INDIVIDUAL DIFFERENCES IN LEARNING AND MEMORY ABILITIES:

THE INFLUENCE OF SELF-EFFICACY

by

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A DISSERTATION

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DISSERTATION ABSTRACT

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The present study examined whether individual differences in memory self-efficacy (MSE)—one's perception and evaluation of their memory abilities—predicts learning and memory ability in a sample of healthy young adults. In three experiments, participants completed a delayed free recall task as well as measures of working memory, episodic long-term memory (LTM), and motivation. Experiment 1 measured global MSE (perceived general memory ability across various memory domains), whereas Experiments 2 and 3 measured concurrent MSE (perceived current memory ability for a specific task one is about to complete). In Experiments 1 and 3, knowledge of strategy effectiveness and use of effective encoding strategies on the delayed free recall task were also measured.

Overall, results revealed global MSE was unrelated to delayed free recall accuracy (our index of learning ability). Concurrent MSE, however, was consistently associated with recall accuracy, insofar that the best performers on the delayed free recall task tended to be individuals who believed they were better capable of learning said task. Follow-up analyses revealed that the strength of this relationship between MSE and learning ability increased with task experience. Moreover, both MSE and overall learning positively correlated with working memory, broad episodic LTM abilities, motivation to perform well, and use of more effective encoding strategies. Critically, though, concurrent MSE (assessed pre-task) did not explain unique variance in learning when accounting for these additional variables. Taken altogether, the present study suggests that concurrent MSE is predictive of learning due to its associations with other meaningful third variables, most of which are cognitive in nature.

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Unsworth, N., Miller, A. L., & Robison, M. K. (2021). No consistent correlation between baseline pupil diameter and cognitive abilities after controlling for confounds—A comment on Tsukahara and Engle (2021). *Cognition*, *215*, 104825.

Unsworth, N., & Miller, A. L. (2021). Individual differences in the intensity and consistency of attention. *Current Directions in Psychological Science*, *30*, 391-400.

Unsworth, N., Miller, A. L., & Robison, M. K. (2021). Are individual differences in attention control related to working memory capacity? A latent variable mega-analysis. *Journal of Experimental Psychology: General, 150,* 1332–1357.

Unsworth, N., Robison, M. K., & Miller, A. L. (2021). Individual differences in lapses of attention: A latent variable analysis. *Journal of Experimental Psychology: General*, *150,* 1303–1331.

Unsworth, N., Miller, A. L., & Robison, M. K. (2021). Is working memory capacity related to baseline pupil diameter? *Psychonomic Bulletin & Review*, *28*, 228-237.

Unsworth, N., & Miller, A. L. (2021). Encoding dynamics in free recall: Examining attention allocation with pupillometry. *Memory & Cognition, 49*, 90-111.

Miller, A. L., & Unsworth, N. (2020). Variation in attention at encoding: Insights from pupillometry and eye gaze fixations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*, 2277-2294.

Robison, M. K., Miller, A. L., & Unsworth, N. (2020). A multi-faceted approach to understanding individual differences in mind-wandering. *Cognition*, *198*, 104078.

Unsworth, N., Miller, A. L., & Robison, M. K. (2020). Individual differences in lapses of sustained attention: Oculometric indicators of intrinsic alertness and preparatory control. *Journal of Experimental Psychology: Human Perception and Performance*, *46*, 569-592.

Miller, A. L., Gross, M. P., & Unsworth, N. (2019). Individual differences in working memory capacity and long-term memory: The influence of intensity of attention at encoding as measured by pupil dilation. *Journal of Memory and Language, 104*, 25-42.

Unsworth, N., Miller, A. L., & Robison, M. K. (2019). Individual differences in encoding strategies and free recall dynamics. *Quarterly Journal of Experimental Psychology, 72,* 2495 – 2508.

Unsworth, N., Robison, M. K., & Miller, A. L. (2019). Individual differences in baseline oculometrics: Examining variation in baseline pupil diameter, spontaneous eye blink rate, and fixation stability. *Cognitive, Affective, & Behavioral Neuroscience, 19*, 1074 – 1093.

Robison, M. K., Miller, A. L., & Unsworth, N. (2019). Examining the effects of probe frequency, response options, and framing within the thought-probe method. *Behavior Research Methods, 51,* 398 – 408.

Miller, A. L., & Unsworth, N. (2018). Individual differences in working memory capacity and search efficiency. *Memory & Cognition*, *46*, 1149-1163.

Robison, M. K., Miller, A. L., & Unsworth, N. (2018). Individual differences in working memory capacity and filtering. *Journal of Experimental Psychology: Human Perception and Performance, 44*, 1038-1053.

Unsworth, N., Robison, M. K., & Miller, A. L. (2018). Pupillary correlates of fluctuations in sustained attention. *Journal of Cognitive Neuroscience, 30*, 1241-1253.

Xu, X., Tupy, S., Robertson, S., Miller, A. L., Correll, D., Nigg, C. R., & Tivis, R. (2018). Successful adherence and retention to daily monitoring of physical activity: Lessons learned. *PLOS ONE*, *13*, e0199839.

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CHAPTER I

INTRODUCTION

Our ability to encode and later retrieve information from long-term memory (LTM) allows us to perform a variety of essential and mundane tasks. Within a given day, we may need to remember an impending deadline at work, where we left our car keys, what our social security number is, our login information to email and social media accounts, and more. Hence our LTM system is one of the most vital aspects of human cognition. Unfortunately, though, everyday memory failures do occur, and some of us find it more difficult than others to remember desired information. And while these memory failures often result in relatively minor effects (e.g., embarrassment from mis-remembering an acquaintance's name or guilt from forgetting a friend's birthday), they can give rise to more adverse consequences. For example, repeatedly forgetting one's anniversary could result in marital strife. Or, a student with poor memory abilities may have pronounced difficulties retrieving information in an academic environment, leading to poor scores on standardized tests or an inability to pass a licensure exam necessary to begin working their intended career. Clearly there is a need to elucidate why some individuals are better able to learn and recall information than others. In doing so, researchers may be more equipped to create interventions that ameliorate memory difficulties for the less able.

Accordingly, researchers have long been interested in examining individual differences in memory processes (Jacobs, 1887). Over the last century, it has become apparent that robust individual differences exist in numerous aspects of LTM, including forgetting, interference control, false memory, testing/retrieval practice (i.e., the testing effect), general retrieval abilities (i.e., retrieval fluency), and strategy use (see Unsworth, 2019 for review). As such, researchers have long sought to understand reasons for which people differ in various facets of LTM. Most of this work has focused on the role of cognitive factors—component processes involved with mental faculties, procedural skills, and knowledge. For example, individual differences in the ability to accurately remember specific experiences from one's past, referred to as episodic memories (Tulving, 2002), has been linked with other important cognitive abilities, including working memory (e.g., Unsworth & Brewer, 2009; Mogle et al., 2008; Shipstead et al., 2014; Unsworth, 2009; Wilhelm et al., 2013), attention control, fluid intelligence, crystalized intelligence (e.g., Hakstian & Cattell, 1974; Underwood et al., 1978; Unsworth, 2010), and processing speed (e.g., Kyllonen et al., 1991; MacDonald et al., 2006; Siedlecki et al., 2005).

In more recent years, we (Miller et al., 2019; Miller & Unsworth, 2020, 2021; Unsworth & Miller, 2021) have further identified two related, yet distinct, aspects of attention that are also important for episodic LTM performance: (1) the ability to consistently keep attention on task rather than off task during learning (i.e., the consistency of attention) and (2) the ability to increase the amount of attention/attentional effort devoted to the to-be-remembered material (i.e., the intensity of attention). And yet, another large portion of existing work has focused on the influence of neural factors (e.g., Kirchhoff, 2009; Kirchhoff & Buckner, 2006; Miller, 2009)—structures in the brain and functioning of those structures. Namely, LTM abilities have been associated with variation in hippocampal volume (e.g., Van Petten, 2004) and medial temporal lobe activity during rest (e.g., Tambini, Ketz, & Davachi, 2010; Wig et al., 2008). Clearly, there are various reasons why people may differ in the ability to learn and remember desirable information.

Despite the abundance of individual differences research in the realm of LTM, little research has examined the role of *conative* factors—variables that largely concern the will or desire to commit a purposeful action—in accounting for these differences. The present set of studies therefore focus on one of these conative variables that is prevalent in the self-regulated learning literature (e.g., Schunk & DiBenedetto, 2020a): self-efficacy. Self-efficacy, first conceptualized by Bandura (1986), is typically defined as one's evaluation of their competence to perform a given task. Note, however, that these beliefs are not simply inert self-appraisals used to predict future performance (Bandura, 1989). Rather, these beliefs ostensibly serve to motivate and regulate courses of action necessary to achieve cognized goals; hence self-efficacy beliefs are self-reflections that are both evaluative and goal oriented (Schunk & DiBenedetto, 2020b).

Self-efficacy has been shown to predict performance outcomes in a variety of domains. For example, a meta-analysis of 114 studies ($N = 21{,}616$) revealed a significant weighted average correlation between self-efficacy and work-related performance ($r = .38$; Stajkovic & Luthans, 1998). Shell and colleagues (1989) demonstrated that self-efficacy significantly predicted reading and writing achievement. Similarly, Zimmerman and Kitsantas (2005) showed self-efficacy for learning predicted academic achievement more broadly (GPA). Given the importance of self-efficacy as a predictor of performance, researchers have long sought to understand the sources of efficacy beliefs. For instance, Berry (1999) proposed a variety of information sources that individuals draw from when judging their ability to complete a given task. These sources include previous task experience (i.e., mastery history); encouragement or ridicule from other people (i.e., social persuasion); observations of the actions of other people (i.e., modeling/vicarious observation); and physiological/mood states (see also Schunk, 2012). Of these information sources, past performance tends to yield the largest and most reliable effects (Bandura, 1997; Berry, 1999).

In terms of mediating processes, self-efficacy seemingly influences performance through a variety of motivational, affective, cognitive, and selection processes (see Bandura, 1993 for more details). For example, people with high self-efficacy set challenging goals and maintain strong commitment to those goals, whereas people with low self-efficacy display weak commitment to the goals they pursue and avoid difficult tasks (Bandura, 1977, 1986). Bandura (1989) asserts that when faced with great challenge, those with low self-efficacy tend to dwell on their personal deficiencies and other worrisome concerns. These concerns, in turn, interfere with "task-related attention" (Elliot & Lachman, 1989, p. 343), leading to decreased effort and a tendency to give up more easily. Indeed, individuals with high self-efficacy are more likely to persist in their efforts and are better able to develop and use effective task strategies than are individuals with low self-efficacy (Bandura, 1989).

The Present Study

Consistent with Bandura's longstanding belief that self-efficacy is a critical feature of task performance, research has demonstrated that higher *memory* self-efficacy—one's perception and evaluation of their memory abilities—is associated with better performance on a variety of LTM tasks (see Bandura, 1989; Beaudoin & Desrichard, 2011; Berry, 1999). Put differently, the best learners tend to feel more competent and confident in their learning and memory abilities. However, a problem with existing research is that the vast majority of these studies have analyzed the efficacy-performance relationship from an aging perspective (Beaudoin & Desrichard, 2011). Older adults tend to believe their memory abilities in general are worse compared to younger adults (Berry et al., 1987, 1989; Cavanaugh & Greene, 1990; Hertzog et al., 1990; West & Berry, 1994), partly due to ageist stereotypes about memory decline (Vallet et al., 2015). Hence most work examining memory self-efficacy (MSE) has focused on the role of MSE as an explanatory factor for age-related declines in episodic memory. It remains unclear whether robust individual differences in MSE exist within healthy young adults and whether these differences explain variation in learning abilities within said age group. Thus, the first major aim of the present study was relatively straightforward insofar that we sought to directly test this notion.

Although the relationship between self-efficacy and performance in the memory domain is well documented, far less is known about *why* MSE predicts actual memory performance. The present study therefore sought to examine potential interrelations between MSE and other crucial variables known to consistently predict learning and memory performance. Namely, prior work suggests that the best performers on episodic LTM tasks tend to be individuals who use more effective encoding strategies (e.g., Bailey, Dunlosky, & Kane, 2008; Miller & Unsworth, 2020; Unsworth, 2016), are highly motivated to perform well (Miller & Unsworth, 2021), and have better working memory abilities (Unsworth & Brewer, 2009; Miller et al., 2019; Mogle et al., 2008; Shipstead et al., 2014; Unsworth, 2009; Wilhelm et al., 2013). Coincidentally, each of the above-mentioned variables has also been associated with MSE. For example, in accord with

Bandura’s (1977, 1986, 1989, 1993) theorizing, Berry and colleagues (1994) found a positive correlation between MSE and self-reported strategy use. Using path analytic techniques, strategy use explained the recall-MSE relationship. Positive correlations have also been observed between self-efficacy and intrinsic motivation (as well as achievement motivation) in a variety of domains (e.g., Hwang & Yi, 2002; Liang & Chang, 2014; Walker, Greene, & Mansell, 2006, Yusuf, 2011)[1], but research within the realm of LTM has yet to address these possible links. Finally, while individuals tend to both under- and over-estimate their abilities (e.g., Bandura, 1989), more recent research demonstrates that individuals who have high MSE tend to be individuals who display better working memory (Beaudoin & Desrichard, 2017; Otsuka & Miyatani, 2020). Such a correlation suggests that performance on similar, complex cognitive tasks may be one way by which previous experience is used to judge broader memory competencies (see Berry, 1999; Bandura, 1993, Hertzog et al., 1990).

Taken altogether, prior research suggests that the best performers on measures of episodic LTM tend to be individuals who believe they are better capable of learning (relative to the worst performers). However, as alluded to above, this work is largely confounded with age, and individual differences research concerning MSE is still in its infancy. Most existing research has failed to comprehensively examine the interrelations between MSE and other theoretically meaningful third variables. This is problematic because relying on a single variable or two to predict learning outcomes produces a narrowly defined learning construct. That is, most constructs have numerous underlying

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[1] Locke and Schattke (2019) define intrinsic motivation as liking a task simply because the activity brings one pleasure, which is seemingly distinct from achievement motivation (i.e., wanting to perform well and be successful on a task) and extrinsic motivation (i.e., doing something as a means to an end).

influences—some of which may explain variance accounted for by the single construct in question. Thus, if only a single predictor is under consideration, there is no way to determine whether learning-related differences in MSE are distinct from learning-related differences in another construct. This is why regression analyses consisting of multiple predictors are critical.

It seems possible that the positive correlation between MSE and learning ability may be entirely due to its shared variance with strategy use, motivation, and working memory. In other words, it remains unclear if MSE continues to explain differences in the ability to learn and remember information when controlling for the influence of these additional important predictors. As such, the present study conducted a series of individual differences experiments with three overarching aims. First, we sought to examine whether the best learners—in a sample of healthy, young adults—tend to be individuals who are more efficacious. Second, if such a relation exists, we wanted to better understand the possible reasons *why* MSE is associated with actual performance. Third, we set out to examine whether self-efficacy would continue to uniquely predict learning and memory performance when taking cognitive factors (e.g., working memory, strategy use) and other important conative variables (e.g., motivation to perform well) into account. To address these questions, participants in three experiments (*N*'s = 137, 139, and 168) completed a delayed free recall task. Measures of working memory, broad episodic LTM abilities, motivation, encoding strategy use, and knowledge of strategy effectiveness were also included. Assessing individual differences in MSE during learning in conjunction with other important variables will allow us to better understand the nature of how conative factors like self-efficacy may support successful learning.

CHAPTER II

EXPERIMENT 1: GLOBAL MEMORY SELF-EFFICACY

A relatively recent meta-analysis reported a small significant weighted mean correlation between MSE and actual memory performance (*r* = .15, Beaudoin & Desrichard, 2011). However, the strength of the relationship between MSE and performance appeared to depend on several factors. Specifically, correlations between self-efficacy and memory performance seem to be largest when the criterion task requires high levels of controlled processing (i.e., when task demands are high). For example, correlations with MSE are stronger when memory performance is assessed with free recall and cued recall paradigms relative to recognition paradigms. Another important factor to consider in the MSE-performance relationship is the specificity of the MSE judgement being assessed. MSE judgments can be thought of as a continuum, ranging from global MSE to concurrent MSE. Global MSE refers to one's perceived general memory ability across various memory domains and situations, whereas concurrent MSE refers to perceived, current memory ability for a task one is about to complete—often referred to as "task-specific self-confidence" (Bandura, 1986). Hence concurrent MSE is specific to both the context in which a task is to be performed and the task itself. This distinction between global and concurrent MSE estimates is important because a recent meta-analysis (Beaudoin & Desrichard, 2011) indicated that concurrent measures more strongly relate to actual memory performance than do global measures.

Critically, Beaudoin and Desrichard (2011) further revealed that the moderating influence of MSE specificity (on memory performance) varied as a function of age (see Table 3). Unfortunately, the authors did not elaborate upon this finding. That said, it is widely accepted that aging is associated with impaired memory (e.g., Craik, 2000; Salthouse, 1991); so reduced MSE among older adults ostensibly reflects an awareness of actual lack of ability. Yet ageist stereotypes likely play a role in reinforcing these beliefs (Cavanauh & Greene, 1990; West & Berry, 1994). Given the saliency of these concerns, it seems possible that global MSE may more strongly impact memory performance for older adults than younger adults (Berry, 1999; West et al., 2009). In other words, younger adults are likely less consumed with worrisome thoughts related to impaired general memory functioning (relative to older adults). Hence younger adults may rely less on perceived, broad memory abilities when completing a specific memory task (Beaudoin & Desrichard, 2011)

Accordingly, our first goal was to examine whether *global* MSE judgments are associated with learning and memory ability within a sample of healthy, young adults. To do so, we will examine zero-order correlations between overall delayed free recall accuracy and a global MSE factor composite made up of scores from two commonly used measures of global MSE. Hertzog and colleagues (2007) demonstrated a significant positive correlation ($r = .20$) between overall recall accuracy (on a paired associates cued recall task) and global MSE when using a similar composite variable comprised of scores from the same two measures used in the present study. Since Hertzog et al. examined these relations among a wide age range (age range 26 to 83), we merely sought to examine whether a similar positive correlation would arise here when using a young adult sample (age range 18 to 35).

Our second goal was to understand possible reasons for which highly efficacious people tend to perform better on learning and memory tasks. If no positive correlation arises between global MSE and overall recall performance, then we merely sought to better understand between-subject variation in learning abilities and global MSE, independent of each other. To this aim, we will assess all zero-order correlations concerning global MSE as well as all zero-order correlations concerning mean delayed free recall accuracy (our index of learning ability). In terms of global MSE, we expected increased MSE to be associated with use of more effective encoding strategies, consistent with prior research (Berry & West, 1993; Berry et al., 1994; Hertzog et al., 2007). The remaining correlations, however, were more exploratory in nature. For instance, no research has reported a correlation between strategy knowledge and MSE. Yet we suspected that people who are more knowledgeable of effective encoding strategies may report an increased sense of competence in their own general memory abilities (i.e., if one knows which tactics are most effective for better remembering, then they may believe they are better capable of remembering; see Pearman et al., 2020).

Similarly, despite research long suggesting that general cognitive abilities may serve as a source of information by which self-efficacy beliefs are based upon (e.g., Garland, 1985; Locke & Latham, 1990), very little empirical research has been devoted to the matter[2]. A few studies (Beaudoin & Desrichard, 2017; Caldeira de Carvalho et al., 2002; Otsuka & Miyatani, 2020) have reported a positive correlation between working memory performance and global MSE, but clearly more evidence is needed. Relatedly, no research has reported a correlation between motivation to perform well (achievement motivation) on a specific memory task and global MSE. That said, Kanfer and colleagues

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[2] Such an account assumes that individuals with low cognitive abilities are aware of past experiences in which they performed poorly on complex mental tasks. Thus, in being aware of other cognitive limitations, low ability individuals may generalize those beliefs to memory functioning.

(2017) suggest that person-based motivation variables (e.g., intrinsic motivation, achievement motivation, goal orientation) primarily influence performance indirectly through process-based motivational factors (e.g., self-efficacy, resource allocation). This notion suggests that individuals who are more inclined to desire a high level of performance on the delayed free recall task may tend to be people who also report being more confident in their general memory abilities. In terms of correlations with overall recall accuracy, we expected the best performers on the delayed free recall task to be those who display better working memory (e.g., Unsworth, 2016), use more effective encoding strategies (e.g., Bailey et al., 2008), report increased knowledge of which encoding strategies are most effective (e.g., Hertzog & Dunlosky, 2006; Price, Hertzog, & Dunlosky, 2008), and report increased motivation to perform well (e.g., Miller & Unsworth, 2021).

If a positive correlation between global MSE and learning ability (mean recall accuracy) arises, our final goal was to assess whether global MSE uniquely predicts learning in a simultaneous regression when accounting for each of the above-mentioned associations. Note measures of general episodic LTM abilities were also administered and included in the present study. These measures were included to control for the influence of broad episodic LTM abilities independent of delayed free recall, because (1) considerable and robust individual differences exist in free recall abilities (Unsworth, 2019); (2) general episodic LTM abilities explain substantial variance in free recall performance (e.g., see Experiment 2 in Miller et al., 2019); and (3) a recent study demonstrated that global MSE was associated with broad episodic LTM abilities independent of the criterion task (Beaudoin & Desrichard, 2017). If global MSE continues to uniquely predict delayed free recall accuracy when controlling for the influence of these other meaningful variables (including general episodic LTM abilities), then we can be more confident in the notion that high efficaciousness plays an important, distinct role in explaining successful learning among young adults. Given "interindividual differences are rarely considered in studies of the MSE-performance relationship" (Beaudoin & Desrichard, 2011, p. 234), we had no explicit hypothesis for this aim.

Methods

Participants and Procedure

A total of 146 participants (61% female) were recruited from the human subject pool at the University of Oregon. Two participants were excluded for being over the age of 35. All other participants were between the ages of 18 and 34 (*M* = 19.68, *SD* = 2.04) and were proficient English speakers. All participants were also awarded course research credit for participation. After obtaining informed consent and demographic information, participants completed three measures of working memory: the operation span task (Ospan), the symmetry span task (Symspan), and the reading span task (Rspan). Upon completion of the working memory tasks, participants were then administered a delayed free recall task that ended with the appearance of a strategy report questionnaire, which was followed by a strategy knowledge questionnaire. After the strategy knowledge questionnaire, participants completed two global MSE questionnaires: The Personal Beliefs about Memory Instrument: Specific Memory Ability Scale (Lineweaver & Hertzog, 1998) and the Memory Controllability Inventory: Present Ability Subscale (Lachman, Bandura, Weaver, & Elliot, 1995). Participants were then asked to report how motivated they were to do well on the delayed free recall task. Finally, participants completed a paired associates (PA) cued recall task, followed by a picture source (PicSource) recognition task. Two participants were excluded due to being outliers on the PicSource (i.e., recall accuracy was below 10%), two other participants were excluded for being outliers on the Specific Memory Ability Scale (i.e., response average was below 10%), and 5 additional participants were excluded for not recalling a single word on any of the PA cued recall lists (final $N = 137$). Of note, participants completed the tasks reported herein as part of a larger experimental test battery lasting approximately 2 hours. Since the other tasks and questionnaires administered during the experimental session do not relate to the current study, they are not reported.

Working Memory Tasks

Operation Span. Participants solved a series of elementary math problems while remembering unrelated letters. First, on computer participants were presented with a math operation (e.g., (4 x 1) + 2 =?) in which they had to click the mouse to indicate that they had solved the problem. A new screen then appeared with an answer to the math solution (e.g., 6), whereby participants had to indicate if the answer listed onscreen was correct of incorrect via mouse click (e.g., in the case above, the answer 6 would be correct). Upon completion of the math operation, participants were then presented with a letter (i.e., F, H, J, K, L, N, P, Q, R, S, T, and Y) for 1 second. Immediately following letter presentation, the next math problem was presented. Set sizes varied randomly from 3 to 7 math operation/letter strings, and participants had to complete 2 trials of each set size for a total possible score of 50. At recall for each set, letters from the corresponding set had to be recalled in order by selecting the relevant letters. See Unsworth, Heitz, Schrock, & Engle (2005) for more details.

Symmetry Span. Participants solved symmetry judgements while remembering the location of a sequence of red squares within a matrix. Symmetry judgements consisted of an 8 x 8 matrix of squares in which some of the squares were filled black and the remaining squares remained white. Participants indicated whether the pattern created by the filled squares was symmetrical about the vertical axis. Once participants indicated whether they believed the pattern was symmetrical or non-symmetrical, participants were shown a 4 x 4 matrix with one of the cells filled red for 650 ms. Immediately following the presentation of the red square matrix, the next symmetry judgement trial began. Set sizes randomly ranged from 2 to 5, and there were 2 trials of each set size for a total possible score of 28. Participants were asked to recall the sequence of red-square locations based on the order in which they were presented across the corresponding trial. Participants indicated the appropriate location of each red-square by clicking on cells in an empty matrix. See Unsworth, Redick, Heitz, Broadway, & Engle (2009) for more details.

Reading Span. While remembering the same unrelated letters as in the Ospan, participants provided judgements about a series of sentences. More specifically, participants read a sentence containing 10 to 15 words and determined whether or not the sentence made sense to them (e.g., “Every now and then I catch myself swimming blankly at the wall”). Nonsense sentences were created by modifying a single word from an otherwise ordinary sentence (e.g., changing “staring” to “swimming” in the case above). Upon indicating whether the sentence made sense or not, participants were then presented with a letter for 1 second. Set sizes randomly varied from 3 to 7 sentence/letter strings, and participants had to complete 2 trials of each set size for a total possible score of 50. At recall for each set, letters from the corresponding set had to be recalled in order by selecting the appropriate letters. See Unsworth et al. (2009) for more details.

Factor Working Memory Score. All complex span tasks showed large inter-correlations: Ospan correlated with Rspan ($r = .62, p < .001$) and Symspan ($r = .37, p < .001$). Rspan correlated with Symspan ($r = .39, p < .001$). All analyses involving working memory therefore used a working memory factor score created for each participant by entering scores on the three complex span measures into a factor analysis using principal axis factoring. Factor loadings for the first unrotated factor were as follows: Ospan (0.76), Symspan (0.49), and Rspan (0.82). This variable allowed us to treat working memory as a continuous variable in all analyses.

Long-Term Memory Tasks

Paired Associates Cued Recall. Participants were administered 3 lists of 30 word-pairs each. Word-pair lists were composed of randomized common nouns selected from the Toronto word pool (Friendly et al., 1982), and all words were between 3 and 6 letters in length. The task began with a “Ready?” signal onscreen, at which point participants pressed the spacebar to begin. Each list began with the same “Ready?” signal. Word pairs were preceded and followed by a blank screen onscreen for 500 ms, and word-pairs were presented vertically for 2 seconds each. All word pairs were associatively and semantically unrelated. Participants were told that the cue would always be the word on top and the target would be on the bottom. After the presentation of the last word pair, participants saw the cue word and ??? in place of the target word. Participants were instructed to type in the target word from the current list that matched cue. Consistent with prior work similarly administering long word-pair lists (e.g., Bailey et al., 2008), cues for the corresponding target words were presented in the same order at recall as they were presented during the encoding phase. Participants had 5 seconds to type in the corresponding word. A participant's score was the proportion of items recalled correctly (i.e., mean recall accuracy).

Picture Source Recognition. During the encoding phase, participants were presented with a picture (30 total pictures) in one of four different quadrants onscreen for 1 second. Participants were explicitly instructed to pay attention to both the picture (item) as well as the quadrant it was located in (source). At test, participants were presented with 30 old and 30 new pictures in the center of the screen. Participants were required to indicate if the picture was new or if it was old. If the picture was deemed old, they also had to specify what quadrant the picture was presented in via key press. Thus, on each test trial participants pressed one of five keys indicating new, old-top left, old-top right, old-bottom left, or old-bottom right. Participants had 5 seconds to press the appropriate key to enter their response. A participant's score was the proportion of correct responses (i.e., mean recall accuracy).

Factor Long-Term Memory Score. Given our interest in examining LTM ability common to various episodic memory tasks—not just free recall—we used the paired associates and source memory tasks to create an episodic LTM factor composite. Consistent with prior work (e.g., Miller et al., 2019), scores on these two tasks were correlated ($r = .35$, $p < .001$) and entered into a factor analysis using principal axis factoring to create a LTM factor score for each participant. The factor loadings for the first unrotated factor were as follows: PA cued recall (0.59) and PicSource (0.59).

Delayed Free Recall

Participants were administered a delayed free recall task that began with 2 practice lists, each containing 10 to-be-remembered *letters*. The real trials consisted of 5 lists, each containing 10 to-be-remembered *words*. Word lists were initially composed of randomized nouns selected from the Toronto word pool (Friendly et al., 1982). All participants received the same lists of words and were instructed to recall as many words as possible from each list. Words were presented onscreen for 1 second, with each word preceded and followed by a 500 ms blank screen. Following presentation of the last word within each list, a 16 second distractor task began that required participants to verbally report a series of 8 three-digit numbers in descending order (adapted from Rohrer & Wixted, 1994). Each 3-digit string was presented onscreen for 2 seconds. After the distractor task, 3 question marks appeared in the center of the screen to prompt participants to recall as many words as possible within a 45 second window. Participants typed their responses in any order they wished and pressed "enter" after each word, thereby clearing the screen. A participant's score was the proportion of items recalled correctly (i.e., mean recall accuracy).

Strategy Use Questionnaire. Upon completion of the last delayed free recall list, participants reported on computer whether or not they used any encoding strategies to help better remember the words. Specifically, participants were shown the following options: (1) Read each word as it appeared, (2) Repeated the words as much as possible, (3) Used a sentence to link the words together, (4) Developed mental images of the words, (5) Grouped the words in a meaningful way, and (6) Did something else. Participants responded by typing their answers and were allowed to select more than one strategy. This strategy report questionnaire was based on similar reports used by Bailey et al. (2008) and Unsworth (2016). Thus, ineffective strategies were characterized as passive reading and rehearsal, whereas effective strategies were characterized as interactive imagery, sentence generation, and grouping. Consistent with this work (Bailey et al., 2008, 2009; Dunlosky & Kane, 2007; Unsworth, 2016), the "other" strategy category was excluded from our analyses because no a priori hypotheses were made as to whether these strategies would be more or less effective.

Strategy Knowledge Questionnaire. We next administered a modified version of the Personal Encoding Preferences questionnaire (Hertzog & Dunlosky, 2004) to measure perceived encoding strategy effectiveness. The Personal Encoding Preferences questionnaire defines various types of encoding strategies with examples. Since this questionnaire has primarily been used in the context of associative learning paradigms, we adapted examples of each strategy so that they were more relevant to delayed free recall. For instance, participants read the following when asked to rate the effectiveness of the sentence generation strategy for learning lists of words: *"Sentence generation: Constructing a sentence to link the words together. If the words 'clown' and 'paper' are presented within a list, an example would be 'the clown wore a paper hat'."* Participants rated the effectiveness of each strategy on a 10-point Likert scale, with 1 being the least effective and 10 being the most effective. Using respondents' ratings, we computed a strategy knowledge index: the average difference between ratings for normatively effective strategies (e.g., interactive imagery, sentence generation, and semantic reference) and normatively less effective strategies (e.g., rote repetition, attentive reading, and focal attention).

Global Memory Self-Efficacy. In accordance with the framework described by Beaudoin and Desrichard (2011), participants completed two questionnaires commonly used to measure global MSE. The first questionnaire was the Personal Beliefs about Memory Instrument (PMBI): Specific Memory Ability Scale (Lineweaver & Hertzog, 1998). This questionnaire asks participants to rate their general memory ability across various aspects of memory (e.g., remembering names, faces, appointments, word meanings, etc.) on a scale of 1 (very poor) to 100 (very good). Participants' ratings across all 24 items were averaged to compute a PMBI score. The second questionnaire was the Memory Controllability Inventory (MCI): Present Ability Subscale (Lachman et al., 1995), which consisted of the following three items: (1) I can remember the things I need to; (2) I'm not good at remembering things (reverse coded); and (3) I can't remember things, even if I want to (reverse coded). Participants' ratings (on a 7-point scale) across the three items were averaged to compute an MCI score. Scores on the PMBI were significantly positively correlated with scores on the MCI ($r = .51, p < .001$). So, consistent with prior work (Hertzog et al., 2007), scores on these two tasks were entered into a factor analysis using principal axis factoring to create a global MSE factor score for each participant. The factor loadings for the first unrotated factor were as follows: PMBI: Specific Memory Ability Scale (0.71) and MCI: Present Ability Subscale (0.71).

Motivation. Upon completion of the delayed free recall task, participants were asked about their motivation during the task (Miller & Unsworth, 2021; Robison & Unsworth, 2018; Robison et al., 2020; Unsworth & McMillan, 2013). Specifically, participants were asked, “How motivated were you to perform well on the task?” Participants responded using a 6-point scale (1 = “Not at all motivated”; 6 = “Extremely motivated”).

Results and Discussion

As demonstrated in Table 1, all measures demonstrated adequate variability around the mean. Assessments of skew and kurtosis were also within acceptable ranges (i.e., skewness < 2; kurtosis < 4; Kline, 2016), suggesting all measures were approximately normally distributed. Reliability estimates were likewise satisfactory. Shown in Table 2 are the zero-order correlations between all measures—our primary analyses of interest[3]. First, we focus on the correlation between global MSE and overall delayed free recall accuracy, our index of learning ability. Table 2 reveals that global MSE was not associated with individual differences in overall recall accuracy in our young adult sample ($r = .04$, $BF_{01} = 8.28$). This result is at odds with Hertzog et al. (2007), who detected a correlation of $r = .20$ when examining the relationship between cued recall accuracy and a similar global MSE composite variable. However, it is important to point out that the present study would be underpowered to detect an effect of this magnitude (with $N = 132$, the present study would only have 64% power to detect an $r = .20$). Nevertheless, the present study suggests that, within a sample of healthy young adults, global MSE does not appear to play an important role in explaining which individuals best learn and remember information in conditions of delayed free recall.

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[3] All correlations throughout the manuscript examine the full usable sample, in which each participant contributed one observation for each variable in the analysis. In cases where there was missing data, pair-wise deletion was used.

Table 1

Descriptive Statistics and Reliability Estimates for all Measures in Experiment 1

Measure	*N*	*M*	*SD*	Skew	Kurtosis	Reliability
Ospan	129	36.59	8.96	-.94	.79	.72
Rspan	132	34.81	8.76	-.61	-.03	.70
Symspan	131	18.94	4.96	-.22	-.27	.55
DFRacc	133	.45	.17	.67	.58	.84
PAacc	135	.24	.20	1.10	.67	.83
PicSource	127	.71	.20	-.94	.27	.95
PMBI	133	72.85	11.80	-.57	.04	.92
MCI	132	4.82	1.34	-.58	-.22	.77
Motivation	132	4.42	1.19	-1.01	1.23	
StratKnow	133	2.26	2.33	-.29	-.16	
EffectiveUse	133	.40	.32	.28	-.91	

Note. Due to program or experimenter error, some tasks are missing data. Ospan = operation span; Rspan = reading span; Symspan = symmetry span; DFRacc = delayed free recall accuracy; PAacc = paired associates cued recall accuracy; PicSource = picture source recognition accuracy; PMBI = mean rating across all items of the PMBI: Specific Memory Ability subscale; MCI = mean rating across all items of the MCI: Present Ability subscale; Motivation = post-task self-reported motivation; StratKnow = strategy knowledge index (i.e., average difference between ratings for normatively effective strategies and normatively less effective strategies); EffectiveUse = proportion of effective strategies used. All reliabilities were calculated using Cronbach's Alpha.

While global MSE was unrelated to overall recall accuracy, we next sought to better understand individual differences in global MSE more generally. Table 2 shows that global MSE was unrelated to all the other variables of interest (all *rs* < .12, all *ps* > .18). In terms of individual differences in learning abilities, Table 2 further demonstrates a variety of variables other than global MSE were associated with performance. Specifically, individuals who best learned the delayed free recall task (i.e., those with the best recall accuracy) tended to, not only perform better on other episodic LTM tasks (*r* = .57), but they also tended to have better working memory abilities (*r* = .34)—consistent with prior research (e.g., Unsworth & Brewer, 2009; Miller et al., 2019; Unsworth, 2019). Those with superior performance on the delayed free recall task also appeared to report increased knowledge of which encoding strategies are most effective (*r* = .28) and report the use of more effective encoding strategies (*r* = .32), replicating previous research (Bailey et al., 2008; Hertzog & Dunlosky, 2006; Price et al., 2008; Unsworth, 2016). Finally, the best performers tended to be individuals who reported being more motivated to perform well on the delayed free recall task, a result similar to those of a recent study examining individual differences in associative learning abilities (Miller & Unsworth, 2021).

Table 2

Correlations Among all Measures in Experiment 1

Measure	1	2	3	4	5	6	7
(1) DFRacc	–						
(2) WM	$.34^{***}$	–					
(3) LTM	$.57^{***}$	$.25^{**}$	–				
(4) GlobalMSE	.04	.02	.04	–			
(5) Motivation	$.33^{***}$	.04	$.29^{***}$	-.02	–		
(6) StratKnow	$.28^{**}$	-.08	.17	.03	$.24^{**}$	–	
(7) EffectiveUse	$.32^{***}$	.04	$.25^{**}$	.12	$.31^{***}$	$.29^{***}$	–

Note. * p <.05, ** p <.01, *** p <.001; DFRacc = mean delayed free recall accuracy; WM = working memory factor composite; LTM = episodic long-term memory ability factor composite; GlobalMSE = global memory self-efficacy factor composite; Motivation = post-task self-reported motivation; StratKnow = strategy knowledge index; EffectiveUse = proportion of effective strategies used.

Collectively, the results of Experiment 1 (Chapter 2) suggest that global MSE—an individual's sense of competence in their overall memory abilities (across a variety of memory domains)—was not predictive of delayed free recall performance among a sample of young adults. While superior free recall accuracy was associated with better working memory, better performance on other episodic LTM tasks, increased motivation to perform well, increased knowledge of which learning strategies are most effective, and use of more effective encoding strategies, global MSE did not significantly correlate with any of these variables. Most of these interrelations were exploratory in nature, but the lack of a relationship between global MSE and effective strategy was unexpected given the notions put forth by self-efficacy theory (Bandura, 1986), and two other studies have documented a positive correlation between global MSE and strategy use (Berry et al., 1994; Hertzog et al., 2007)[4].

That said, both prior studies examined the MSE-performance and MSE-strategy use relationships in samples comprised of older adults. This suggests that, while global MSE does not seem to be associated with other meaningful predictors of learning (and performance itself) within a sample of healthy young adults, global MSE may still play a role in explaining age-related difficulties in learning and memory abilities. Indeed, considering the salience of everyday memory failures among the elderly (whether it be due to actual lack of ability or beliefs perpetuated by society), it seems possible that the impact of global MSE on performance may be larger for older adults than younger adults (Beaudoin & Desrichard, 2011).

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[4] Note that the association between global MSE and use of spontaneous encoding strategies is not always found (Beaudoin & Desrichard, 2017; Hertzog et al., 1998, 2010). In each of these studies, however, encoding strategies were assessed via open-ended questions following task completion (responses were coded by experimenters).

CHAPTER III

EXPERIMENT 2: CONCURRENT MEMORY SELF-EFFICACY

The prior chapter suggests that *global* MSE was not predictive of one's ability to learn and remember information in conditions of delayed free recall, at least within a sample of healthy young adults. But, as previously mentioned, *concurrent* MSE judgments seem to correlate with memory performance more strongly than global MSE judgements (Beaudoin & Desrichard, 2011). Therefore, the first aim of Chapter 3 (Experiment 2) was to examine whether concurrent MSE—perceived, current memory ability for a task one is about to complete—is associated with enhanced delayed free recall performance within a young adult sample. To do so, we will first examine zero-order correlations between memory predictions, a commonly used measure of concurrent MSE, and overall delayed free recall accuracy. Given (1) the null relation observed between global MSE and performance in Experiment 1, and (2) previous research suggests the effect of MSE specificity on performance depends on age (Beaudoin & Desrichard, 2011, see Table 3), we reasoned that the effect of concurrent MSE on performance—among young adults—may be more similar to the effect observed in older adults. Thus, we expected to find a positive correlation between memory predictions and recall accuracy in the present study, consistent with prior work examining these relations with older samples (e.g., ages 20-79, Herzog et al., 1990).

Note previous research (Bandura & Wood, 1989) further suggests that self-efficacy plays an increasingly important role in performance across the duration of a task; hence our second goal was to examine whether the strength of the MSE-performance relationship changes as a function of task experience. Theoretically, when discrepancies between one's current level of performance and their performance standard are detected, a series of negative self-reactions (dissatisfaction) occur (Kanfer, 1990). Thus, a person who struggles to learn may become increasingly frustrated in their performance, which may lead to discouragement in their abilities (i.e., reduced MSE). This reduction in MSE presumably results in lower effort expenditure and lower performance over trials (Bandura, 1986). Accordingly, self-efficacy judgments are also partially determined by past performance. As individuals gain task experience, individuals become more accurate in assessing their abilities through active performance monitoring (e.g., Hertzog & Dunlosky, 2004; Lineweaver & Hertzog, 1998). This assertion is based on the “upgrading effect”, whereby MSE judgements made at the end of a task correlate more strongly with performance than do MSE judgments made at the beginning of a task (Hertzog et al., 1990, 1994; West et al., 1996). Therefore, memory performance and concurrent MSE have a reciprocal impact on one another (Bandura, 1997). Regardless of the directionality of the MSE-performance relationship, though, the self-reaction and performance monitoring accounts both suggest that the strength of the correlation between concurrent MSE and recall accuracy should increase across lists. To test this hypothesis, we will submit memory predictions (concurrent MSE) to a repeated measures ANOVA with list as a within-subjects factor and mean recall accuracy (learning ability) as a covariate. The presence of an interaction between recall accuracy and list would lend support for this hypothesis.

If the best learners tend to display more confidence in their memory capabilities specific to the task at hand, the third goal of Experiment 2 was to understand *why* such a relationship exists. To this aim, we will again assess all zero-order correlations concerning concurrent MSE and overall recall accuracy. With respect to individual differences in learning, we anticipated similar results to Experiment 1 (Chapter 2). Overall recall accuracy should positively correlate with working memory, general episodic LTM abilities, and motivation (strategy use and strategy knowledge were not assessed due to time constraints). In terms of concurrent MSE, we expected a positive correlation to arise with motivation to perform well on the delayed free recall task. As previously mentioned, Kanfer and colleagues (2017) suggest that person-based motivational variables (e.g., intrinsic motivation, achievement motivation) largely influence performance indirectly through processes involved in goal choice and goal striving (e.g., expected value, self-efficacy, resource allocation). Thus, at an individual differences level, those who care less about performing well on a given memory task should tend to be individuals who perceive themselves as being less capable of performing well on said memory task. Considering no research, to date, has reported a correlation between concurrent MSE and working memory, we didn't have any explicit hypothesis for this relationship. But based on the logic outlined in Experiment 1, a positive correlation seemed plausible—so long as one were to assume that previous performance on measures of other complex cognitive abilities may serve as a source of information by which concurrent MSE beliefs are based upon (e.g., Garland, 1985; Locke & Latham, 1990).

Finally, like the prior chapter, the fourth aim of Experiment 2 (Chapter 3) was to assess whether concurrent MSE uniquely predicts overall learning ability (mean recall accuracy) when entered into a simultaneous regression with working memory, general episodic LTM abilities, and motivation as additional predictors. Since cognitive abilities and other relevant variables are often not controlled for when MSE is used as a predictor of memory performance, we had no explicit hypothesis for this aim. Furthermore, we should note that, given people rely heavily on previous performance in judging their future competencies (Bandura, 1993), we opted to use pre-task estimates of concurrent MSE (performance predictions made before beginning the task) as the dependent variable in all individual differences analyses. Pre-task MSE judgments are not confounded with prior performance and active performance monitoring (people have not yet been exposed to task stimuli) and thus provide the best test of what role efficacy *beliefs* may play in learning.

Methods

Participants and Procedure

A total of 145 participants (47.5% female) were recruited from the human subject pool at the University of Oregon. One participant was excluded for being over the age of 35. All other participants were between the ages of 18 and 29 (*M* = 19.83, *SD* = 1.78), were proficient English speakers, and were awarded course research credit for participation. After obtaining informed consent and demographic information, all participants completed the same three measures of working memory described in Experiment 1. Participants were then administered a delayed free recall task, during which concurrent MSE was assessed via a series of performance predictions. Upon completion of the delayed free recall task, participants were asked to report how motivated they were to do well on the delayed free recall task. Finally, participants completed a PA cued recall task, followed by a PicSource recognition task. Four participants were excluded for not recalling a single word on any of the PA cued recall lists, and another participant was excluded for not recalling a single word on any of the delayed free recall lists (final $N = 139$). The tasks reported herein were again part of a larger experimental test battery lasting approximately 2 hours. Since the other tasks administered during the experimental session do not relate to the current study, they are not reported.

Working Memory Tasks

Same as Experiment 1. Ospan correlated with Rspan ($r = .68$, $p < .001$) and Symspan ($r = .40$, $p < .001$). Rspan also correlated with Symspan ($r = .36$, $p < .001$). All analyses involving working memory used a working memory factor score created for each participant by entering scores on the three complex span measures into a factor analysis using principal axis factoring. Factor loadings for the first unrotated factor were as follows: Ospan (.88), Symspan (.46), and Rspan (.77).

Long-Term Memory Tasks

Same as Experiment 1, except the PA cued recall task now consisted of three lists, each containing 10 word-pairs each (as opposed to 30 word-pairs each). Mean accuracy on PA cued recall and PicSource were correlated ($r = .35$, $p < .001$), so we created a LTM factor score for each participant by entering their scores into a factor analysis using principal axis factoring. The factor loadings for the first unrotated factor were as follows: PA cued recall (0.59) and PicSource (0.59).

Delayed Free Recall

Same as Experiment 1.

Concurrent Memory Self-Efficacy. After completing the two practice lists with 10 to-be-remembered letters (i.e., before beginning the first list of the real trials), participants were asked “If presented with a list of 10 words, how many words do you think you’ll remember?”. This question was repeated for each upcoming list on the delayed free recall task, yielding five total performance predictions—a commonly used metric of concurrent MSE (Beaudoin & Desrichard, 2011). Ratings were converted into proportions.

Motivation. Same as Experiment 1.

Results and Discussion

Descriptive statistics for all measures are shown in Table 3. As can be seen, most of the measures had generally acceptable values of reliability, and all measures were approximately normally distributed. First, we sought to examine whether variation in pre-task concurrent MSE is associated with individual differences in learning and memory performance. Critically, we observed a moderate[5], positive correlation between concurrent MSE (assessed pre task) and mean delayed free recall accuracy (r = .27). Thus, consistent with research using samples comprised of older adults (e.g., Herzog et al., 1990), the best learners, in our young adult sample, tended to be individuals who predicted they would obtain high recall accuracy on the memory task they were about to complete.

Our next analysis sought to examine whether the strength of this MSE-performance relationship changes as a function of task experience. To this aim, we submitted concurrent MSE scores (predicted percent correct) to a repeated measures ANOVA with list (5 levels: 1-5) as a within-subjects factor and learning ability (mean recall accuracy) as a covariate. Results revealed main effects of both list (F[4, 516] =

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[5] We used updated effect size guidelines, as recommended by Gignac and Szodorai (2016).

11.76, $p < .001$, partial $\eta^2 = .083$, $MSE = .008$) and learning ability ($F[1, 129] = 93.05$, $p < .001$, partial $\eta^2 = .419$, $MSE = .037$), which were qualified by a significant interaction, $F(4, 516) = 8.36$, $p < .001$, partial $\eta^2 = .061$, $MSE = .008$. As demonstrated in Figure 1, the best learners maintained a high sense of efficacy across the entire task (no significant effect of list). The worst learners, on the other hand, demonstrated a significant decline in efficacy across the entire task, $F(4, 116) = 5.79$, $p < .001$, partial $\eta^2 = .166$, $MSE = .008$; negative linear trend: $F(1, 29) = 21.70$, $p < .001$, partial $\eta^2 = .428$. Thus, consistent with previous research (Hertzog et al., 1990; Hertzog et al., 1994; West et al., 1996), MSE judgements made at the end of the task were more strongly associated with performance than were MSE judgments made prior to the beginning of the task.

Table 3

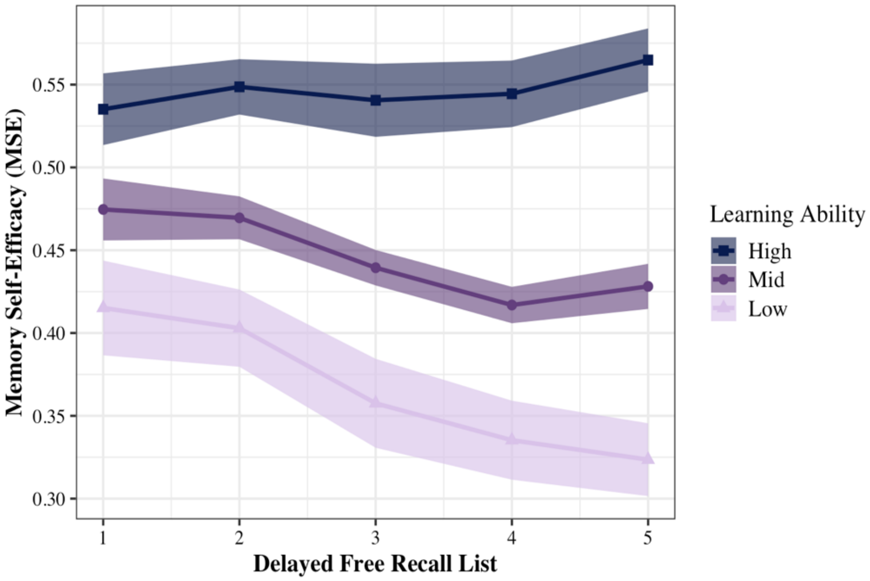
Descriptive Statistics and Reliability Estimates for all Measures in Experiment 2

Measure	*N*	*M*	*SD*	Skew	Kurtosis	Reliability
Ospan	138	38.12	8.76	-1.35	2.40	.73
Rspan	139	37.00	9.35	-1.15	1.61	.74
Symspan	139	19.33	4.92	-.39	-.41	.60
DFRacc	137	.51	.13	.58	.55	.77
PAacc	136	.38	.27	.73	-.74	.89
PicSource	137	.75	.19	-1.27	1.14	.93
MSE	137	.45	.11	-.11	.63	.87
Motivation	137	4.51	1.09	-.99	1.02	

Note. Due to program or experimenter error, some tasks are missing data. Ospan = operation span; Rspan = reading span; Symspan = symmetry span; DFRacc = delayed free recall accuracy; PAacc = paired associates cued recall accuracy; PicSource = picture source recognition accuracy; MSE = memory self-efficacy (predicted recall accuracy) before beginning real trials; Motivation = post-task self-reported motivation. All reliabilities were calculated using Cronbach's alpha.

Figure 1

Changes in Memory Self-Efficacy Across Each List of the Delayed Free Recall Task as a Function of Learning Ability (High vs Mid vs Low).



Note. For graphical purposes only, using a quartile split, the uppermost 25% of performers on the delayed free recall task was categorized as high learning ability, whereas the lowermost 25% performers were categorized as low learning ability. Individuals falling within the middle of these points were categorized as mid learning ability.

Since the worst learners appear to be individuals who display increasingly less confidence in their memory capabilities specific to the context and task at hand, we next sought to understand why such a relationship exists. An examination of Table 4 reveals that concurrent MSE positively correlated with motivation (*r* = .18), suggesting less efficacious individuals tend to be those who are unmotivated to perform well on the task at hand—consistent with theorizing by Bandura (1993) and Kanfer et al. (2017). Concurrent MSE also positively correlated with working memory (*r* = .29) and broad episodic LTM abilities (*r* = .19). Thus, people who predicted they would achieve low levels of performance under conditions of delayed free recall tended to be people who performed poorly on measures of working memory and other episodic LTM tasks. This finding is consistent with Hertzog and colleagues (1990), who demonstrated a significant latent correlation (*r* = .54) between a higher order verbal memory factor and a MSE factor; hence self-efficacy beliefs seem to be partly based on actual ability levels (Garland, 1985; Locke & Latham, 1990). In the case of the present study, it seems possible that individuals who performed worse on the working memory battery (administered immediately before the delayed free recall task) likely gauged themselves to be doing poorly on said tasks. These low working memory individuals may have used this prior experience to predict how they would perform on the upcoming delayed free recall task.

In terms of individual differences in learning, Table 4 demonstrates similar correlations to those described in Experiment 1 (Chapter 2). Namely, individuals with inferior delayed free recall accuracy tended to be individuals with worse working memory (*r* = .35), worse episodic LTM abilities in general (*r* = .55), and less motivation to perform well (*r* = .36). Given learning ability and concurrent MSE demonstrated similar interrelations with these additional variables of interest (working memory, broad episodic LTM ability, and motivation), we next sought to examine whether concurrent MSE is predictive of learning ability when taking the previously mentioned variables into account. As seen in Table 5, working memory, general episodic LTM abilities, pre-task concurrent MSE, and motivation together accounted for 40% of the variance in delayed free recall accuracy. Critically, though, with all variables entered as predictors in a simultaneous regression, concurrent MSE did not account for unique variance in overall recall accuracy. So, one's belief in their memory capabilities (in the context of a specific memory task) is important when trying to understand differences in learning and memory performance. But this relationship between concurrent MSE and actual performance seems to be largely driven by overlapping sources of variance with other meaningful predictors. In other words, those who believe they will perform well in conditions of delayed free recall (i.e., those with high concurrent MSE) tend to demonstrate better learning outcomes (i.e., superior recall accuracy) primarily because these high MSE individuals also tend to be individuals with better working memory abilities, better general episodic LTM abilities, and increased motivation.

Table 4

Correlations Among all Measures in Experiment 2

Measure	1	2	3	4	5
(1) DFRacc	–				
(2) WM	$.35^{***}$	–			
(3) LTM	$.55^{***}$	$.31^{***}$	–		
(4) MSE	$.27^{**}$	$.29^{***}$	$.19^{*}$	–	
(5) Motivation	$.36^{***}$	$.24^{**}$	$.21^{*}$	$.18^{*}$	–

Note. * p <.05, ** p <.01, *** p <.001; DFRacc = mean delayed free recall accuracy; WM = working memory factor composite; LTM = episodic long-term memory factor composite; MSE = memory self-efficacy (memory prediction) before beginning real trials; Motivation = post-task self-reported motivation.

Table 5

Simultaneous Regression Predicting Delayed Free Recall Accuracy in Experiment 2

Variable	β	*t*	sr^2	R^2	*F*
WM	.12	1.64	.013		
LTM	.45	6.07^{***}	.174		
MSE	.11	1.51	.011		
Motivation	.22	3.11^{**}	.046	.40	21.16^{***}

Note. * p <.05, ** p <.01, *** p <.001; Participants with missing data were excluded from this analysis via pairwise deletion. WM = working memory factor composite; LTM = long-term memory ability factor composite; MSE = memory self-efficacy (memory prediction) before beginning real trials; Motivation = post-task self-reported motivation.

CHAPTER IV

EXPERIMENT 3: DOES CONCURRENT MEMORY SELF-EFFICACY PREDICT UNIQUE VARIANCE IN LEARNING WHEN INCORPORTATING OTHER METHODS?

Experiment 2 (Chapter 3) demonstrated that individuals who predict they will remember more items on a delayed free recall task tend to be people who actually perform better on said task, suggesting the best learners have a high sense of efficacy for the specific task at hand. Results further revealed that these individuals with high concurrent MSE (and those with high learning ability) also appear to be people who have better working memory, better episodic LTM abilities more generally, and are more motivated to perform well. Critically, though, when accounting for these interrelations, concurrent MSE (assessed pre-task) did not account for unique variance in learning ability, as indexed by delayed free recall accuracy. Note, however, that Experiment 2 assessed concurrent MSE with performance predictions. This method relies on a single question in which participants are asked to indicate the number of items that they expect to recall on a task (or trial) they are about to complete.

Other methods, such as the Memory Self-Efficacy Questionnaire (Berry, West, & Dennehey, 1989), use multiple self-report indices to increase the accuracy (and reliability) of efficacy judgments made. That is, the Memory Self-Efficacy Questionnaire assesses perceived ability across increasing levels of task difficulty. For example, if one's task is to remember 10 words, individuals are first asked whether they can remember 2 out of 10 words, 4 out of 10 words, 6 out of 10 words, etc. Confidence ratings are then made for each level of difficulty so that variation in one's confidence is also taken into account. But the idea behind this technique is that assessment of people's beliefs across different task levels seemingly better defines the upper bounds of one's perceived abilities—as well as gradations of efficacy below this point (Bandura, 1989). Therefore, rather than rely on a series of performance predictions, Experiment 3 (Chapter 4) sought to examine whether a similar pattern of results would arise when incorporating a version of the Memory Self-Efficacy Questionnaire modified to reflect current memory ability specific to the delayed free recall task (concurrent MSE).

Again, the hypotheses and associated analyses are relatively straightforward. Our first goal was to replicate the effects observed in the prior chapters. Specifically, we expected to find a positive correlation between concurrent MSE and mean recall accuracy. We also anticipated the strength of this MSE-performance correlation to become stronger as a function of task experience, insofar that the largest correlations should be observed for MSE judgments made at the end of the task. And, finally, we anticipated highly efficacious individuals (and high learning individuals) to display better working memory, perform better on other episodic LTM tasks, and report increased motivation to perform well.

To build upon Experiment 2, encoding strategy use and encoding strategy knowledge were assessed in the present study. Given previous research suggests the effect of self-efficacy on performance is partly explained by strategy use (Berry, 1999; Berry & West, 1993; Berry et al., 1994; Hertzog et al., 2007), we hypothesized a similar result to arise here. Individuals who are more efficacious should tend to be those who report using more effective encoding strategies. The correlation between concurrent MSE and strategy knowledge was more exploratory in nature since prior research on the matter is rather limited. That said, similar to Experiment 1 (Chapter 2), we reasoned that strategy knowledge might serve as a proxy of task-relevant experience—a supposed source of self-efficacy beliefs (e.g., Berry, 1999). Indeed, Bandura (1989) suggested that "people must draw on their preexisting knowledge" when trying to gauge future competencies. These notions suggest that individuals who are aware of which learning strategies are most effective may tend to be individuals who believe they are better capable of learning. In sum, delayed free recall accuracy should positively correlate with concurrent MSE. Concurrent MSE (and recall accuracy) should likewise positively correlate with working memory, general episodic LTM abilities, motivation, effective encoding strategy use, and—potentially—knowledge of strategy effectiveness.

Third, we sought to examine whether pre estimates of concurrent MSE would now uniquely predict learning and memory ability (overall delayed free recall accuracy) when entered into a simultaneous regression with the following as predictors: working memory, general episodic LTM abilities, motivation, effective encoding strategy use, and knowledge of strategy effectiveness The presence of a unique effect of concurrent MSE judgements (assessed pre task) would lend the best support for the idea that people's *beliefs* in their memory capabilities (specific to a task and context) are a distinct component of successful learning.

Methods

Participants and Procedure

A total of 173 participants (59% female) were recruited from the human subject pool at the University of Oregon. One participant was excluded for being over the age of 35. All other participants were between the ages of 18 and 32 (*M* = 19.41, *SD* = 2.19) and were proficient English speakers. All participants were also awarded course research credit for participation. After obtaining informed consent and demographic information, participants completed the working memory battery described previously (Ospan, Symspan, and Rspan). The working memory tasks were followed by the delayed free recall task. Concurrent MSE was assessed pre and post task via performance predictions in addition to an adapted version of the Memory Self-Efficacy Questionnaire. Participants were similarly asked both pre and post task to report how motivated they were to do well on the delayed free recall task. Participants then completed the same LTM battery (PA cued recall and PicSource) described in Experiments 1 and 2. One participant was excluded due to having a concussion less than two weeks prior to their session, and three additional participants were excluded for not recalling a single word on any of the delayed free recall lists. Eight more participants were excluded for cheating on the delayed free recall task (e.g., they wrote down the to-be-remembered items), one participant was excluded for incorrectly responding to the Memory Self-Efficacy Questionnaire (i.e., straight-lined responses), and two participants were excluded for performing well below chance on the PicSource (final $N = 157$). Finally, the tasks reported herein were again part of a larger experimental test battery lasting approximately 2 hours. Since the other tasks administered during the experimental session do not relate to the current study, they are not reported.

Working Memory Tasks

Same as prior experiments. Ospan correlated with Rspan ($r = .47, p < .001$) and Symspan ($r = .36, p < .001$). Rspan correlated with Symspan ($r = .25, p = .002$). All analyses involving working memory used a working memory factor score created for each participant by entering scores on the three complex span measures into a factor analysis using principal axis factoring. Factor loadings for the first unrotated factor were as follows: Ospan (.86), Symspan (.47), and Rspan (.63). See Experiment 1 for more details.

Long-Term Memory Tasks

Same as Experiment 2. Mean accuracy on PA cued recall and PicSource were correlated ($r = .39$, $p < .001$). We proceeded to create a LTM factor score for each participant by entering their scores on PA cued recall and PicSource into a factor analysis using principal axis factoring. The factor loadings for the first unrotated factor were as follows: PA cued recall (0.63) and PicSource (0.63).

Delayed Free Recall

Same as prior experiments. See Experiment 1 for more details.

Concurrent Memory Self-Efficacy. Similar to Experiment 2, except before (after completing two practice lists with letters) and after completion of the real trials, we also administered an adapted version of the Memory Self-Efficacy Questionnaire (Berry, 1999). Participants were first asked to indicate via mouse click whether they agreed with the following statements, with "No" meaning they disagreed and "Yes" meaning they agreed:

If studying a list of 10 words, I could remember 2 out of 10 words.
If studying a list of 10 words, I could remember 4 out of 10 words.
If studying a list of 10 words, I could remember 6 out of 10 words.
If studying a list of 10 words, I could remember 8 out of 10 words.
If studying a list of 10 words, I could remember 10 out of 10 words.

"Yes" responses were summed to create a self-efficacy *level* score. Next, participants were subsequently asked to select the number that best reflected how confident they were with each of the above statements, with 10% reflecting the lowest confidence and 100% reflecting the highest confidence. These confidence ratings were averaged to create a self-efficacy *strength* score (see Berry, 1999 for more details). Participants were then asked to provide a performance prediction (see Experiment 2 for more details but note that participants were now only asked to provide performance predictions twice: pre and post task).

A pre MSE factor score was created for each participant by entering pre estimates of self-efficacy level, self-efficacy strength, and the performance prediction into a factor analysis using principal axis factoring. The factor loadings for the first unrotated factor were as follows: pre MSE level (.72), pre MSE strength (.67), and pre prediction (.87). The same procedure was used to create a post MSE factor score using the scores collected immediately upon completion of the final delayed free recall trial. The factor loadings for the first unrotated factor were as follows: post MSE level (.78), post MSE strength (.57), and post prediction (.89). Note for all individual differences analyses, we rely on the pre MSE factor score since this is a purer measure of one's actual memory beliefs. That is, pre-task MSE judgments are not confounded with prior task performance and performance monitoring (as is the case for post-task MSE judgments).

Strategy Use Questionnaire. Same as Experiment 1.

Strategy Knowledge Questionnaire. Same as Experiment 1.

Motivation. Prior research suggests that when motivation is only measured after completing a task, performance on said task may reactively influence these reports (see

Exp 2 in Miller & Unsworth, 2021). Thus, to reduce potential reactivity effects, participants were now asked about their level of motivation twice during the task. The first (i.e., pre-task) self-report item appeared after completing the practice trials, directly before beginning the real trials of the delayed free recall task but after completion of the MSE self-report items described above. This pre-motivation item specifically asked participants to indicate how motivated they were to perform the upcoming real trials. The second (i.e., post-task) self-report item appeared immediately upon completion of the delayed free recall task. The two measures of motivation were highly correlated ($r = .90$, $p < .001$), so we used the mean of these reports for our analyses. See Experiment 1 for more details.

Results and Discussion

Table 6 shows the descriptive statistics for all measures. Consistent with the prior experiment, concurrent MSE positively correlated with mean recall accuracy ($r = .24$, see Table 7). Interestingly, despite the incorporation of the Memory Self-Efficacy Questionnaire (Berry, 1999; Berry et al., 1989), the magnitude of this correlation did not significantly differ from the correlation observed when using performance predictions in Experiment 2 ($r = .27$), Fishers $Z = .27$, $p = .79$. Nonetheless, we proceeded to examine whether the strength of the MSE-performance correlation would again vary as a function of task experience. To this aim, we submitted concurrent MSE factor scores to a repeated measures ANOVA with time (2 levels: pre-task vs post-task) as a within-subjects factor and learning ability (mean recall accuracy) as a covariate. Results revealed main effects of both time ($F[1, 155] = 18.46$, $p < .001$, partial $\eta^2 = .106$, $MSE = .334$) and learning ability ($F[1, 155] = 46.98$, $p < .001$, partial $\eta^2 = .233$, $MSE = .801$), which were qualified by a significant interaction, $F(1, 155) = 19.79$, $p < .001$, partial $\eta^2 = .113$, $MSE = .334$. The best learners demonstrated an increase in efficacy across the entire task (positive liner trend: $F[1, 41] = 13.80$, $p = .001$, partial $\eta^2 = .252$, $MSE = .271$), whereas the worst learners demonstrated a decline in efficacy across the entire task (negative linear trend: $F[1, 38] = 8.51$, $p = .006$, partial $\eta^2 = .183$, $MSE = .387$). Thus, we further replicated Experiment 2 (Chapter 3) insofar that self-efficacy judgments provided at the end of delayed free recall task ($r = .59$) correlated more strongly with performance than self-efficacy judgments provided before the beginning of the task ($r = .24$).

Next, we examined the interrelations among all other variables. Like the prior chapter, those who were more confident in their ability to achieve high levels of performance tended to be people with better working memory ($r = .30$), better general episodic LTM abilities ($r = .24$), and increased motivation to perform well ($r = .26$). The present study expanded upon these findings by further demonstrating that these highly efficacious individuals tended to, not only be those with increased knowledge of strategy effectiveness ($r = .18$), but also be those who reported the use of more effective encoding strategies ($r = .20$; see Berry et al., 1994). Mean recall accuracy demonstrated similar associations with working memory ($r = .37$), general episodic LTM abilities ($r = .43$), motivation ($r = .27$), and effective strategy use ($r = .28$)—but not knowledge of strategy effectiveness ($r = .10$, $p = .23$). Collectively, these results suggest that concurrent MSE and overall learning ability are positively related to each other in addition to other important individual differences variables.

Table 6

Descriptive Statistics and Reliability Estimates for all Measures in Experiment 3

Measure	*N*	*M*	*SD*	Skew	Kurtosis	Reliability
Ospan	156	37.31	8.48	-.74	.20	.70
Rspan	157	36.06	8.76	-.77	.42	.75
Symspan	157	18.68	5.43	-.49	-.46	.63
DFRacc	157	.49	.13	-.01	.05	.81
PAacc	157	.55	.27	-.00	-1.15	.87
PicSource	156	.75	.16	-.96	.36	.94
MeanMotiv	157	4.46	1.20	-.80	.25	.95
PreMSElevel	157	3.19	1.34	.10	-1.12	.72
PreMSEstrength	157	.54	.19	.14	-.78	.85
PrePrediction	157	.49	.15	.01	-.22	
EffectUse	157	.38	.30	.12	-1.05	
StratKnow	157	.31	3.05	-.38	.01	

Note. Due to program or experimenter error, some tasks are missing data. Ospan = operation span; Rspan = reading span; Symspan = symmetry span; DFRacc = mean delayed free recall accuracy; PAacc = mean paired associates cued recall accuracy; PicSource = mean picture source recognition accuracy; MeanMotiv = mean motivation using pre and post scores; PreMSElevel = pre task MSE level (number of yes responses out of 5 total MSEQ items); PreMSEstrength = pre task MSE strength (average confidence across all 5 MSEQ items); PrePrediction = pre-task performance prediction; EffectUse = proportion of effective strategies used; StratKnow = strategy knowledge index. Reliabilities for all measures were calculated using Cronbach's alpha.

Given the variety of interrelations described above, our final analysis examined whether concurrent MSE would explain unique variance in learning when controlling for these other meaningful variables. Working memory factor scores, episodic LTM factor scores, pre task concurrent MSE factor scores, mean motivation scores, and proportions of effective strategy use were all added to a simultaneous linear regression model predicting overall delayed free recall accuracy (strategy knowledge was not added as a predictor since it did not correlate with mean performance). As demonstrated in Table 8, the predictors altogether accounted for 30% of the variance in recall accuracy, *F*(5, 149) = 12.90, $p < .001$, *MSE* = .012. Like Experiment 2, however, concurrent MSE did not explain unique variance in overall recall accuracy when accounting for the influence of these additional predictors. Thus, the best learners tend to have a high sense of efficacy for the specific task at hand, but these learning-related differences in concurrent MSE seem to be entirely due to a combination of other important factors. Namely, high MSE individuals outlearn low MSE individuals because high MSE individuals tend to display better working memory abilities, better episodic LTM abilities in general, are more motivated to perform well, and utilize more effective encoding strategies.

Table 7

Correlations Among all Measures in Experiment 3

Measure	1	2	3	4	5	6	7
(1) DFRacc	–						
(2) WM	$.37^{***}$	–					
(3) LTM	$.43^{***}$	$.20^{*}$	–				
(4) PreMSE	$.24^{**}$	$.30^{***}$	$.24^{**}$	–			
(5) MeanMotiv	$.27^{**}$	$.20^{*}$	$.33^{***}$	$.26^{**}$	–		
(6) EffectUse	$.28^{***}$	.13	$.23^{**}$	$.20^{*}$	$.32^{***}$	–	
(7) StratKnow	.10	.14	$.21^{*}$	$.18^{*}$	.06	$.36^{***}$	–

Note. * *p* <.05, ** *p* <.01, *** *p* <.001; DFRacc = mean delayed free recall accuracy; WM = working memory factor composite; LTM = long-term memory ability factor composite; PreMSE= pre memory self-efficacy factor; MeanMotiv = mean self-reported motivation using pre and post scores; EffectUse = proportion of effective strategies used; StratKnow = strategy knowledge index.

Table 8

Simultaneous Regression Predicting Delayed Free Recall Accuracy in Experiment 3

Variable	β	*t*	sr^2	R^2	*F*
WM	.27	3.71^{***}	.065		
LTM	.31	4.18^{***}	.082		
PreMSE	.04	.47	.001		
MeanMotiv	.06	.82	.003		
EffectiveUse	.15	2.02^{*}	.019	.30	12.90^{***}

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; Participants with missing data were excluded from this analysis via pairwise deletion. WM = working memory factor score, LTM = general episodic memory ability factor score, PreMSE = memory self-efficacy factor score, MeanMotiv = mean motivation (average of pre and post motivation items), EffectiveUse = proportion of effective strategies used.

CHAPTER V

GENERAL DISCUSSION

The present study conducted three individual differences experiments with three overarching aims. First, we sought to better understand if the best learners in conditions of delayed free recall—among a sample of healthy young adults—tend to be individuals who are more efficacious. The present study collectively suggests that, among samples of healthy young adults (ages 18 to 35), the relationship between self-efficacy and learning ability largely depends on the specificity of MSE judgments. That is, Experiment 1 revealed that *global* MSE was unrelated to individual differences in learning ability (r = .04), which is at odds with prior research whose samples largely consisted of older adults (e.g., ages 20 to 79, Hertzog et al., 1990). Note, however, that Beaudoin and Desrichard (2011, see Table 3) revealed that the moderating influence of MSE specificity (on memory performance) depended on age, yet the authors did not elaborate upon this finding. Given the salience of everyday memory failures among the elderly, the results of the present study are consistent with the notion that the impact of global MSE on performance may be larger for older adults than younger adults.

While global MSE judgments were not predictive of young adults' abilities to learn and remember information in conditions of delayed free recall, a different pattern of results arose when examining *concurrent* MSE. In both Experiment 2 and Experiment 3, estimates of concurrent MSE—collected prior to exposure of the task stimuli—were consistently associated with better overall learning (high overall recall accuracy, *rs* ranging from .24 to .27). Thus, the best learners tended to display more confidence in their memory capabilities specific to the task and context at hand but did not appear to believe they had better general memory ability across various other memory domains and situations.

Given prior research has yet to comprehensively examine the interrelations between performance, MSE, and other theoretically meaningful third variables, our second goal was to better understand possible reasons why increased MSE is associated with better learning. Our third, related goal was to examine whether MSE would uniquely predict learning when taking a variety of cognitive factors (e.g., working memory, general episodic LTM abilities, encoding strategy use) and other conative factors (e.g., motivation) into account. Experiment 2 and Experiment 3 revealed that individuals with high concurrent MSE (and the best learners) appeared to be individuals with better working memory, better general episodic LTM abilities, increased motivation to perform well, and report the use of more effective encoding strategies. Critically, both experiments further revealed that pre-task concurrent MSE did not account for unique variance in learning ability (mean recall accuracy) when controlling for working memory, general episodic LTM ability, motivation, and effective strategy use. Therefore, learning-related differences in concurrent MSE seem to be entirely due to a combination of other important factors, most of which are cognitive in nature.

Multiple Factors Contribute to the Efficacy-Memory Performance Relationship

While individuals tend to both under- and over-estimate their abilities (e.g., Bandura, 1989), the present study repeatedly demonstrated that individuals with high concurrent MSE tend to be people who perform better on measures of working memory (*r* in Exp 2 = .29; *r* in Exp 3 = .30) and measures of episodic LTM other than free recall (*r* in Exp 2 = .19; *r* in Exp 3 = .24). Of note, recent research has shown similar positive correlations between MSE, working memory, and general episodic LTM abilities independent from the memory task at hand (e.g., Beaudoin & Desrichard, 2017; Otsuka & Miyatani, 2020). These results collectively suggest that those with superior cognitive abilities may be relatively accurate in judging relevant capabilities as being high, and those with inferior cognitive abilities may be reasonably accurate in judging their relevant capabilities as low. That is, awareness of prior performance on other, complex cognitive tasks—relevant to the memory task at hand—may be one example of how people draw upon pre-existing knowledge when gauging current and future competencies (see Berry, 1999; Bandura, 1993, Hertzog et al., 1990). So not only may working memory and broad episodic LTM abilities predict one's MSE specific to conditions of delayed free recall, but concurrent MSE may also be predictive of performance on these tasks.

Of course, there are likely a multitude of ways by which pre-existing knowledge may influence judgments about one's current abilities. Indeed, the present study revealed a positive correlation between knowledge of strategy effectiveness and concurrent MSE judgements (*r* = .18), albeit this relationship was weaker than those described above. Nonetheless, the present study is the first to demonstrate such an effect. While replication is certainly needed, it seems possible that people who are more knowledgeable of effective task-relevant strategies may tend to believe they have the tools necessary to perform well on the memory task at hand (i.e., people with more strategy knowledge may feel better prepared). Hence having knowledge of which task-relevant strategies are most effective may promote beliefs of learning competence (Pearman et al., 2020). But we should note that Experiment 1 demonstrated a significant positive correlation between strategy knowledge and overall recall accuracy (*r* = .28), whereas Experiment 3 did not detect a significant correlation between the two (*r* = .10). Thus, strategy knowledge might promote a heightened sense of efficacy, although it is unclear whether increased strategy knowledge in itself explains why concurrent MSE is associated with enhanced learning. Having knowledge of which strategies are most effective doesn't necessarily mean an individual will successfully implement an effective strategy.

In sum, preexisting knowledge—whether it be knowledge of effective learning strategies or awareness of previous performance on relevant cognitive tasks—is a likely source of concurrent MSE judgements (Berry, 1999, Bandura, 1993, Hertzog et al., 1990). However, the present study revealed a third possible source of self-efficacy: Motivation. Experiment 2 and Experiment 3 each revealed positive correlations between concurrent MSE and motivation to perform well on the delayed free recall task (Exp 2 *r* = .18; Exp 3 *r* = .26). Those who cared less about performing well on the free recall task tended to be individuals who perceived themselves as being less capable of performing well. This finding is consistent with theorizing by Kanfer and colleagues (2017), who suggest that person-based motivational variables (e.g., intrinsic motivation, achievement motivation) influence performance indirectly through processes involved in goal choice and goal striving (e.g., self-efficacy)[6]. That said, the results herein are correlational in nature, so future studies will need to make use of experimental designs to better understand cause-effect relationships. As a case in point, other research suggests that inefficacious beliefs lower motivation (e.g., Bandura, 1989, 1993; Cavanaugh & Green,

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[6] Those who are less efficacious avoid difficult tasks, set low standards for performance, and tend to also display weak commitment to the goals they pursue (Bandura, 1993).

1990; Yusuf, 2011).[7]

Yet another possible mechanism thought to underly the MSE-performance relationship concerns strategy use. According to self-efficacy theory, heightened MSE encourages individuals to use effective task strategies, contributing to superior performance (Bandra, 1977, 1986, 1989). That is, self-efficacy seemingly exerts an indirect effect on performance through optimal strategy use (Locke & Latham, 1990). Consistent with these notions, Experiment 3 revealed a modest positive correlation (r = .20) between concurrent MSE and use of effective encoding strategies, meaning individuals with high efficacy specific to the task at hand tended to be individuals who were better able (or more willing) to develop and use effective encoding strategies on said task. Concurrent MSE and effective strategy use were, in turn, both associated with superior recall accuracy (better learning). These results are consistent with Berry et al. (1994), who revealed strategy use accounted for MSE's effect on word-recall performance (see Berry, 1999). To better probe the directionality of this relationship, future research should test whether actively manipulating concurrent MSE produces changes in encoding strategies, or whether differences in MSE are observed when assigning people to different strategy conditions.

Bidirectional Relationship between Performance and Memory Self-Efficacy

Previous research (Bandura & Wood, 1989) suggests that concurrent self-efficacy plays an increasingly important role in performance across the duration of a task. Accordingly, we examined whether the strength of the concurrent MSE-performance

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[7] However, motivation is an umbrella term used throughout many domains to encompass a variety of concepts thought to underlie fluctuations in the desires, wants, and needs that elicit voluntary action (Kanfer et al., 2017). Indeed, in the context of self-efficacy, motivation is generally used to refer to goal choice, effort, and persistence (Bandura, 1993; Cavanaugh & Green, 1990; Shunk & DiBenedetto, 2020).

relationship changes as a function of task experience. In Experiment 2 and Experiment 3, the magnitude of the correlation between concurrent MSE and overall recall accuracy significantly increased from pre-task (Exp 2 $r = .27$; Exp 3 $r = .24$) to post-task (Exp 2 $r = .68$; Exp 3 $r = .59$). Those with enhanced learning abilities either maintained or increased self-efficacy across trials, whereas those with deficient learning abilities demonstrated a steady decline in self-efficacy across trials. This finding is consistent with the notion that continuous reductions in MSE among low learning individuals may reflect lowered motivation and task disengagement—a withdrawal of effort—attributed to dissatisfaction in one's performance (Kanfer, 1990). Theoretically, this lower effort expenditure would thereby contribute to lower performance on future trials (Bandura, 1986; Kahneman, 1973; Kanfer & Ackerman, 1989).

However, the finding that MSE judgments made at the end of a task correlate far more strongly with overall performance (relative to MSE judgements made before beginning the task) is also indicative of past performance's impact on subsequent MSE judgements. Specifically, as individuals actively monitor their performance and gain task experience, they become more calibrated (i.e., accuracy of MSE assessments improves). Accurately gauging prior performance serves as the primary means by which task experience informs future self-efficacy judgements (Bandura, 1997; Berry, 1999). Indeed, an examination of the correlations across all lists and performance predictions in Experiment 2 (see Table A3 in Appendix A) reveals that the largest correlations were observed between self-efficacy judgments and performance on the immediately preceding trial. For example, the correlation between performance on list 3 and the performance prediction made for list 4 ($r = .69$) was larger than the correlation between the performance prediction made for list 4 and actual performance on list 4 (*r* = .47)—consistent with Hertzog and colleagues (1990, 1994). Thus, while memory performance and concurrent MSE seemingly have a bidirectional relationship (Bandura, 1997), the effect of performance on concurrent MSE is likely larger than the effect of concurrent MSE on performance.

Limitations and Future Directions

We would be remiss not to address several limitations of the current study. First and foremost, the bidirectional relationship between concurrent MSE and performance is complex. The present study adopted an individual differences approach in an attempt to identify the mechanisms relevant to the MSE-performance relationship. But, as stated above, such an approach prevents us from examining the direction of causality among these constructs. Future research examining MSE-related differences in learning and memory needs to combine aspects of experimental and differential psychology to better discern cause-effect relations. Future research would also benefit from more powerful techniques that reduce measurement error, such as structural equation modeling, to better ascertain whether efficacy evaluations tied to a given task and context apply to a wider range of episodic LTM tasks. That is, it remains to be seen whether there are there stable, trait-like individual differences in concurrent MSE within a particular memory domain (see West & Berry, 1994).

Second, Experiment 1 may have been underpowered to detect an effect of global MSE on performance. Using a sample with a wider age range (26 to 83), Hertzog and colleagues (2007) reported a correlation of *r* = .20 when examining the relationship between recall accuracy and a similar global MSE composite variable. Experiment 1 would only have 64% power to detect an effect of this magnitude, which is further complicated by the possibility that effects of global MSE on performance may be larger for older adults than younger adults (Beaudoin & Desrichard, 2011). Future research needs to replicate Experiment 1 with a sufficiently large sample size to determine whether a smaller effect of global MSE arises for young adults. Regardless, the present study suggests that this effect, if it exists, is not particularly robust.

Third, the present study revealed a consistent, moderately positive correlation between concurrent MSE (assessed pre task) and overall recall accuracy. Given the moderate strength of this association, it is perhaps unsurprising that concurrent MSE did not significantly predict unique variance in performance when controlling for a multitude of interrelated factors. Note, however, MSE has its largest effects on complex, unfamiliar tasks (e.g., Berry, 1999). In all experiments reported herein, the criterion task (delayed free recall) immediately followed three complex span working memory tasks. Delayed free recall and complex span tasks ostensibly tap distinct aspects of memory (episodic LTM in the case of the former, working memory in the case of the latter). But no task is process pure, and the same strategies (e.g., rehearsal) are afforded by both tasks (Bailey et al., 2008). Thus, future research should examine whether similar results arise in more novel, challenging learning conditions. For example, the free recall task used in the present study consisted of three lists of 10 to-be-remembered words. To increase task difficulty, researchers could increase the number of to-be-remembered items in each list. Or, to reduce task similarity and assess generalizability to other memory paradigms, future research could examine these relations using associative learning tasks.

Conclusion

The current study clarified the relation between MSE and one’s ability to learn and remember information in conditions of delayed free recall. In three experiments, it was found that concurrent, but not global, MSE judgements were predictive of overall learning ability in a sample of healthy, young adults. Thus, while beliefs in general memory abilities (across a variety of tasks and situations) were unrelated to performance, the best learners tended to be individuals who maintained a high sense of efficacy for the specific task at hand. The worst learners, on the other hand, tended to display low efficacy, which continued to decrease as a function of task experience. That said, concurrent MSE (assessed before beginning the task) did not explain unique variance in learning when controlling for the influence of various interrelated predictors. Thus, learning-related differences in concurrent MSE appear to be due to shared variance with working memory, general episodic LTM abilities, motivation to perform well, and use of effective encoding strategies.

APPENDIX A

CORRELATIONS AND REGRESSIONS WITH ALL CONCURRENT MEMORY SELF-EFFICACY JUDGEMENTS IN EXPERIMENT 2

Table A1

Correlations Among all Measures in Experiment 2

Measure	1	2	3	4	5	6	7
(1) DFRacc	–						
(2) WM	.35***	–					
(3) LTM	.55***	.31***	–				
(4) MSEb4L1	.27**	.29***	.19*	–			
(5) MSEb4L5	.68***	.30***	.42***	.41***	–		
(6) MeanMSE	.65***	.38***	.36***	.73***	.82***	–	
(7) Motivation	.36***	.24**	.21*	.18*	.31***	.32***	–

Note. * p <.05, ** p <.01, *** p <.001; DFRacc = delayed free recall accuracy; WM = working memory factor score; LTM = episodic long-term memory factor score; MSEb4L1 = memory self-efficacy (memory prediction) before beginning list 1; MSEb4L5 = memory self-efficacy (memory prediction) before beginning list 5; MeanMSE= mean memory self-efficacy (average of all memory predictions); Motivation = post-task self-reported motivation.

Table A2

Simultaneous Regression Predicting Delayed Free Recall Accuracy in Experiment 2

Variable	β	*t*	sr^2	R^2	*F*
WM	.03	.42	.001		
LTM	.35	5.41***	.101		
MeanMSE	.47	6.93***	.165		
Motivation	.14	2.19*	.016	.55	40.33***

Note. * p <.05, ** p <.01, *** p <.001; Participants with missing data were excluded via pairwise deletion. WM = working memory factor score; LTM = episodic LTM ability factor score; MeanMSE = average of all memory predictions; Motivation = post-task motivation.

Table A3

Correlations Among all Concurrent MSE Judgments (Predicted Proportion Correct) and Mean Recall Accuracy for Each List in Experiment 2

Measure	MSE_B4L1	MSE_B4L2	MSE_B4L3	MSE_B4L4	MSE_B4L5
(1) RecallAccL1	$.22^{*}$	$.62^{***}$	$.36^{***}$	$.36^{***}$	$.36^{***}$
(2) RecallAccL2	.16	$.32^{***}$	$.64^{***}$	$.42^{***}$	$.50^{***}$
(3) RecallAccL3	$.25^{**}$	$.37^{***}$	$.39^{***}$	$.69^{***}$	$.57^{***}$
(4) RecallAccL4	$.22^{**}$	$.31^{***}$	$.42^{***}$	$.47^{***}$	$.64^{***}$
(5) RecallAccL5	.16	.15	$.30^{***}$	$.41^{***}$	$.40^{***}$

Note. * *p* <.05, ** *p* <.01, *** *p* <.001; RecallAccL1 = recall accuracy on list 1; RecallAccL2 = recall accuracy on list 2; RecallAccL3 = recall accuracy on list 3; RecallAccL4 = recall accuracy on list 4; RecallAccL5 = recall accuracy on list 5; MSE_B4L1 = predicted accuracy for list 1; MSE_B4L2 = predicted accuracy for list 2; MSE_B4L3 = predicted accuracy for list 3; MSE_B4L4 = predicted accuracy for list 4; MSE_B4L5 = predicted accuracy for list 5.

APPENDIX B

CORRELATIONS AND REGRESSIONS WITH PRE, POST, AND MEAN CONCURRENT MEMORY SELF-EFFICACY IN EXPERIMENT 3

Table B1

Correlations Among all MSE Measures and Mean Recall Accuracy in Experiment 3

Measure	1	2	3	4
(1) DFRacc	–	$.60^{***}$	$.44^{***}$	$.36^{***}$
(2) Prediction	$.19^{*}$	–	$.68^{***}$	$.50^{***}$
(3) MSElevel	$.22^{**}$	$.67^{***}$	–	$.42^{***}$
(4) MSEstrength	$.24^{**}$	$.64^{***}$	$.49^{***}$	–

Note. * p <.05, ** p <.01, *** p <.001. Correlations below the diagonal reflect all MSE measures collected pre-task, whereas correlations above the diagonal reflect all MSE measures collected post-task. DFRacc = delayed free recall accuracy; Prediction = predicted recall accuracy; MSElevel = self-efficacy level scores (total "yes" responses); MSEstrength = self-efficacy strength scores (mean confidence rating).

Table B2

Correlations Among all Measures in Experiment 3

Measure	1	2	3	4	5	6	7	8	9
(1) DFRacc	–								
(2) WM	$.37^{***}$	–							
(3) LTM	$.43^{***}$	$.20^{*}$	–						
(4) PreMSE	$.24^{**}$	$.30^{***}$	$.24^{**}$	–					
(5) PostMSE	$.59^{***}$	$.30^{***}$	$.29^{***}$	$.47^{***}$	–				
(6) MeanMSE	$.48^{***}$	$.35^{***}$	$.31^{***}$	$.86^{***}$	$.85^{***}$	–			
(7) MeanMotiv	$.27^{**}$	$.20^{*}$	$.33^{***}$	$.26^{***}$	$.30^{***}$	$.33^{***}$	–		
(8) EffectUse	$.28^{***}$	.13	$.24^{**}$	$.20^{*}$	$.40^{***}$	$.35^{***}$	$.32^{***}$	–	
(9) StratKnow	.10	.14	$.21^{*}$	$.18^{*}$	.10	$.17^{*}$	.06	$.36^{***}$	–

Note. * p <.05, ** p <.01, *** p <.001; DFRacc = delayed free recall accuracy; WM = working memory factor score; LTM = episodic LTM ability factor score; PreMSE= pre memory self-efficacy factor; PostMSE= post memory self-efficacy factor; MeanMSE= mean memory self-efficacy factor (average of pre MSE factor and post MSE factor); MeanMotiv = mean self-reported motivation using pre and post scores; EffectUse = proportion of effective strategies used; StratKnow = strategy knowledge index.

Table B3

Simultaneous Regression Predicting Delayed Free Recall Accuracy in Experiment 3

Variable	β	t	sr^2	R^2	F
WM	.20	2.89**	.036		
LTM	.27	3.80***	.062		
MeanMSE	.29	3.82***	.062		
MeanMotiv	.02	.32	.000		
EffectUse	.09	1.19	.006	.36	17.01***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; Participants with missing data were excluded via pairwise deletion. WM = working memory factor score; LTM = episodic LTM ability factor score; MeanMSE = mean memory self-efficacy (mean of the pre-task and post-task MSE factor scores); MeanMotiv = mean motivation (average of pre and post motivation items); EffectUse = proportion of effective strategies used.

REFERENCES CITED

Bailey, H., Dunlosky, J., & Hertzog, C. (2009). Does differential strategy use account for age-related deficits in working-memory performance? *Psychology and Aging, 24*, 82-92.

Bailey, H., Dunlosky, J., & Kane, M.J., (2008). Why does working memory span predict complex cognition? Testing the strategy affordance hypothesis. *Memory & Cognition*, 36, 1383-1390.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology*, *4*, 359-373.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology, 25*, 729-735.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*, 117-148

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: W. H. Freeman.

Bandura, A., & Wood, R. (1989). Effect of perceived controllability and performance standards on self-regulation of complex decision making. *Journal of Personality and Social Psychology*, *56*, 805-814.

Beaudoin, M., & Desrichard, O. (2011). Are memory self-efficacy and memory performance related? A meta-analysis. *Psychological Bulletin*, *137*, 211-241.

Beaudoin, M., & Desrichard, O. (2017). Memory self-efficacy and memory performance in older adults: The mediating role of task persistence. *Swiss Journal of Psychology, 76*, 23-33.

Berry, J. M. (1999). Memory self-efficacy in its social cognitive context. In T. H. Hess and F. Blanchard-Fields (Eds.), Social Cognition and Aging. CA: Academic Press, San Diego, pp. 70–96.

Berry, J. M., Acosta, M., Baldi, R., Burrell, C., & Rotondi, J. (1994). *Age differences in memory processing, outcome, and appraisal: A self-efficacy analysis.* Paper presented at the 3rd Practical Aspects of Memory Conference, College Park, MD.

Berry, J. M., Geiger, H., Visocan, K., & Siebert, J. (1987). Age differences on subjective and objective measures of memory. In 40th Annual Scientific Meeting of the Gerontological Society of America, Washington, DC.

Berry, J. M., & West, R. L. (1993). Cognitive self-efficacy in relation to personal mastery and goal setting across the life span. *International Journal of Behavioral Development, 16*, 351-379.

Berry, J. M., West, R. L., & Dennehey, D. M. (1989). Reliability and validity of the memory self-efficacy questionnaire. *Developmental Psychology*, *25*, 701-713.

Caldeira de Carvalho, S., Marcourakis, T., Artes, R., & Gorenstein, C. (2002). Memory performance in panic disorder patients after chronic use of clomipramine. *Journal of Psychopharmacology, 16,* 220–226.

Cavanaugh, J. C., & Green, E. E. (1990). I believe, therefore I can: Self-efficacy beliefs in memory aging. In E. A. Lovelace (Ed.), *Aging and Cognition: Mental Processes, Self-Awareness, and Intervention* (pp. 189-230). North-Holland.

Craik, F. I. M. (2000). Age-related changes in human memory. In D. C. Park & N. Schwarz (Eds.), *Cognitive aging: A primer* (pp. 75-92). Philadelphia, PA: Psychology Press.

Dunlosky, J., & Kane, M. J. (2007). The contributions of strategy use to working memory span: A comparison of strategy assessment methods. *Quarterly Journal of Experimental Psychology, 60*, 1227-1245.

Elliott, E. S., & Lachman, M. E. (1989). Enhancing memory by modifying control beliefs, attributions, and performance goals in the elderly. In P. S. Fry (Ed.), Advances in psychology: Psychological perspectives of helplessness.

Friendly, M., Franklin, P.E., Hoffman, D., & Rubin, D.C. (1982). The Toronto word pool: Norms for imagery, concreteness, orthographic variables, and grammatical usage for 1,080 words. *Behavioral Research Methods & Instrumentation, 14,* 375-399.

Garland, H. (1985). A cognitive mediation theory of task goals and human performance. *Motivation and Emotion*, 9, 345-367.

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers*. Personality and Individual Differences, 102*, 74-78.

Hakstian, A. R., & Cattell, R. B. (1974). The checking of primary ability structure on a broader basis of performances. *British Journal of Educational Psychology, 44*, 140 –154

Hertzog, C., Dixon, R. A., & Hultsch, D. F. (1990). Relationships between metamemory, memory predictions, and memory task performance in adults. *Psychology and Aging*, 5, 215-227.

Hertzog, C., Saylor, L. L., Fleece, A. M., & Dixon, R. A. (1994). Metamemory and aging: Relations between predicted, actual and perceived memory task performance. *Aging and Cognition*, *1*, 203-237.

Hertzog, C., McGuire, C. L., & Lineweaver, T. T. (1998). Aging, attributions, perceived control, and strategy use in a free recall task. *Aging, Neuropsychology, and Cognition*, *5*, 85-106.

Hertzog, C., & Dunlosky, J. (2004). Aging, metacognition, and cognitive control. In Ross, B.H. (Ed.), *The Psychology of Learning and Motivation: Advances in Research and Theory* (pp. 215–251). San Diego, CA: Academic Press.

Hertzog, C., & Dunlosky, J. (2006). Using visual imagery as a mnemonic for verbal associative learning: Developmental and individual differences. In T. Vecchi, & G. Bottini (Eds.), *Imagery and spatial cognition: Methods, models and cognitive assessment* (pp. 268−284). Amsterdam: John Benjamins Publishers.

Hertzog, C., Dunlosky, J., & Robinson, A. E. (2007). *Intellectual abilities and metacognitive beliefs influence spontaneous use of effective encoding strategies*. Unpublished manuscript.

Hertzog, C., McGuire, C. L., Horhota, M., & Jopp, D. (2010). Does believing in "use it or lose it" relate to self-rated memory control, strategy use, and recall? *The International Journal of Aging and Human Development, 70*, 61-87.

Hwang, Y., & Yi, M. (2002). Predicting the use of web-based information systems: intrinsic motivation and self-efficacy. Paper presented at the Eighth America's Conference on Information Systems Proceedings, 1076-1081.

Jacobs, J. (1887). Experiments on "prehension." Mind, 12, 75–79.

Kahneman, D. (1973). *Attention and effort.* Upper Saddle River, NJ: Prentice Hall.

Kanfer, R. (1990). Motivation and individual differences in learning: An integration of developmental, differential, and cognitive perspectives. *Learning and Individual Differences, 2*, 221-239.

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

Kanfer, R., Frese, M., & Johnson, R. E. (2017). Motivation related to work: A century of progress. *Journal of Applied Psychology, 102*, 338-355.

Kirchhoff, B. A. (2009). Individual differences in episodic memory: The role of self-initiated encoding strategies. *The Neuroscientist, 15*, 166–179.

Kirchhoff, B. A., & Buckner, R. L. (2006). Functional-anatomic correlates of individual differences in memory. *Neuron, 51*, 263–274.

Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). New York, NY: Guilford Press.

Kyllonen, P. C., Tirre, W. C., & Christal, R. E. (1991). Knowledge and processing speed as determinants of associative learning. *Journal of Experimental Psychology: General, 120*, 57–79.

Lachman, M. E., Bandura, M., Weaver, S. L., & Elliott, E. (1995). Assessing memory control beliefs: The Memory Controllability Inventory. *Aging, Neuropsychology, and Cognition, 2*, 67–84.

Liang, C., & Chang, C. C. (2014). Predicting scientific imagination from the joint influences of intrinsic motivation, self-efficacy, agreeableness, and extraversion. *Learning and Individual Differences, 31*, 36-42.

Lineweaver, T. T., & Hertzog, C. (1998). Adults' efficacy and control beliefs regarding memory and aging: Separating general from personal beliefs. *Aging, Neuropsychology, and Cognition, 5*, 264-296.

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance*. Prentice-Hall, Inc.

Locke, E. A., & Schattke, K. (2019). Intrinsic and extrinsic motivation: Time for expansion and clarification. *Motivation Science*, *5*, 277-290.

MacDonald, S. W. S., Stigsdotter-Neely, A., Derwinger, A., & Bäckman, L. (2006). Rate of acquisition, adult age, and basic cognitive abilities predict forgetting: New views on a classic problem. *Journal of Experimental Psychology: General, 135*, 368 –390.

Miller, M. B. (2009). Individual differences in the engagement of the cortex during an episodic memory task. In M. S. Gazzaniga's (Ed.) The cognitive neurosciences IV (pp. 739–750). Cambridge, MA: MIT Press.

Miller, A. L., Gross, M. P., & Unsworth, N. (2019). Individual differences in working memory and long-term memory: The influence of intensity of attention to items at encoding as measured by pupil dilation. *Journal of Memory and Language*, *104*, 25-42.

Miller, A. L., & Unsworth, N. (2020). Variation in attention at encoding: Insights from pupillometry and eye gaze fixations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 46*, 2277–2294.

Miller, A. L., & Unsworth, N. (2021). Attending to encode: The role of consistency and intensity of attention in learning ability. *Journal of Memory and Language, 121*, 104276.

Mogle, J. A., Lovett, B. J., Stawski, R. S., & Sliwinski, M. J. (2008). What's so special about working memory? An examination of the relationships among working memory, secondary memory, and fluid intelligence. *Psychological Science, 1*9, 1071–1077.

Otsuka, K., & Miyatani, M. (2020). Memory classes and group working memory span tasks change memory self-efficacy of older adults. *Educational Technology Research*, 43108.

Pearman, A., Lustig, E., Hughes, M. L., & Hertzog, C. (2020). Initial evidence for the efficacy of an everyday memory and metacognitive intervention. *Innovation in Aging*, *4*, 1-11.

Price, J., Hertzog, C., & Dunlosky, J. (2008). Age related differences in strategy knowledge updating: Blocked testing produces greater improvements in metacognitive accuracy for younger than older adults. *Aging, Neuropsychology, and Cognition, 15(5), 601-626.*

Robison, M. K., & Unsworth, N. (2018). Cognitive and contextual correlates of spontaneous and deliberate mind-wandering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 44*, 85-98.

Robison, M. K., Miller, A. L., & Unsworth, N. (2020). A multi-faceted approach to understanding individual differences in mind wandering. *Cognition, 198*, 104078.

Rohrer, D., & Wixted, J. T. (1994). An analysis of latency and interresponse time in free recall. *Memory & Cognition, 22*, 511–524.

Salthouse, T. A. (1991). Mediation of adult age differences in cognition by reductions in working memory and speed of processing. *Psychological Science, 2*, 179-183.

Schunk, D. H. (2012). Social cognitive theory. In K. R. Harris, S. Graham, & T. Urdan (Eds.), *Theories, Constructs, and Critical Issues: Vol. 1. Educational Psychology* handbook (pp. 101–123). Washington, DC: American Psychological Association.

Schunk, D. F., & DiBenedetto, M. K. (2020a). Motivation and social cognitive theory. *Contemporary Educational Psychology, 60*, 101832.

Schunk, D. F., & DiBenedetto, M. K. (2020b). Self-efficacy and human motivation. *Advances in Motivation Science, 8*, 153-179.

Shell, D. F., Murphy, C. C., & Bruning, R. H. (1989). Self-efficacy and outcome expectancy mechanisms in reading and writing achievement. *Journal of Educational Psychology, 81*, 91–100.

Shenhav, A., Musslick, S., Lieder, F., Kool, W., Griffiths, T. L., Cohen, J. D., & Botvinick, M. M. (2017). Toward a rational and mechanistic account of mental effort. *Annual Review of Neuroscience, 40*, 99–124.

Shipstead, Z., Lindsey, D. R. B., Marshall, R. L., & Engle, R. W. (2014). The mechanisms of working memory capacity: Primary memory, secondary memory, and attention control. *Journal of Memory and Language, 72,* 116 –141.

Siedlecki, K. L., Salthouse, T. A., & Berish, D. E. (2005). Is there anything special about the aging of source memory? *Psychology and Aging, 20*, 19 –32.

Stajkovic, A. D., & Luthans, F. (1998). Self-efficacy and work-related performance: A meta-analysis. *Psychological Bulletin, 124*, 240–261.

Tambini, A., Ketz, N., & Davachi, L. (2010). Enhanced brain correlations during rest are related to memory for recent experiences. *Neuron, 65*, 280–290.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of psychology, 53*, 1–25.

Underwood, B. J., Boruch, R. F., & Malmi, R. A. (1978). Composition of episodic memory. *Journal of Experimental Psychology: General, 107*, 393– 419.

Unsworth, N. (2009). Variation in working memory capacity, fluid intelligence, and episodic recall: A latent variable examination of differences in the dynamics of free recall. *Memory & Cognition, 37*, 837– 849.

Unsworth, N. (2010). On the division of working memory and long-term memory and their relation to intelligence: A latent variable approach. *Acta Psychologica, 134*, 16 –28.

Unsworth, N. (2016). Working memory capacity and recall from long-term memory: Examining the influences of encoding strategies, study time allocation, search efficiency, and monitoring abilities. J*ournal of Experimental Psychology: Learning, Memory, and Cognition, 42*, 50-61.

Unsworth, N. (2019). Individual differences in long-term memory. *Psychological Bulletin, 145*, 79-139.

Unsworth, N., & Brewer, G. (2009) Examining the relationships among item recognition, resource recognition, and recall from an individual differences perspective. *Journal of Experimental Psychology: Learning, Memory and Cognition, 35*, 1578-1585.

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37*, 498-505.

Unsworth, N., & McMillan, B.D. (2013). Mind wandering and reading comprehension: Examining the roles of working memory, interest, motivation, and topic experience. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 39*, 832-842.

Unsworth, N., & Miller, A. L. (2021). Individual differences in the intensity and consistency of attention. *Current Directions in Psychological Science, 30*, 391-400.

Unsworth, N., Redick, T.S., Heitz, R.P., Broadway, J., & Engle, R.W. (2009). Complex working memory span tasks and higher-order cognition: A latent variable analysis of the relationship between processing and storage. *Memory, 17*, 635-654.

Vallet, F., Agrigoroaei, S., Beaudoin, M., Fournet, N., Paignon, A., Roulin, J. L., & Desrichard, O. (2015). Older adults' beliefs about forgetting and aging predict memory self-efficacy above and beyond actual memory performance and mental health. *Revue Internationale de Psychologie Sociale*, *28*, 57-79.

Van Petten, C. (2004). Relationship between hippocampal volume and memory ability in healthy individuals across the lifespan: Review and meta-analysis. *Neuropsychologia, 42*, 1394-1413.

Walker, C. O., Greene, B. A., & Mansell, R. A. (2006). Identification with academics, intrinsic/ extrinsic motivation, and self-efficacy as predictors of cognitive engagement. *Learning and Individual Differences, 16*, 1-12.

West, R. L., & Berry, J. M. (1994). Age declines in memory self-efficacy: General or limited to particular tasks and measure? In J.D. Sinnott (Ed.), *Interdisciplinary Handbook of Adult Lifespan Learning* (pp. 426–445). New York: Greenwood Press.

West, R. L., Dark-Freudeman, A., & Bagwell, D. K. (2009). Goals-feedback conditions and episodic memory: Mechanisms for memory gains in older and younger adults. *Memory, 17*, 233-244.

West, R. L., Dennehy-Basile, D., & Norris, M. P. (1996). Memory self-evaluation: The effects of age and experience. *Aging, Neuropsychology, and Cognition*, *3*, 67-83.

Wig, G. S., Grafton, S. T., Demos, K. E., Wolford, G. L., Petersen, S. E., & Kelley, W. M. (2008). Medial temporal lobe BOLD activity at rest predicts individual differences in memory ability in healthy young adults. *Proceedings of the National Academy of Sciences of the United States of America, 105*, 18555–18560.

Wilhelm, O., Hildebrandt, A., & Oberauer, K. (2013). What is working memory capacity, and how can we measure it? *Frontiers in Psychology, 4*, 433.

Yusuf, M. (2011). The impact of self-efficacy, achievement motivation, and self-regulated learning strategies on students' academic achievement. *Procedia-Social and Behavioral Sciences*, *15*, 2623-2626.

Zimmerman, B. J., & Kitsantas, A. (2005). Homework practices and academic achievement: The mediating role of self-efficacy and perceived responsibility beliefs. *Contemporary Educational Psychology*, *30*, 397-417.