pairs than older adults who did not use strategies. Thus, providing descriptions of strategies increased the likelihood that older adults would report using a strategy, and this strategy use improved recall performance.

Though not studying older adults, Berthold, Knuckles, and Rankl (2007) devised a method to encourage undergraduate students to use cognitive strategies to increase performance on a writing task. Subjects were presented with a lecture on developmental psychology, and then assigned a writing task. During the task, they were presented with cognitive and cognitive prompts. These prompts consisted of questions that, while not providing any new substantive information about the material, encouraged subjects to initiate effective learning strategies. For instance, a prompt designed to encourage elaboration asked, “Which examples can you think of that illustrate, confirm, or conflict with the learning contents?” and another, designed to stimulate monitoring and self-diagnosis, asked, “Which main points have I already understood well?” As hypothesized, subjects exposed to the cognitive and cognitive prompts outperformed subjects who were not given prompts, and the relationship between prompts and performance was mediated by the use of cognitive strategies. In-task cognitive and cognitive prompts offer an effective way to stimulate the use of cognitive learning strategies. Similar methods will be utilized in the current study to examine if cognitive and cognitive prompts can increase learning performance for older adults.

In summary, nearly a century of research provides evidence that cognitive strategies increase performance on cognitive tasks. Yet older adults are less likely to self-initiate these strategies. When explicitly encouraged to do so, older adults are capable of utilizing cognitive strategies, which in turn improves their cognitive performance. Cognitive and cognitive prompts inserted into the training material offer a method to encourage older adults to use these strategies. Accordingly, I hypothesize:

Hypothesis 1: Older adults encouraged to use cognitive strategies will perform better on a learning task compared to older adults who are not so encouraged.

Stereotype Threat

Age-related declines in cognitive abilities represent a difficult obstacle in teaching older adults new information. However, there are other practical concerns that may affect older adults' learning abilities. One potential complication in training older adults is stereotype threat. Stereotype threat was initially defined by Steele and Aronson (1995) as "being at risk of confirming, as self-characteristic, a negative stereotype about one's group" (p. 797). For example, African American students can be aware of negative stereotypes concerning Blacks and scholastic performance. When put into a situation where they feel they are being evaluated scholastically, the threat of confirming this stereotype may cause anxiety and a lack of motivation, which in turn causes African Americans to perform below their full potential on scholastic tasks. The same effect is hypothesized to exist for any group stereotyped in a certain way: for instance, women performing poorly on math evaluations or White men playing badly on the basketball court.

The theory that members of groups might perform poorly on stereotyped tasks when the stereotype is made salient has been supported empirically (Cadinu, Maass, Frigerio, Implagliazzo, & Latinotti, 2003; Davies, Spencer, Quinn, & Gerhardstein, 2002; Steele & Aronson, 1995). In a seminal study (Steele & Aronson, 1995), Black and White college students were administered a section of the Graduate Record Exam. Subjects in the control condition were told that they were participating in an experiment on personal factors that affect performance on problem solving. Subjects in the experimental condition were told that they were taking a test that reflected a genuine measure of their reading and verbal abilities. The description of the test used in the experimental condition was designed to highlight stereotypical beliefs about African-Americans' inferiority on cognitive based tasks, thus eliciting stereotype threat. As expected, Blacks in the control condition performed significantly better on the test than Blacks in the experimental condition; furthermore, Blacks in the experimental condition performed significantly worse than Whites in the experimental condition (both of these results were found after controlling for Scholastic Aptitude Test score). The authors interpreted these results as supporting their hypothesis- namely, that activating stereotype threat caused the stereotyped group to underperform.

Findings of the negative effect of stereotype threat on performance have been replicated with other groups as well. A study conducted by Davies et al. (2002) examined the effect of negative stereotypes concerning women and math abilities. Both male and female undergraduate students with comparable math abilities were shown either female stereotypic (experimental condition) or counter-stereotypic (control condition) commercials. The commercials were actual advertisements that had aired on network television. An example of the stereotypic commercial is a woman extremely excited to try a new beauty product; an example of a counter-stereotypic commercial is a woman impressing a man with her knowledge of engineering. These commercials were chosen because they portrayed women in stereotypic or counter-stereotypic ways, and did not focus specifically on math ability. Women in the control condition performed as well as men, but similar to Steele and Aronson (1995), in the experimental condition women performed significantly worse than males, presumably due to stereotype threat induced by the commercials.

Several studies provide results that reveal a significant effect for stereotype threat. A meta-analysis of 76 published reports conducted by Nguyen and Ryan (2008) reported a mean *d* of .26 for stereotype threat. Depending on moderators such as type of minority (race or gender) and strength of stereotype cue, *d*s fluctuated from a low of .11 to a high of .80. Though this represents a wide range of possible effect sizes, the mean effect size of .26 fits nicely with a previous meta-analysis conducted by Walton and Cohen (2003), who reported a mean *d* for stereotype threat of .24 across 43 studies.

Stereotype threat can occur in any group with well-known stereotypes, and older adults are no exception. Multiple studies (e.g., Heckhausen, Dixon, & Baltes, 1989; Hendrick, Knox, Gekoski, & Dyne, 1988; Lineweaver, et al., 2009) provide evidence that older adults are generally thought of as having poorer cognitive abilities than younger adults. Older adults are stereotyped as forgetful, absent-minded, slower, and having poorer memory. Consequently, older adults should be susceptible to stereotype threat on any task conceived of as cognitively challenging, especially if it involves a memory component.

Indeed, research evidence supports this supposition. Hess, Auman, Colcombe, and Rahhal (2003) tested the memory performance of 28 older adults (M_{age}=70.8 years) and 28 younger adults (M_{age}=19.3 years). Before performing a free-recall task of 30 words, negative older-adult stereotypes were activated by informing participants of recent research that either confirmed (negative condition) or contradicted (positive condition) the traditional view that memory performance decreases with age. A control condition was given no information about memory performance and age. A significant main effect was found for age, with younger adults outperforming older adults in every condition. A significant effect was also found for threat within the older participant group. Older adults in the negative condition performed significantly worse than older adults in either the positive or control conditions.

Further analysis of the data revealed that older adults in the negative condition were less likely to use the cognitive strategy of clustering (grouping words into categories to facilitate memorization) than in the control condition. Clustering accounted for approximately 58% of the variance in stereotype threat related effects in recall. The authors proposed that strategy use may mediate the relationship between stereotype threat and memory performance.

Research by Lachman and colleagues (Lachman & Andreoletti, 2006; Lachman, Andreoletti, & Pearman, 2006) provides further support that strategy use mediates the relationship between older adults' beliefs about their memory and actual memory performance. The authors argued that both real and perceived decline in cognitive abilities causes older adults to believe they have less control over their memory, which in turn leads to lower strategy use, resulting in poorer memory performance. Lachman and

Andreoletti (2006) observed empirical support for this hypothesis. The results of their study showed that control beliefs were significantly related to memory performance, and that this relationship was partially mediated by strategy use.

In summary, negative stereotypes have repeatedly been shown to affect performance on stereotyped tasks. Prevalent stereotypes degrading the cognitive ability of older adults can thus be expected to hinder their performance on cognitive tasks, and this thesis has received empirical support. Furthermore, there is evidence that this relationship is affected by strategy use – that is, perceiving themselves as less competent, older adults are less likely to use cognitive strategies, which in turn degrades their memory performance. Accordingly, I hypothesize:

Hypothesis 2: Older adults under stereotype threat will perform more poorly on a learning task than those not under threat.

Hypothesis 3: There will be an interaction effect between cognitive strategy use and stereotype threat, such that cognitive prompts will lead to greater improvement on learning performance for participants in the stereotype threat condition, than for those in the no stereotype threat condition.

Cognitive Theory of Multimedia Learning

Thus far, I have described a number of cognitive deficits associated with aging. Mayer's (2005) cognitive theory of multimedia learning offers a framework that helps to understand how these cognitive deficits affect older adults' ability to learn and use new information. Though Mayer developed his theory to address learning in general, several key points, especially his emphasis on working memory capacity, have direct implications for the training of older adults. The following section provides an overview of Mayer's model.

Mayer's (2005) CTML has received much attention in the past decade as an effective way to teach learners new information, especially causal systems. Multimedia learning is defined by Mayer (1997) as the presentation of information in more than one mode, such as visually as well as auditorily. For example, a computer animation with simultaneous narration would be considered multimedia because it conveys information through both sight and sound.

Mayer's (1997) research, which began with the goal of increasing student understanding of scientific phenomena, has focused exclusively on the explanation of casual models. A causal model is a model where changes in one part of the model cause changes in another part of the model. Examples include the mechanisms of a bike pump, the formation of lightning storms, and the functioning of hydraulic brakes. Because Mayer's goal was to have the students understand the information, rather than just memorize it, he chose to test learning with transfer tests as opposed to mere retention tests. In these transfer tests, students are asked to solve novel problems that require reasoning with the presented information, as opposed to simply repeating the information they learned, which is measured through recall.

Drawing on research from cognitive psychology, including Baddeley's (1992) model of working memory, Sweller's (e.g., Sweller, Chandler, Tierney & Cooper, 1990) cognitive load theory (CLT) and Wittrock's (1989) generative theory, Mayer (1996) designed the SOI model of learning, which in turn led to the development of the CTML (Mayer, 2005). The SOI model (Mayer, 2006) is named after the three cognitive processes involved in knowledge construction: selecting, organizing, and integrating. *Selecting* is defined as selecting information from the environment and adding that information to working memory. During the selection process, a learner distinguishes relevant from irrelevant information, focusing conscious attention on the relevant pieces. Mayer labels the second process *organizing*, defined as creating a coherent structure that accommodates key pieces of information. In the organizing process, the learner builds internal connections between pieces of information, organizing them into a coherent structure. The outcome of this process is ideally an internally connected model. The final process is *integrating*, during which the knowledge being constructed in working memory is related to analogous knowledge in long-term memory. This process can be thought of as relating the new knowledge to what one already knows. While integrating, the learner builds external connections between the organized new knowledge and existing knowledge.

Mayer (2005) built upon his SOI model to develop CTML. CTML is based upon three assumptions: the dual channel, the limited capacity, and the active processing. The dual channel assumption states that the human information processing system has separate channels for visual and auditory information, and that these channels have independent working memory capacities. Multimedia presentations can maximize working memory capacity by presenting information simultaneously to both channels. The limited capacity assumption states that the amount of information that can be processed in one channel at any given time is limited. A learner can only hold so many visual and auditory representations in working memory at one time. Limited capacity is important because it is in working memory that information is organized into coherent models and eventually integrated into long-term memory. The final assumption is the active processing assumption. This assumption states that humans carry out a coordinated set of cognitive processes to build coherent mental representations of incoming material. Because learners are actively trying to structure material, information in multimedia presentations should have a coherent structure, and should provide guidance for learners on how to build that structure.

Figure 1 provides a visual depiction of CTML (Mayer, 2005). During a multimedia presentation, words and pictures enter into sensory memory. Relevant information is selected into working memory, where sounds and images are organized separately into verbal and pictorial models. These models are then integrated together, and into long term memory.

According to Mayer (2003) one of the greatest obstacles to learning is limited working memory capacity. This concept draws upon CLT advanced by Sweller (1988). Sweller (1988) noted that traditional learning methods can often be ineffective, and hypothesized that this was due to the fact that the learning paradigm itself requires such a large amount of working memory capacity that no capacity remains for the construction and acquisition of schema. Schema are mental frameworks of knowledge, and are vital for retaining and using learned information (Sweller, 1988). Sweller (1988) referred to the demand characteristics of a learning task as *cognitive load*. Sweller, van Merriënboer, and Paas (1998) subsequently proposed three types of cognitive load. *Intrinsic load* refers to the nature of the learning materials themselves, and cannot be altered by instructional design. *Germane load* reflects the cognitive effort necessary for schema construction. For example, if watching a multimedia presentation on how a bicycle pump works, germane load would reflect the mental effort required to mentally organize the parts of the pump and how they interact. *Extraneous load* is the method through which the instruction is presented; it is unnecessary and can be prevented through instructional intervention. For example, providing unnecessary background music, or pleasant but meaningless graphics, represents extraneous load. Thus, working memory architecture and its limitations should be thoroughly considered in the design of learning environments (Mayer, 2003).

Together, the SOI and CLT models offer a possible explanation to how metacognitive strategies facilitate learning. According to Mayer (1984), text comprehension can be facilitated through the use of strategies that aid in the selection of relevant information, the organization of information within working memory, and the integration of information into long-term memory. It is likely that metacognitive strategies facilitate learning by helping the learner in these three processes. From the perspective of CLT, when the learner is able to focus on selecting, organizing, and integrating only the most relevant learning material, the learner can simultaneously maximize intrinsic and germane load and minimize extraneous load. By doing so, the learning applies scarce working memory resources where they are most needed for effective learning.

In sum, CTML focuses on the use of multimedia presentations to maximize the use of working memory resources during a learning task, thereby freeing up resources for the selection, organization, and integration processes that are vital for building cohesive models of new information and integrating those models into long-term memory. Because aging is associated with declines in working memory, CTML can be particularly beneficial for designing training programs for older adults by highlighting aspects of the training program that tax cognitive resources for purposes other than learning.

Conclusion

Older workers are going to make up a substantial portion of the labor market in the coming years, and multimedia learning theory offers an efficient way to train older adults. Previous work on multimedia learning theory has focused on reducing cognitive load. Though this is an important and fruitful line of research, the importance of cognitive and metacognitive strategy use has yet to be explored. Strategy use offers a venue for increasing older adults' performance on learning tasks, and may offer a buffer to the negative effects of stereotype threat.

Method

Sample

After the removal of non-eligible participants (i.e., two participants who suffered from cognitive damage, and one participant who was above the maximum age) the current sample consisted of 131 individuals between the ages of 55 and 70 years old. Though there is no objective definition of "older adults", fifty-five was chosen as the lower cutoff point of this age range because age related cognitive declines should be noticeable in most of the population by age 55 (Park & Payer, 2006). Seventy was chosen as the upper cutoff point to minimize the number of participants suffering from dementia (Kawas, 2000).

Participants in the sample had a mean age of 59.71 years (*SD*=4.312). On a Likert-type scale asking, "Please rate the extent to which you agree with the following statement: I consider myself an older adult," (1= strongly disagree, 5= strongly agree), the mean response was 3.27 (*SD*= 1.227).

The sample was 49.6% male (65) and 48.9% female (64), with two participants not responding. The sample was racially homogenous: 96.2% (126) of participants identified as White; .8% (1) of participants identified as Hispanic; 2.3% (3) of participants identified as Asian; and .8% (1) of participants identified as Native American. No participants identified as African American.

The sample was well-educated: 1.5% (2) of participants did not graduate from high school; 9.2% (12) of participants achieved a high school degree; 25.2% (33) of the participants attended some college but did not graduate; 32.8% (43) of participants graduated from college; and 31.3% (41) of participants had graduate training (e.g., MBA, PhD, Master's degree).

The majority of the participants were employed (64.9%; 85 participants), and worked an average of 41.8 hours per week (*SD*= 11.8). Unemployed participants accounted for 6.1% of the sample (8 participants); 3.1% (4) of participants volunteered an average of 9.25 hours per week (*SD*= 7.5); 26.7% (35) of participants were retired, with an average retirement age of 58.8 years (*SD*= 5.2); 7.6% (10) participants had a miscellaneous employment status. Some participants categorized themselves as members of more than one employment category, which is why the cumulative percentage exceeds 100% of the sample size.

To ensure that it was appropriate to combine employed, unemployed, and retired individuals in the sample, transfer performance was regressed on employment status to see if a significant relationship existed. Employment status was dummy coded with "employed" serving as the reference group, "UnEmpDummy" representing unemployed individuals, and "RetDummy" representing retired individuals. Controlling for previous knowledge, education, experimental manipulations (i.e., CPDummy and STDummy), and the interaction of experimental manipulations (i.e., CPXST), employment status did not explain a significant amount of variance in transfer performance: ΔR^2=.002, $\Delta F(2, 111)$=.145, p=.865. It was thus deemed appropriate to include employed, unemployed, and retired individuals in the subsequent analyses.

Recruitment

The experiment was posted to an electronic survey site (Qualtrics.com). Participants could access the experiment online whenever and wherever they wanted. Participants were recruited through several methods.

First, undergraduate psychology students were offered extra credit if they could get an older adult (e.g., parent, grandparent, co-worker) to participate in the experiment. An alternative form of extra credit of approximately the same difficulty level was offered to discourage students from pretending to be in the correct age range even if they were not. Furthermore, students were told of the importance of having an accurate sample.

Second, the researcher contacted dozens of senior centers from across the United States, described the experiment, provided recruitment materials, and asked for help in recruiting. No incentive was offered for participation.

Third, the researcher posted a description of the experiment and a link to the study on discussion boards likely to be frequented by older adults (e.g., AARP). No incentive was offered for participation.

Finally, the researcher used a snowball method to recruit participants, asking friends and family to recruit people from the age range, and asking people within that age range to recruit friends who were also eligible to participate. No incentive was offered for participation.

Because it is impossible to know how many individuals came in contact with recruitment materials, it is impossible to calculate a response rate.

Materials

Prior knowledge. Before beginning training, participants were asked to indicate, on a scale of 1-5 (1 indicating no prior knowledge and 5 indicating extensive prior knowledge), their understanding of how a four-stroke, internal combustion engine works. Single item measures of prior knowledge have been shown to correlate highly with multiple-item measures of the same knowledge, and, in addition, are easier than multiple item measures to administer and to complete (Towler et al., 2008).

Multimedia Presentation. Subjects were asked to watch a multimedia presentation briefly describing the principles of how a four-stroke, internal combustion engine works. This presentation, though of different subject matter, was designed to be as similar as possible to the learning materials used in Mayer's multimedia research, specifically Mayer, Heiser, and Lonn's (2001) multimedia learning material, and represents the same class of training content that has been used by Mayer and his colleagues in multimedia studies (e.g, Mayer & Anderson, 1991; Mayer & Anderson, 1992). This presentation was presented via a timed and narrated Microsoft PowerPoint 2007 presentation (see Appendix A).

Stereotype threat

For the stereotype threat group, the training began with a brief description of the experiment designed to activate stereotype threat by directly conveying the message of subgroup differences in cognitive ability and performance in a test-taking context. This description was accompanied by pictures depicting older adults in a stereotyped fashion (e.g., in wheelchairs). The no stereotype threat condition received a description of the study designed to minimize threat activation by presenting evidence contrary to common stereotypes about older adults' cognitive performance. This description was accompanied by pictures depicting older adults in an astereotypical fashion (e.g., involved in healthy outdoor activities). These materials were adopted from Hess, Auman, Colcombe, and Rahhal (2003) and Hess, Emory, and Queen (2009), with guidance from Nguyen and Ryan (2008). See Appendix B for a copy of the stimulus materials.

Cognitive prompts

For the cognitive prompt group, participants were presented with slides encouraging them to use cognitive (e.g., which are the main points in your opinion?) and metacognitive (e.g., which main points haven't I understood yet?) strategies during logical breaks in the presentation. These prompts were adapted from Berthold et al. (2007). See Appendix C for a copy of the stimulus materials.

The no cognitive strategy control group was presented with slides located in the same place during the presentation, however the slides simply said, "Please wait for the presentation to continue", and remained for the same duration as the cognitive prompts.

Learning outcomes. Participants' transfer performance was assessed using Mayer et al.'s (2001) transfer test about lightning formation, adapted to fit the current subject matter (see Appendix D).

Procedure

To access the study, participants followed a link to a website that contained an electronic version of the experiment. Unbeknownst to the participant, as soon as they arrived at the website they were randomly assigned to one of four conditions: in the first condition, participants were not exposed to either the stereotype threat or cognitive prompts; this condition will be referred to as the “no stereotype threat/ no cognitive prompt” condition. In the second condition, participants were exposed to stereotype threat, but not cognitive prompts; this condition will be referred to as the “stereotype threat/ no cognitive prompt” condition. In the third condition, participants were not exposed to stereotype threat, but were exposed to the cognitive prompts; this condition will be referred to as the “no stereotype threat/ cognitive prompt” condition. Finally, in the fourth condition, participants were exposed to both stereotype threat and cognitive prompts; this condition will be referred to as the “stereotype threat/ cognitive prompt” condition.

Participants were given a consent form that changed slightly depending on which condition they were in. Participants in the stereotype threat conditions were told that they would be exposed to negative information about older adults and learning, and that this might cause psychological distress. Participants in the no stereotype threat conditions were not given this warning.

After reviewing the consent form and consenting to participate, all participants were given the single item measure assessing previous knowledge of engines. Participants in the stereotype threat conditions were then asked their age, and “Have you experienced any event (for example, stroke or brain damage) or are you suffering from any condition (for example, Alzheimer's or dementia) that might affect your cognitive performance?” Because even simple demographic questions have been shown to illicit stereotype threat, these questions were not asked until after participants had completed the learning outcome measure in the no stereotype threat conditions. These questions can thus be considered part of the stereotype threat manipulation.

Participants were then shown the training video, with either the stereotype threat/ no stereotype threat and cognitive prompt/ no cognitive prompt manipulations (as described in the materials section above) depending on which condition they were in.

After being shown the training video, participants in all conditions were immediately presented six transfer questions and given five minutes to answer each question. After completing the transfer questions, participants in the no stereotype threat conditions were asked their age, and “Have you experienced any event (for example, stroke or brain damage) or are you suffering from any condition (for example, Alzheimer's or dementia) that might affect your cognitive performance?” All participants were then given a standard demographic questionnaire that included questions on ethnicity, gender, and educational attainment.

After completing the demographic questionnaire, participants were debriefed and thanked for their time.

Analyses

A multiple linear regression was run to test for a main effect for cognitive strategy use and stereotype threat on learning outcomes, as well as an interaction effect for cognitive strategy use and stereotype threat. Control variables included previous knowledge and education level. Contrasts were then run to see whether or not the mean of each group’s performance was significantly different from all other group means.

Results

Scoring

Responses to the six transfer questions were scored by six research assistants (RAs) using objective scoring criteria (see Appendix D). After reviewing the scoring criteria with the RAs as a group, I trained them on how to score the responses. They then practiced scoring several responses. After practicing, each RA was given 10 responses to score. The RAs then shared their scores with the group. Any discrepancies in scores were discussed until the group agreed upon a correct score for the response. The RAs were then given 20 more responses to score. Each RA gave the same score as the other RAs to each of the 20 responses. The remaining responses were then split up among the RAs to score individually.

Because the transfer questions varied widely on the number of possible points a respondent could earn, the transfer questions were converted to z-scores in order to standardize the metric. The z-scores from each transfer question were then averaged together to give each participant one overall score for their transfer responses. This overall score remained in the z-score metric (i.e., M=0, SD=1, prior to the removal of outliers).

Calculated variables

Three variables were created. *CPDummy* (short for cognitive prompt dummy) is a dummy coded variable representing which cognitive prompt condition a participant was in (1=received cognitive prompts; 0=did not receive cognitive prompts). *STDummy* (short for stereotype threat dummy) is a dummy coded variable representing which stereotype threat condition a participant was in (1=stereotype threat condition; 0=no stereotype threat condition). Finally *CPXST* was created to represent the interaction between the cognitive prompt and stereotype threat conditions. This term was calculated by multiplying *CPDummy* by *STDummy*.

Testing assumptions

To appropriately conduct multiple linear regression, several assumptions about the data must be met.

First, linearity was assessed in a number of ways. The dependent variable (i.e., transfer performance) was first regressed on *STDummy* controlling for previous knowledge and education level. Next, *CPDummy* was regressed on *STDummy*, using the same control variables. The residuals for these models were saved, and plotted against one another on a scatterplot (Figure 2). Results revealed that a linear model was appropriate.

To further check for linearity, each dependent variable was regressed on *CPDummy* controlling for previous knowledge and education level. Next, *STDummy* was regressed on *CPDummy*, using the same control variables. The residuals from these models were saved and plotted against one another on a scatterplot (Figure 3). Results revealed that a linear model was appropriate.

Next, the full model was analyzed. The dependent variable was regressed simultaneously on *CPDummy*, *STDummy*, and *CPXST*, controlling for previous knowledge and education. Both the residuals and predicted values for these models were saved, and plotted against one another (Figure 4). No patterns were found in the plot, supporting the appropriateness of a linear model.

Next, the residuals from the full model were plotted on a histogram and a normal probability plot. The histogram approximated a normal distribution (Figure 5), and the normal probability plot approximated a straight line (Figure 6).

Because these assumptions were met, it was deemed appropriate to continue with the multiple linear regression.

Locating outliers

Outliers were located through a number of methods. All these methods necessitated running the predicted model to calculate criteria for outliers. The model included the following variables: previous knowledge and education as control variables, the cognitive prompt dummy code and stereotype threat dummy code as independent variables, and a variable representing the interaction of cognitive prompt and stereotype threat. The model had transfer performance as the dependent variable.

First, studentized deleted residuals were calculated. All cases with a studentized deleted residual greater than ± 2 were removed. This led to the removal of five cases.

Next, Cook's distance was calculated for each case. Values higher than 4/n (.0305 for this dataset) were removed. This led to the removal of six cases.

In all, 11 cases were identified as outliers and removed from the analysis.

Regression Analyses

First, descriptive statistics were used to calculate the number of individuals in each of the four experimental manipulations. Thirty individuals were in the no stereotype threat/ no cognitive prompt group; 34 individuals were in the stereotype threat/ no cognitive prompt group; 31 individuals were in the no stereotype threat/ cognitive prompt group; 24 individuals were in the stereotype threat/ cognitive prompt group. Fifty-five individuals received cognitive prompts, whereas 64 did not; 58 individuals were exposed to stereotype threat, whereas 61 were not (see Table 3).

Using multiple linear regression, transfer performance was regressed on cognitive prompts and stereotype threat, while controlling for previous knowledge and education. Responses to the six transfer questions were scored and converted into z-scores to achieve a common metric. They were then averaged together, yielding a total transfer score for each participant that was also a z-score.

First, transfer performance was regressed on the control variables, previous knowledge and education. The model was significant $R^2=.222$, $F(2, 116)=16.557$, $p<.001$. Together, the two control variables accounted for 22.2% of the variance in transfer performance (see Table 1 for the results of all transfer regression models).

To assess the main effect of cognitive prompts, *CPDummy* was added to the analysis. Controlling for previous knowledge and education, cognitive prompts had a significant relationship with transfer performance, $\Delta R^2=.106$, $\Delta F(1, 115)=18.226$, $p<.001$. This relationship was in the opposite direction of the hypothesis. Cognitive prompts explained 10.6% of the variance in transfer performance beyond the control variables. However, as described in the following paragraphs, the interaction effect between cognitive prompts and stereotype threat was significant, and the effect of cognitive prompts needs to be interpreted in light of the interaction.

To assess the main effect of stereotype threat, transfer performance was regressed on stereotype threat, controlling for previous knowledge and education. The simple main effect of stereotype threat was not significant, $\Delta R^2=.021$, $\Delta F(1, 115)=3.258$, $p=.074$.

Again, this effect should be interpreted in light of the interaction between cognitive prompts and stereotype threat, described in the next paragraph.

Next, a model was specified to test the effect of an interaction between cognitive prompts and stereotype threat. First, *CPDummy* and *STDummy* were entered into the equation after controlling for previous knowledge and education. Next, the interaction term was entered. The model including cognitive prompts and stereotype threat explained a significant amount of variance above and beyond the control variables, R^2=.137, F(1, 114)=12.212, p<.001. The interaction effect of cognitive prompts and stereotype threat was also significant, ΔR^2=.023, ΔF(1,113)=4.166, p=.044 (see Figure 7).

Finally, contrasts were run to assess the simple main effects of cognitive prompts and stereotype threat on transfer performance. To correct for family-wise error rate, a Bonferroni correction was used to set a more stringent alpha level of .008 (i.e, the previous alpha level of .05 divided by the six possible comparisons). These results are presented in Table 2, and described below.

First, the no stereotype threat/ no cognitive prompt condition was compared to all other conditions. The contrast coefficients, as well as significance levels, for each group with the no stereotype threat/ no cognitive prompt condition as the reference group (controlling for previous knowledge and education at the mean) follow: for the no stereotype threat/ cognitive prompt condition, the contrast coefficient was significant (ß=-.430, t=4.733, p<.001); for the stereotype threat/ no cognitive prompt condition, the contrast coefficient was significant (ß=-.029, t=-3.129, p=.002); for the stereotype threat/ cognitive prompt condition the contrast coefficient was significant (ß =-.405, t=4.557, p<.001). Next, the no stereotype threat/ cognitive prompt condition was compared to all remaining conditions. The contrast coefficients, as well as significance levels, for the remaining groups with the no stereotype threat/ cognitive prompt condition as the reference group follow: for the stereotype threat/ no cognitive prompt condition, the contrast coefficient was not significant (ß=-.148, t=-1.667, p=.098); for the stereotype threat/ cognitive prompt condition, the contrast coefficient was not significant (ß =.013, t=.137, p=.891). The final contrast compared the stereotype threat/ no cognitive prompt condition to the stereotype threat/ cognitive prompt condition. The contrast coefficient was not significant (ß =.147, t=1.701, p=.092).

In sum, after controlling for education and previous knowledge, both the cognitive prompts and stereotype threat manipulation had a significant negative effect on learning performance as measured by transfer questions. The relationship between cognitive prompts and performance was stronger in the no stereotype threat group than in the stereotype threat group. Contrasts revealed significant differences in the mean performance of the no stereotype threat/ no cognitive prompt condition and all other conditions (i.e., the no stereotype threat/ cognitive prompt condition, the stereotype threat/ no cognitive prompt condition, and the stereotype threat/ cognitive prompt condition). No other differences in mean performance between groups were significant.

Finally, it should be noted that I considered the possibility that the task was gender biased, and thus may have inadvertently served as a stereotype threat manipulation for women but not men. To test this possibility, I first tested to see if gender was significantly correlated with transfer performance. It was (r^2=.079, ß=-.477, $t(116)$=-3.157, p=.002), however, this relationship became non-significant after controlling for previous knowledge and education (ß =-.104, $t(116)$=-.937, p=.351). It was also plausible that due to the possible gender bias of the task, women would react more strongly to the stereotype threat manipulation than men. To test this, I added a variable representing gender to the regression formula, as well as an interaction term between gender and stereotype threat. The addition of these two variables did not explain a significant amount of additional variance beyond the full model, ΔR^2=.022, $\Delta F(2,110)$=2.014, p=.138.

Discussion

The purpose of the study was to examine the effects of cognitive prompts and stereotype threat on older adults in an online learning environment. In this study, there was a simple main effect for cognitive prompts for participants in the no-stereotype threat condition, but not in the stereotype threat condition. However, the simple main effect for cognitive prompts was in the opposite direction as hypothesized. That is, cognitive prompts inhibited performance on the learning task. There was also a simple main effect for stereotype threat when participants were not exposed to cognitive prompts, but not when participants were exposed to cognitive prompts. When participants were not exposed to cognitive prompts, stereotype threat had a significant negative effect on performance. Finally, there was an interaction effect between the stereotype threat and cognitive prompts. The presence of cognitive prompts within the instructional program negatively affected subsequent performance on the learning task when participants were not exposed to stereotype threat. For participants who were exposed to stereotype threat, cognitive prompts had no significant effect on performance. These results are in direct contradiction to the hypothesized results, and thus possible explanations are warranted.

Though contrasts revealed no significant difference in performance between participants in the stereotype threat and no stereotype threat condition when participants were shown cognitive prompts, participants in the stereotype threat condition did perform significantly worse than participants in the no stereotype condition when participants were not shown cognitive prompts. This supports previous research showing that stereotype threat can impede performance on certain tasks, and specifically research that has shown that older adults are susceptible to stereotype threat (e.g., Hess et al., 2003; Hess, Emery, & Queen, 2009). The lack of a statistically significant difference in performance between the stereotype threat and no stereotype threat groups when they were shown cognitive prompts is likely due to a floor effect. The strong, negative effect of cognitive prompts caused participants in both groups to perform so poorly that the effect of the stereotype threat manipulation was overshadowed. In the following sections, possible causes of the negative effect of the cognitive prompts will be discussed.

In regard to cognitive prompts, the results are contrary to several prior studies on the effectiveness of cognitive prompts on learning. For example, Berthod et al. (2007) found that inserting cognitive prompts into a learning protocol increased learning outcomes as compared to a control group who received no prompts. Similarly, Bannert, Hildebrand, and Mengelkamp (2009) found that inserting a metacognitive support device into a learning program increased performance on transfer questions compared to a control group that was not given the metacognitive support device. In the present study, the use of cognitive prompts had a detrimental effect on learning outcomes.

The results of this study pose an interesting question: if previous research has shown that cognitive prompts can help individuals perform better on learning tasks (e.g., Berthod et al., 2007; Bannert et al., 2009), why in this experiment did cognitive prompts have a negative effect on learning outcomes? The answer, I believe, has to do with working memory (WM) capacity. As previously noted, WM capacity is positively related to performance on tasks that require memory and complex cognition, such as the learning task used in this study (McCabe et al., 2010; Chen & Li, 2007). As people age, their WM capacity tends to decline (Park & Payer, 2006). This decline may compromise performance on cognitive tasks, like learning, especially when there is an environmental condition that demands non-task-relevant resources. This likely explains why the stereotype threat manipulation was successful. WM capacity has been shown to moderate the effect of stereotype threat on performance: individuals with lower WM capacity are more susceptible to the negative effects of stereotype threat (Régner, Smeding, Gimmig, Thinus-Blanc, Monteil, and Huguet 2010). In the current study, the stereotype threat manipulation likely absorbed cognitive resources necessary for the learning task, from a sample that consisted of individuals with fewer cognitive resources to spare. In other words, the results are consistent with the proposition that stereotype threat hinders performance by occupying cognitive resources that would otherwise be applied to the task at hand.

Similarly, the cognitive prompts had the same effect on performance as the stereotype threat manipulation. Instead of focusing their cognitive resources on learning the material, participants may have used their resources to process the cognitive prompts. This, ultimately, led to poorer learning performance, and would explain why older adults in the no-stereotype threat/ cognitive prompt condition performed significantly worse than older adults in the no-stereotype threat/ no-cognitive prompt condition, and just about as well as older adults in both stereotype threat conditions. Instead of facilitating learning, the cognitive prompts in this study possibly inhibited learning by pilfering WM capacity away from the learning task.

Berthold, Roder, Knorzer, Kessler, and Renkl (2010) provided recent empirical support for the argument that prompts can actually impede performance by consuming cognitive resources. Berthold et al. investigated whether or not prompts (similar to the ones used in the current study) could actually inhibit performance on a learning task, and found support for their hypothesis that prompts can facilitate performance on the task the prompt is targeting, while simultaneously inhibiting performance on other tasks (compared to groups that received no prompts). The researchers explained their findings using cognitive load theory: the prompts increased the cognitive load placed on learners, facilitating performance on the tasks targeted by the prompts, but directing cognitive resources away from other tasks, thus inhibiting performance. The cognitive prompts in the current study, then, might be thought of as belonging to a broader category of "things that distract older people from the learning task," a category which would also include stereotype threat.

Research showing increased distractibility with age supports the hypothesis that the cognitive prompts may have distracted the older adults during the learning task. Several studies have demonstrated that presenting older adults with task irrelevant information disrupts their learning performance (Connelly, Hasher, & Zacks, 1991; Hasher & Zacks, 1988) For instance, in a study by Wolfson and Kraiger (2010), older adults in a "high extraneous load" condition were given seductive details within a training task. These seductive details were highly interesting and appealing pieces of information that were only tangentially related to the training material. Older adults who were given the training task with seductive details performed significantly worse on training outcomes than older adults not given the seductive details. This effect most likely occurred because the details distracted the older learners from the main learning task. The cognitive prompts in the current study were designed to facilitate learning, but it seems more likely that they acted as distracters to the older adults, impeding their performance on the learning task.

Why did these specific cognitive prompts have a deleterious effect on learning outcomes, when other metacognitive interventions have been shown to have the exact opposite effect (e.g., Bannert et al., 2009; Berthod et al., 2007)? First of all, the cognitive prompts were presented for a predetermined duration of time (30 seconds per prompt). Previous studies that found a positive influence of metacognitive interventions on learning outcomes specifically with an older adult population have used a self-paced design (Dunlosky, Kubat-Silman, & Hertzog, 2003). As noted above, one of the most widely observed cognitive declines associated with aging is slower speed of cognitive processing (Salthouse, 1996). It is possible that older adults could not process the prompts in the given amount of time, and continued to expend cognitive resources on the prompts after the training video had continued.

Secondly, it is possible that the cognitive prompts were too general. To prevent accidentally providing extra information about the topic through the prompts, very general prompts were chosen (e.g., “What points have you understood well? What points have you not understood well?”). Though this may have encouraged the older adults to reflect on the learning material, they may have reflected on the less important parts of it, and spent their cognitive resources processing information that wasn't critical to understanding the material as a whole. Thought there's no direct support for this claim in the literature, there are a number of studies that provide evidence that older adults are more easily distracted than younger adults (e.g., Connelly et al., 1991; Hasher & Zacks, 1988). It is possible that the cognitive prompts distracted older adults from their main task, which was supposed to be learning the material. This in turn led to decreased performance on the learning outcomes.

Research and Practical Implications

The current study contributes two important results to the literature on older adults and training. First, the simple main effect for stereotype threat provides evidence that older adults are susceptible to this phenomenon. In the current study, the "sledge-hammer" technique was used to induce stereotype threat: that is, several manipulations were used simultaneously to try and induce stereotype threat (i.e., showing pictures of stereotypical older adults, contrasting older adults and younger adults, describing older adults in a stereotypical fashion, and asking for participants' age before the learning task as opposed to after). It is impossible to know what exactly triggered the stereotype threat effect. What is clear, however, is that the manipulation worked. When designing training programs for older adults, trainers should be aware of the possibility that stereotyping older adults can lead to poor performance, and trainers should avoid mentioning common stereotypes associated with aging, allowing older adults to feel as if they are being compared to younger adults, and collecting demographic information prior to training.

The second contribution of the current study is to show boundary conditions for metacognitive interventions. Though metacognitive interventions can lead to improved performance compared to training programs without metacognitive interventions, researchers and practitioners alike need to be aware that these interventions can, under certain circumstances, actually impede performance. The reasons for this effect still need to be more thoroughly researched, but for now the results of the current study provide a warning against designing a training program with a metacognitive intervention and expecting to facilitate performance. Instructional designers and trainers should consider piloting cognitive prompts rather than just assuming they work, especially with older learners.

Limitations

There are several limitations to this study. The first is the sample. Each participant in this study had access to a computer and the Internet, and was at least technologically competent enough to navigate to and through the study. Technology is pervading most peoples' lives at this point, and this includes older adults (Mitzner et al., 2010). Still, it may be unwarranted to assume that older adults with a computer and Internet access are representative of the entire population of older adults; it is possible that this sample differed from the population of older adults as a whole in important and meaningful ways. However, the specific purpose of this study was to investigate effective training design for older adults for the purpose of workplace training. Though recruiting a sample that had access to a computer limits the generalizability of these findings to all older adults, this sample might be closer to the population of older working adults (who likely need to use computers in the course of their job) than the population of older adults in general.

The fidelity of the training program and the artificiality of the task are also limitations. Participants completed the task at a time and location of their own choosing. This may be very different than how workplace tasks are usually completed (except for telecommuters). Furthermore, participants had no particular motivation to seriously apply themselves to the learning task, or to answering the questions accurately. Unlike job performance, their performance on the experimental tasks provided no meaningful consequences (e.g., being fired). Though it's difficult to say how these aspects of the task may have affected the results, practitioners should keep these limitations in mind when applying these findings to a field setting.

A final limitation to this study is the choice of the dependent variable. Because this research was based mainly on Mayer's (2005) CTML, the procedure was designed to be similar to the procedure used in the majority of Mayer's studies (e.g., Mayer, 1992; Mayer & Anderson, 1991, 1992). Specifically, participants were trained on a cause/ effect model (i.e., where A causes B to happen). The dependent variable, transfer performance, was also taken from Mayer's studies (e.g., Mayer 1992; Mayer & Anderson, 1991, 1992). Transfer performance is commonly measured as a training outcome, and is traditionally likened to Kirkpatrick's (1960) construct of "behavior", which is defined as using learned principles and techniques on the job. However, Mayer uses the term somewhat idiosyncratically to mean using learned information to solve new problems (Mayer, 2005). Mayer (2005) recommends using his transfer measure when the researcher is interested in how well participants have understood what they have learned, and how participants cognitively construct meaningful learning outcomes. The reader should thus keep in mind that the transfer questions in this study don't represent transfer as it is traditionally defined.

Future Directions

This study provides as many questions as answers. Specifically, it would be beneficial to understand precisely why the cognitive prompts were harmful to learning. I proposed that these cognitive prompts used up cognitive resources which otherwise could have been applied to the learning task itself. Future research should test this proposition empirically. For instance, a future study could measure WM capacity, and then test to see if that variable moderated the relationship between cognitive prompts and learning outcomes. If it did, it would provide evidence that cognitive prompts did inhibit learning by absorbing needed cognitive resources from individuals who had no resources to spare.

Another question left unanswered by this study is why did these cognitive prompts inhibit learning, when other metacognitive interventions have been shown to do the exact opposite (Bannert et al., 2009; Berthod et al., 2007; Dunlosky et al., 2003)? How can trainers design metacognitive interventions to ensure they facilitate performance on learning outcomes, not impede it? Several studies could be designed to answer these questions. These studies could systematically manipulate aspects of the metacognitive intervention, for example, set-paced versus self-paced conditions, and specific versus general cognitive prompts. The results of the current study provide evidence that the method used for this experiment was sensitive to differences in learning efficiency, and the basic design of the study appears to be appropriate for future studies of the same phenomena.

Another important question for future research is to understand if cognitive prompts of these types only hurt the performance of older adults, or if the same pattern would be seen with younger adults. A future study could use the same research design within a younger population, and, again, aspects of the cognitive prompts could be systematically manipulated.

Finally, future research should address the effects of cognitive prompts and stereotype threat in other training situations with other outcomes. As mentioned in the limitations section, this study employed the use of a dependent variable (i.e., transfer question performance) that is designed to capture how well participants understood the information in the training program, and if they were able to use it to solve novel problems. Training studies have traditionally focused on four levels of outcomes: reactions (trainees' liking of and feelings for a training program); learning (principles, facts, and techniques understood and absorbed); behavior (using learned principles and techniques on the job); and results (ends, goals, desired results) (Alliger & Janak, 1989). The outcome used in this study would most likely be considered as an aspect of the second category, "learning". Future research should focus on other training outcomes. For instance, it's not hard to imagine that stereotype threat would negatively impact participant reactions. Furthermore, training programs are most often designed specifically to impact behavior (e.g., how people actually apply what they've learned on the job). It would be interesting to see the effects of both stereotype threat and cognitive prompts on this outcome.

Conclusion

In conclusion, this study provided evidence in support of the literature that stereotype threat can negatively affect the performance of older adults on a learning task. Contrary to expectations, cognitive prompts also negatively affected the performance of older adults on learning tasks. Though the specific mechanism for this remains unclear, the message of the results does not: practitioners involved in training design need to be aware the cognitive interventions can impede performance as well as facilitate it, and they need to use these interventions intelligently and cautiously when designing training programs for older adults.

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TABLES

Table 1 *Results of multiple linear regression model with transfer performance as the dependent variable.*

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
	ß	ß	ß	ß	ß
Previous Knowledge	.399**	.408**	.392**	.401**	.402**
Education	.318**	.303**	.338**	.327**	.342**
Cognitive Prompts		-.327**		-.342**	-.488**
Stereotype Threat			-.148	-.178*	-.321**
Cognitive Prompts*Stereotype Threat					.245*
R^2	.222	.328	.244	.359	.355
F	16.557**	18.753**	12.339**	15.985**	13.976**
ΔR^2		.106	.021	.137	.023
ΔF		18.226**	3.258	12.212**	4.166*

Note. N=119. *p<.05. **p<.01.

Table 2 *Contrast coefficients with transfer performance as the dependent variable.*

Condition	CP0ST0		CP0ST1		CP1ST0	
	ß	*t*	*ß*	*t*	*ß*	*t*
CP0ST0						
CP0ST1	-0.290	3.129*				
CP1ST0	-0.430	4.733*	-0.148	1.667*		
CP1ST1	-0.405	4.577*	0.147	1.701	0.013	0.137

Note. CP0ST1 = no cognitive prompt/ no stereotype threat; CP0ST1=no cognitive prompt/ stereotype threat; CP1ST0= cognitive prompt/ no stereotype threat; CP1ST1= cogntive prompt/ stereotype threat; *MD*= mean difference; all mean differences are expressed as positive values; significance value was corrected for family-wise error rate for the six possible contrasts (.05/6=.008). *p<.008

Table 3 *Number of participants in each experimental manipulation*

	No Stereotype Threat	Stereotype Threat	Total
No Cognitive Prompts	30	34	64
Cognitive Prompts	31	24	65
Total	61	58	119

FIGURES

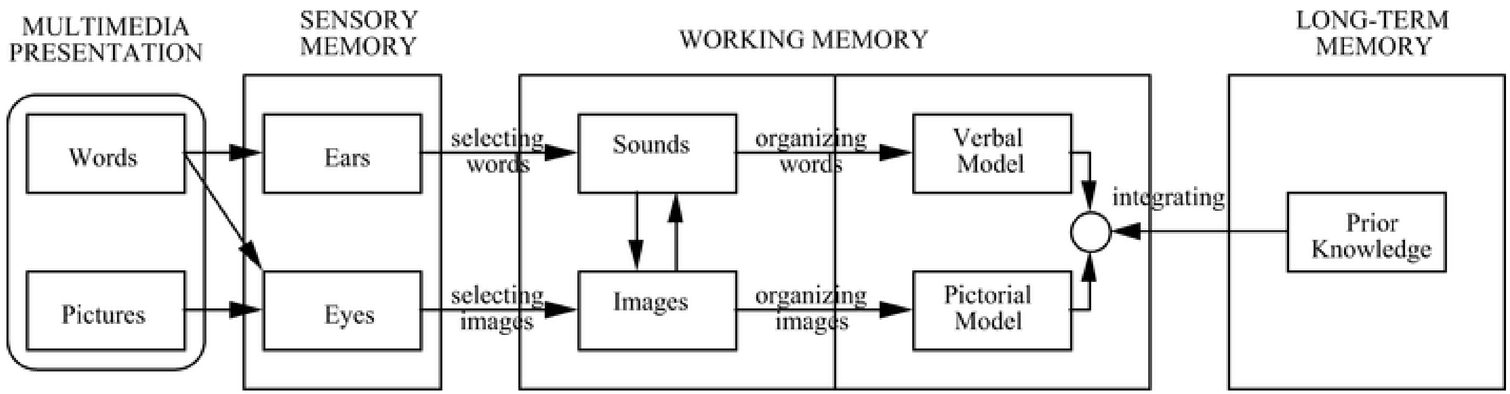


Figure 1: Mayer's (2005) Cognitive Theory of Multimedia Learning

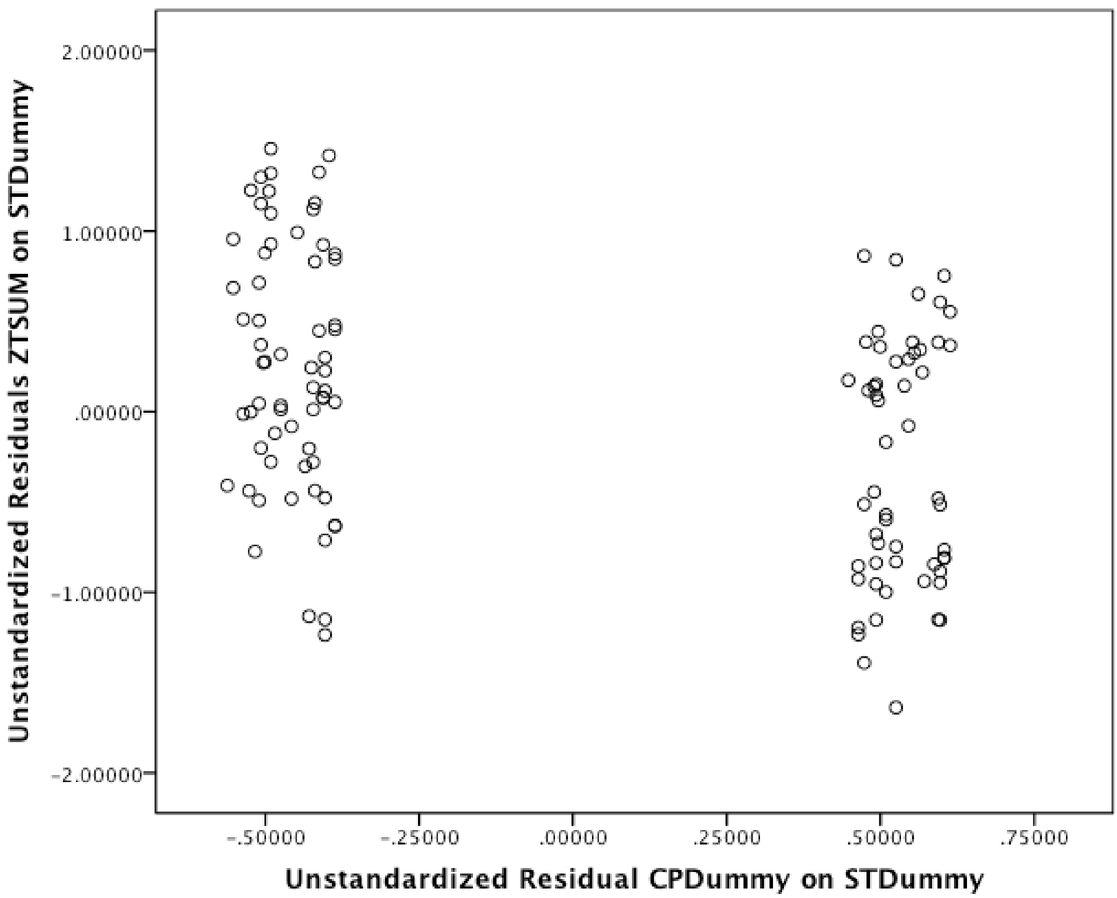


Figure 2: Scatterplot of unstandardized residuals from a model regressing ZTSUM on STDummy (Y-axis) and CPDummy on STDummy (X-axis) to investigate the appropriateness of a linear model. The lack of a distinct pattern in the scatterplot provides evidence that a linear model is appropriate.

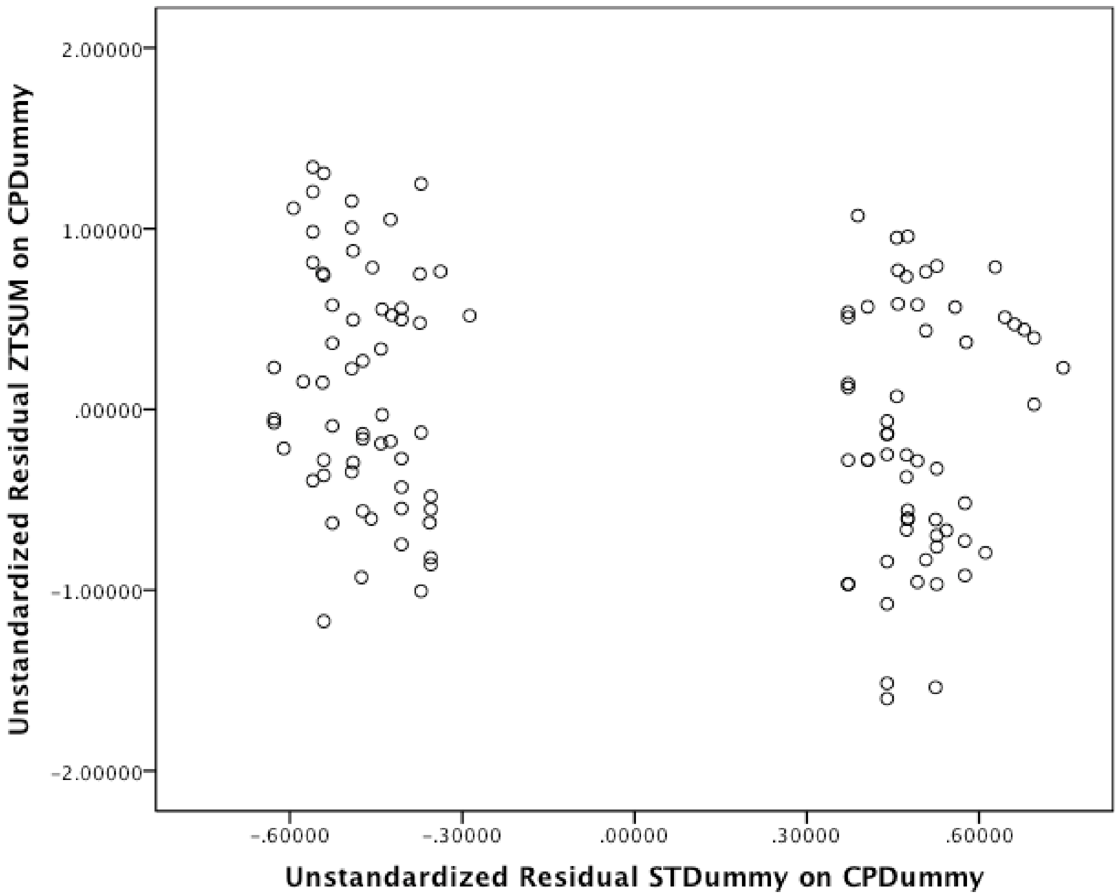


Figure 3: Scatterplot of unstandardized residuals from a model regressing ZTSUM on CPDummy (Y-axis) and STDummy on CPDummy (X-axis) to investigate the appropriateness of a linear model. The lack of a distinct pattern in the scatterplot provides evidence that a linear model is appropriate.

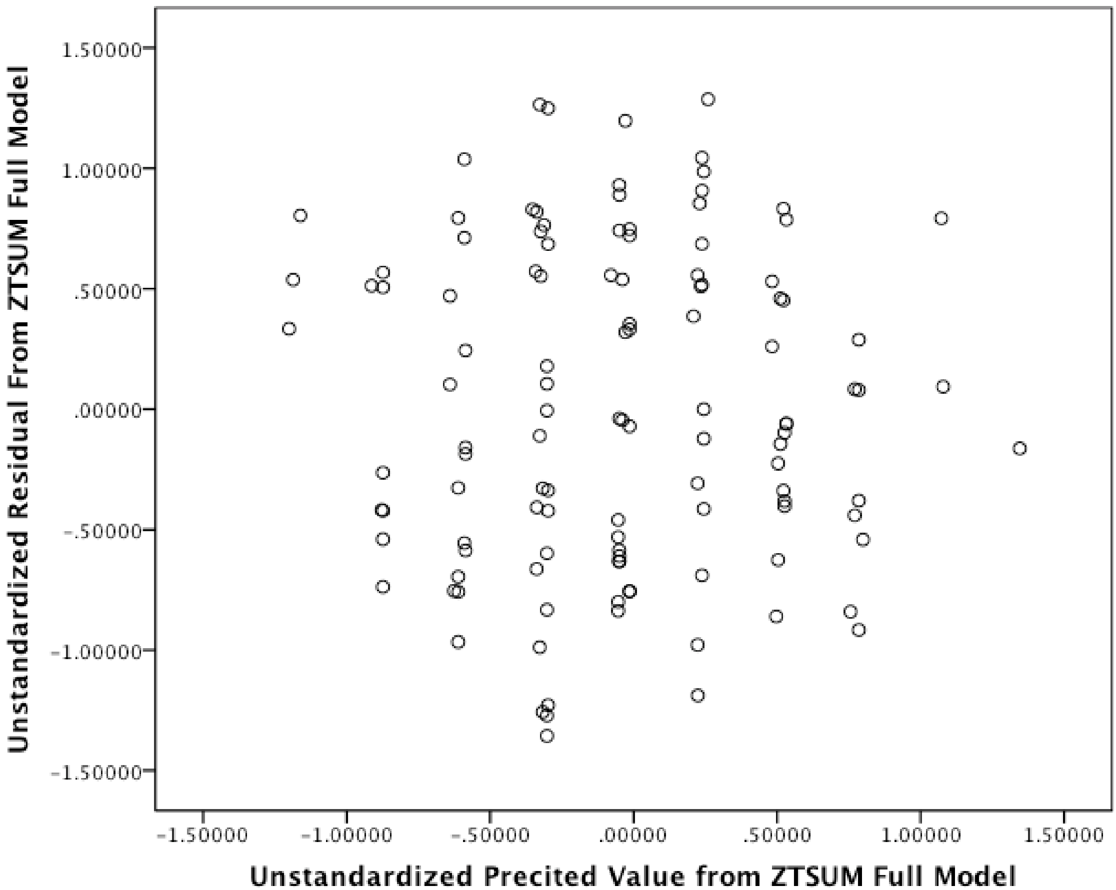


Figure 4: Scatterplot of unstandardized residuals (Y-axis) and unstandardized predicted values (X-axis) from the model regressing ZTSUM on previous knowledge, education level, CPDummy, STDummy, and CPXST. The lack of a distinct pattern in the scatterplot provides evidence that a linear model is appropriate.

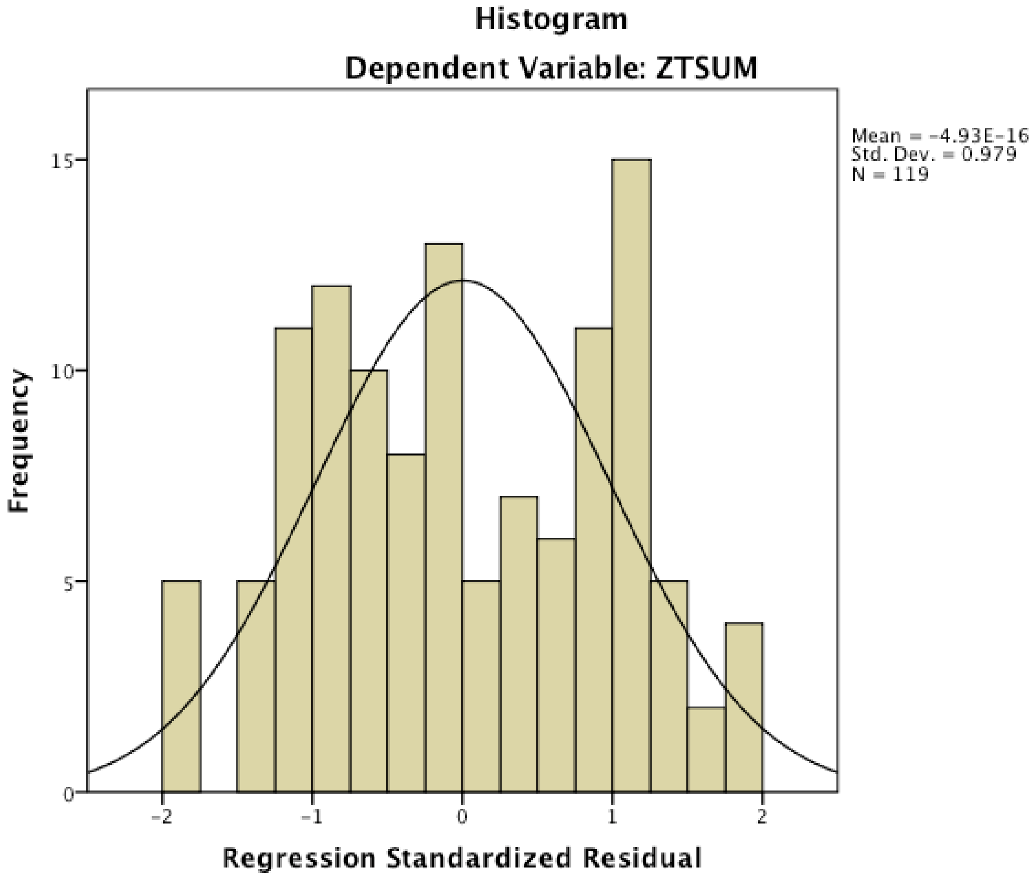


Figure 5: Histogram of the standardized residuals from the model regressing ZTSUM on previous knowledge, education level, CPDummy, STDummy, and CPXST. The histogram approximates a normal distribution.

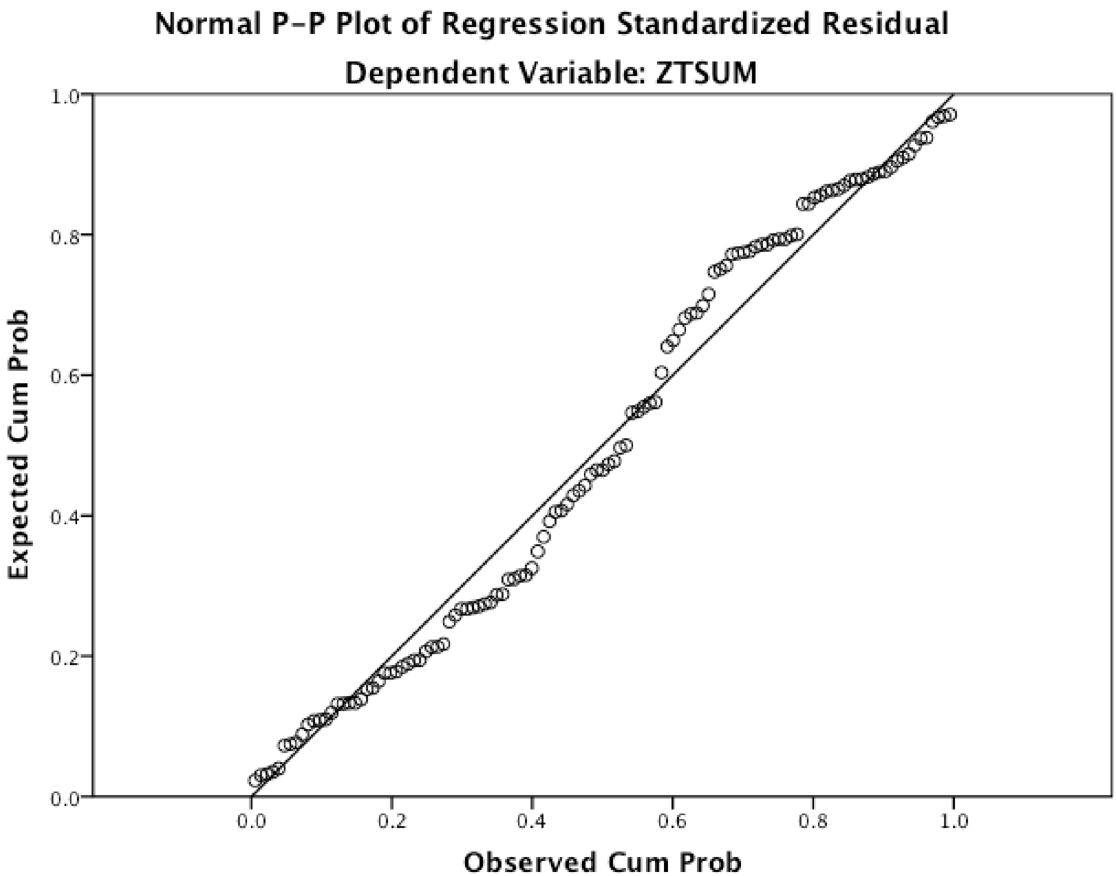


Figure 6: A normal p-plot of standardized residuals from the model regressing ZTSUM on previous knowledge, education level, CPDummy, STDummy, and CPXST. The plot approximates a straight line.

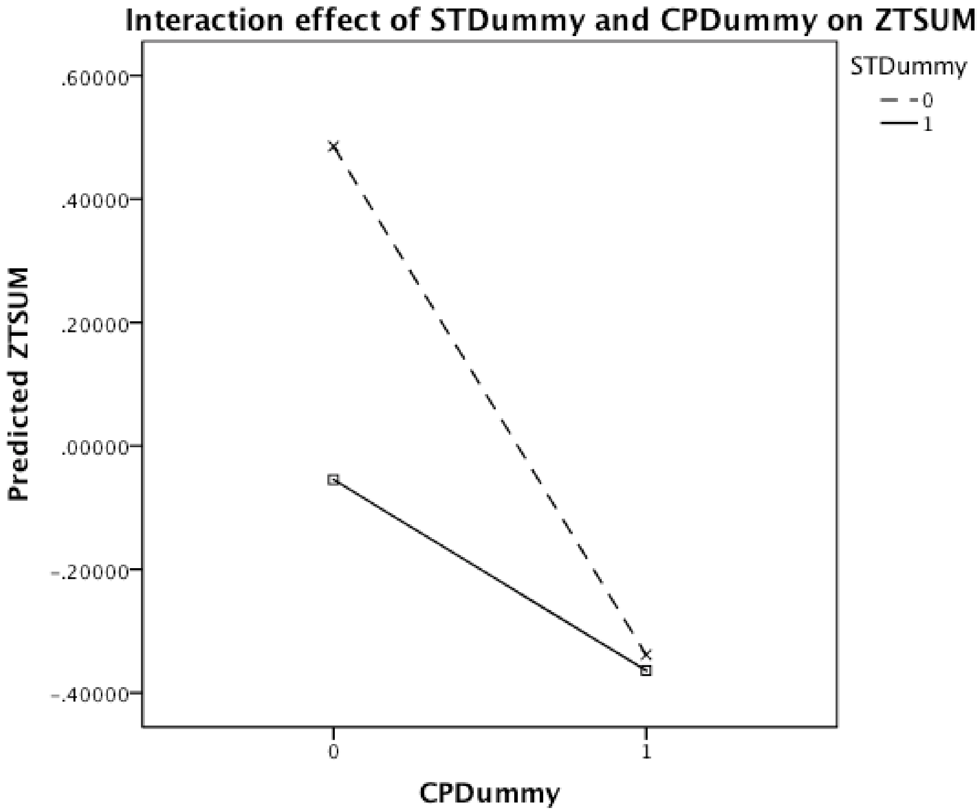
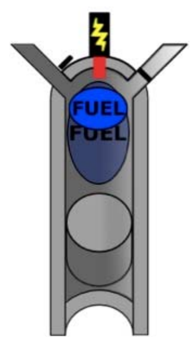


Figure 7: Interaction effect of stereotype threat and cognitive prompts on transfer performance. The separate lines represent the stereotype threat and no stereotype threat conditions. Previous knowledge and education were held constant at their means (*M*=2.12 and *M*=3.80, respectively).

APPENDICES

Appendix A: Internal Combustion Engine Multimedia Presentation

Narration: The cylinder creates energy using a repeating pattern of four strokes. In the first stroke, known as the intake stroke, the fuel valve opens. The piston moves down, reducing the air pressure within the cylinder. Atmospheric pressure from outside forces a mixture of fuel and air into the cylinder.



Narration: In the second stroke, known as the compression stroke, both the fuel valve and exhaust valve are closed. The piston moves up, compressing the mixture of fuel and air so that it burns more efficiently.

Narration: In the third stroke, the spark plug emits a spark. This ignites the fuel, which expands as it burns, forcing the piston back down. This stroke is known as the power stroke, because it creates the power that spins the wheels of the car, as well as the power to move the piston through the other three strokes.

Narration: In the fourth stroke, the exhaust valve opens. The piston moves up, pushing the exhaust out of the cylinder. The process then repeats.

Appendix B: Stereotype Threat Manipulation

Stereotype Threat Condition

Recent research has shown conclusive evidence that memory and mental function decrease with age. While these findings reinforce our most negative conceptions of aging on mental abilities, researchers note that this does not necessarily imply that older adults are unable to function in everyday life. They suggest, however, that in order to maintain adequate levels of functioning, older adults may have to increasingly depend upon the help of memory tools as well as friends and family.

One goal of this study is to examine age differences in memory ability. I am now going to examine your memory ability using a test that has been used extensively by researchers to study aging effects on memory. Younger adults typically do much better than older adults on this task.

No Stereotype Threat Condition

Recent research has begun to call into question the once-common belief that aging is associated with poor memory and mental function. Findings such as these continue to encourage us to rethink our negative conceptions of the effects of aging on mental abilities. Rather than supporting the view that biological changes lead to inevitable losses, these findings suggest that memory loss is largely under control of the environment and the individual.

One goal of this study is to examine individual differences in ability and the factors that account for those differences. I am now going to examine your ability to process verbal information. In an effort to reduce potential biases, we will be using a task that has been shown to be appropriate for individuals of all ages. Interestingly, older adults have been shown to do quite well on this task.

Appendix C: Cognitive Prompts

Which are the main points in your opinion?
Which examples can you think of that illustrate, confirm, or conflict with the learning contents?
Can you create any links between the contents of the presentation and your knowledge from everyday experience?
Which aspects of the learning materials do you find interesting, useful, convincing, and which not?
Which main points have I already understood well?
Which main points haven't I understood yet?
How can I best explain my comprehension problem?
Which questions, in my opinion, were not sufficiently clarified by the presentation?
What possibilities do I have to overcome my comprehension problems?
Which passage of the video should I try to recapitulate in my mind's eye?

Appendix D: Scoring Criteria

TRANSFER 1

What would happen if the engine's spark plug didn't spark?

The fuel would not ignite (1 point)
The fuel would not expand (1 point)
The piston would not move (1 point)
No power would be produced (1 point)

Good (4 points)
If the spark plug didn't spark, the fuel would not ignite. If the fuel didn't ignite, it would not expand, and the piston wouldn't move. So the engine wouldn't produce any power.

Medium (2 points)
If the spark plug didn't spark, the fuel wouldn't ignite and the piston wouldn't move.

Acceptable (1 point)
The fuel wouldn't ignite.

Bad (0 points)
The engine wouldn't work.

TRANSFER 2

Often, internal combustion engines experience problems at high altitudes, where air pressure is substantially lower than at sea level. According to the video, what could be the cause of these problems?

Not as much fuel will enter the cylinder (1 point)
There won't be as much fuel to burn (1 point)
There is less oxygen at higher altitudes, so the fuel won't burn as efficiently (1 point)
The engine won't be as powerful (1 point) (only give them a point for this if they give a reason, i.e., if they mention one of the above answers)

Good (4 points)
Because the outside air pressure is lower, it will not push as much fuel into the cylinder. The engine will not produce as much power because there is less fuel to burn. Also, there is less oxygen at higher altitudes, so the fuel won't burn as efficiently.

Medium (2 points)
Not as much fuel will enter the cylinder so the engine will not be as powerful.

Acceptable (1 point)
Not as much fuel will enter the cylinder.

Bad (0 points)
The engine won't be as powerful.

TRANSFER 3

What could be done to increase the power of the power stroke? List as many ways as you can think of.

More fuel in the cylinder (1 point)
More air in the cylinder (1 point)
More mixture in the cylinder (1 point)
Bigger cylinder (1 point)
Lighter piston (1 point)
More flammable fuel (1 point)
Bigger spark from spark plug (1 point)
A stronger compression stroke could increase how efficiently the fuel burned (1 point)
Better lubrication (1 point)

Good (7 points)
A number of things could be done to increase the power of the power stroke. For instance, more fuel and air could be pushed into the cylinder. A bigger cylinder with a lighter piston could be used. More flammable fuel would increase the power, and so would a bigger spark from the spark plug. A stronger compression stroke would increase how efficiently the fuel burned, and this would make more power, too.

Medium (4 points)
Many things could be done to increase the power of the power stroke, such as getting more fuel and air into the cylinder, using a bigger cylinder, or a more flammable fuel.

Acceptable (2 points)
Pushing more air and fuel into the cylinder would increase the power of the power stroke.

Bad (0 points)
A bigger engine would make more power.

TRANSFER 4

If you wanted to reduce the amount of exhaust created by the power stroke, what could you do? List as many ways as you can think of.

Use a cleaner burning fuel (1 point)
Reduce the amount of fuel in the cylinder (1 point)

Use smaller cylinders (1 point)
Compress the fuel and air more so that the fuel burns more efficiently (1 point)
Increase the spark on the spark plug so that the fuel burns more efficiently (1 point)

Good (5 points)
If you wanted to reduce the amount of exhaust created by the power stroke, you could use a cleaner burning fuel, reduce the amount of fuel in the cylinder, use smaller cylinders, compress the fuel and air more so that they burn more efficiently, or increase the size of the spark from the spark plug so the fuel burns more efficiently.

Medium (3 points)
To reduce the exhaust, you could use a cleaner burning fuel, or use smaller cylinders. You could also use less fuel in the cylinders.

Acceptable (1 point)
You could use a better fuel.

Bad (0 points)
You could use an electric hybrid.

TRANSFER 5

What are the most important properties of the fuel used in a four-stroke engine? List as many as you can think of.

Flammable/ releases energy/ combustible (1 point)
Expands when burns (1 point)
Compressible (1 point)
Burns in air (1 point)
Liquid/ gas (1 point)
Clean/ few impurities (1 point)

Good (5 points)
A good fuel for an internal combustion engine must be flammable, it must burn in air and expand when it burns, it must be compressible, and it must be a liquid or a gas.

Medium (3 points)
A good fuel needs to be flammable in air and be a liquid or gas.

Acceptable (1 point)
The fuel should be flammable.

Bad (0 points)
The fuel should be cheap.

TRANSFER 6

If you were choosing a material to make an engine out of (for example, metal, wood or plastic), what would be the most important properties of that material, and why would those properties be important? Please list as many as you can think of.

Property: Heat resistant/ high melting point (1 point)
Reason: Won't warp/ melt (1 point)

Property: Non-corrosive/ won't rust/ resistant to wear (1 point)
Reason: Lasts longer

Property: Non-flammable (1 point)
Reason: Won't burn when the fuel does (1 point)

Property: Strong / durable (1 point)
Reason: Able to withstand the explosion of the fuel/ pressure in the engine (1 point)

Property: Light (1 point)
Reason: More efficient/ uses less fuel/ better fuel economy (1 point)

Cost/ availability (1 point)

Good (6 points)
The material should be non-flammable, so it doesn't burn when the fuel does. It should also be strong, so it can withstand the pressure in the engine. If the material were also light, it would be more efficient.

Medium (3 points)
The material should be non-flammable, so it doesn't burn when the fuel ignites. It should also be strong, so it doesn't explode.

Acceptable (1 point)
The material should be strong.

Bad (0 points)
You can only use metal to make engines.