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Thinking about thinking about thinking … & feeling: A model for metacognitive and meta-affective processes in task engagement

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Abstract

Metacognition, or thinking about thinking, is a phenomenon that has received much attention across the numerous fields of Psychological Science. The overarching goal has centered on understanding how humans monitor their internal mental processes and exert control over these processes. However, discipline-focused approaches with little generalized discussion across the field have yielded an incomplete understanding of the construct of metacognition. Consider, for example, the cognitive approach: from this perspective, researchers have developed predictive models and useful frameworks. Further, the field has produced sophisticated techniques to measure monitoring accuracy and define attributes that contribute to monitoring assessments and control process selection. However, the impact of this research has been relatively limited and isolated from metacognitive investigations that consider other important constructs such as motivation and affect. The approaches taken in subfields, such as educational psychology, emotion, and neuropsychology when combined with the cognitive approach, may result in a more complete picture and thorough understanding of metacognition. In this article, we present an argument that the study of metacognition should bridge the various subfields of psychological inquiry. We present a framework toward an integrative approach to understanding metacognition as a complementary process to meta-affect and encourage researchers to consider the study of metacognition from a broader perspective.

This article is categorized under:

Psychology > Memory

Psychology > Emotion and Motivation

KEYWORDS

emotion regulation, metacognition, metamemory, self-regulated learning

1 | INTRODUCTION

As it is fundamental to the human experience, most people possess at least some folk understanding of metacognition. We generally understand how to engage in self-reflection and introspection. We operate under the assumption that self-reflection may foster behavioral change, which we can control. In this focused review article, we present an approach to metacognition that demonstrates how integral metacognitive processes are in our lives and how the diverse, but siloed research programs that have examined metacognition developmentally, cognitively, emotionally, socially, and educationally may be united under a cross-discipline framework which we hope will foster an integrative approach. Assessing knowledge, forecasting future emotional states, and evaluating certainty are elements of metacognition that are woven through many distinct sub-disciplines of psychology. Determining what information to study, establishing a plan for learning, choosing whether to watch a horror movie, or deciding to answer or not answer specific questions are generally conscious choices that are often influenced by our predictions of future emotional states, assessments of access to learned information, and even intangible feelings of familiarity.

The primary aim of this article is to present a new approach to thinking about metacognition that unites these disconnected fields and bridges across our common experiences. We define metacognition as the ability to monitor and control thinking as informed by motivation and demands of the task. Importantly, we suggest that metacognition should not be considered independently of parallel processes engaged to monitor and control affect. In this article, we present the meta-affect metacognition (MAMC) Framework.

Generally, the meta-affect literature, the emotion regulation literature, and the self-regulation of learning (SRL) literature has operated independently, although each focus on similar aspects of monitoring and control of emotions (but see, Tzohar-Rozen & Kramarski, 2018) For example, Efklides (2008) presented a model that, like ours, proposes processes involved in both cognition and emotion, but this model does not directly consider how specific cues associated with affective/emotional experiences are evaluated in the context of cognitive processes.

The present model, informed by the emotion regulation literature (e.g., Gross, 1998; Gross et al., 1997; Gross & Levenson, 1997; Richards & Gross, 2000), explicitly presents meta-affect as a mechanism that operates in tandem with metacognition, and is composed of both object-level and meta-level processes. We refer to meta-affect similarly to how researchers have traditionally referred to metacognition. That is, meta-affect is self-awareness about affect states. We consider meta-affect to encompass an ability to monitor and control affect states. We suggest that emotion regulation is a meta-affective process and can occur both analytically and non-analytically. For example, a student who has consistently had to deal with structural racism in the context of math education may decide that engaging in math results in too many negative emotions, and the student may choose to no longer take math courses (for salient examples see, McGee & Martin, 2011). In contrast, an older adult may deploy attention to positive features in a visual environment and avoid processing negative features.

In this framework, we suggest that metacognition and meta-affect are primary factors that directly impact the shared space of cognitive output and emotional experience. While other frameworks and models (mostly found within the education domain) have suggested the importance of monitoring and control of emotions within the context of learning, we suggest that meta-affect and metacognition are complementary and interconnected constructs that impact how we learn, regulate our wellbeing, and consider any new task that requires higher order cognitive processes. Within our framework, monitoring and control (how the individual engages with a task) is dynamic, continuous, and may be a conscious assessment or a rapid heuristic-like decision process (Koriat & Levy-Sadot, 1999, 2001; Metcalfe et al., 1993; Reder & Ritter, 1992). Importantly, we suggest that monitoring and control are dynamic and cyclical processes occurring in association with cognition and affect. Implicit in our model is the engagement in cognitive and affective processes across any task that requires consideration of emotional wellbeing in the context of learning. Further, the nature or demands of the task both influence and are influenced by the interaction between the meta level and object level of the model (see, Nelson & Narens, 1994).

Thus, the demands of any task represent another critical component of the proposed model. The task demands may require the individual to alter their approach and perhaps access relevant prior experience or knowledge. For example, an individual may be motivated to manage anxiety as they begin a high stakes final exam. Their success on the exam may require not only effective metacognitive processes (e.g., allocating the appropriate amount of time to answer a question) but also meta-affective processes (e.g., managing stress and anxiety to facilitate access to previously learned material; see, Smith et al., 2016). The task demands that the individual reduces feelings of anxiety internally so they can direct cognitive resources toward memory retrieval and problem solving. As the individual assesses their ability to successfully regulate their emotional state, they may find that the task itself may require them to use prior similar instances of successful regulation of anxiety to support their present goals. As another example, from a typical episodic memory task, an individual may be presented with a list of words from two distinct sources (words read, words heard). If the task requires the individual to remember the words and the source (read, heard) their approach may be different than if the memory test simply requires selection of previously presented items.

Our model is intentionally general, and purposefully does not present operationalized constructs. We see this as a strength as it allows for proposed constructs (e.g., metacognition, meta-affect) to be examined across a variety of different situations and tasks. For example, meta-affective processes could apply to student test-takers trying to manage anxiety or older adults trying to maintain a positive emotional state, while engaging in a neuropsychological assessment as part of a regular health exam.

In Figure 1, we represent these interacting factors within a hypothetical framework. As illustrated in Figure 1, an individual begins any task with some internal motivational state that guides their initial assessment or monitoring of what the task may require of them. Once the learner begins a task, they consider the demands of the task and the available resources. How individuals choose to approach a task will be influenced by their understanding of their own ability, an understanding of how the context or situation may constrain their ability, and the processing resources they have available. These examples all fall within a consideration of what our model presents as "resources." Importantly, our model suggests that resources will impact and are impacted by downstream meta processes. Importantly, this consideration is a meta-process, in and of itself. The factors that individuals bring to a given task, such as beliefs about their own abilities in each situation and their mental capacity to monitor or control output, are also considered in this framework as "resources," which inform monitoring and control of cognition and emotion. As the MAMC process unfolds, it constrains the available resources one must engage in the downstream processes. That is, these meta-processes which unfold over time, are dynamic, and often cyclical. We may monitor ongoing learning, implement strategies achieve

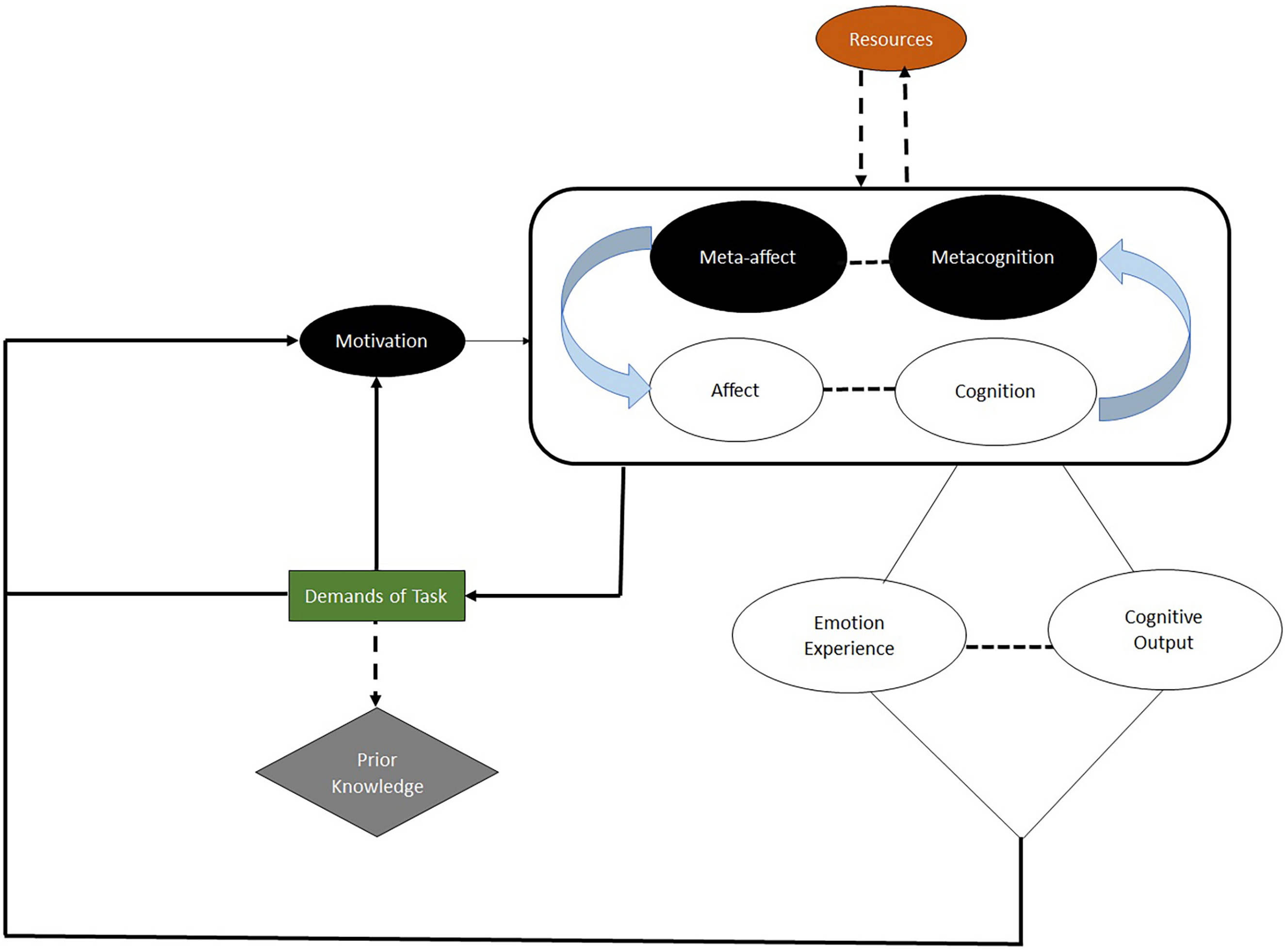

FIGURE 1 Meta-affect metacognition (MAMC) model of task engagement

desired states of learning, and repeat. As the cycle unfolds, resources available to engage are impacted. In this way, meta-processes (metacognitive and meta-affective) will impact resources.

Assessment of demands requires consideration of prior knowledge and prior experiences. The influence of prior knowledge may be automatic or more effortful. The evaluation of task demands, as informed by prior knowledge and relevant experiences, will inform motivational states. For example, when the task demands are high, but initial motivation is low, the motivational state my shift to accommodate those demands. Conversely, if motivation to perform accurately remains low, task demands may be ignored if assessed performance is not relevant or salient to the individual.

Important to this conceptualization, the evaluation of resources and task demands may result in revision to the control processes chosen to complete the task. Novel in our model is the separation of meta-affect and metacognitive processes with each operating at the meta-levels and influencing the object levels. A useful example to understand this important distinction is to consider the student who must take a high stakes final exam. The task requires affective and cognitive processing at the object level and monitoring and control of those processes at the meta level. Both meta-affect and metacognition would be influenced by the student's assessment of the demands of the task and the student's motivation associated with task performance. The individual's experience with the task (i.e., their emotional experience and cognitive performance) can feedback into and lead to revisions to their ongoing motivation. That is, an individual's approach to a task, be it regulating emotional states while preparing for an exam or giving testimony in the context of a criminal trial, will be guided by internal goals and motivations.

Our goal with bringing these elements together is not only to connect what we see as relevant and related constructs, but also to connect disparate areas of research. We see this framework as a way to integrate the important findings across cognitive psychology, educational research, and research focused on emotion. In addition, there is also significant work in neuropsychology and cognitive neuroscience that connects metacognition with executive functions (Fernandez-Duque et al., 2000) and prefrontal brain areas (Shimamura, 2002). Similarly, recent work by Fleming and colleagues (Bang & Fleming, 2018; Fleming et al., 2014) have examined the relationship between prefrontal cortical contributions to metacognitive tasks. Our framework considers research from neuropsychology and cognitive neuroscience as neural correlates representing the support of resources necessary for effective meta-processing.

Like models of metacognition within the Cognitive Psychological tradition, we argue that monitoring and control are key components. However, we expand traditional cognitive approaches to include both meta-affective and metacognitive processes which, we argue, are informed by task demands, individual motivations, cognitive resources, and access to relevant prior knowledge and experiences.

2 | METACOGNITION, EMOTION REGULATION, AND SELF-REGULATED LEARNING

Our proposed model is informed by research from the Cognitive Psychology, Cognitive Neuroscience, Emotional Regulation, and Education Psychology literature. Cognitive Psychologists have largely been influenced by the framework proposed by Nelson (1990), in which cognitive processes are split into two interrelated levels—the meta-level and the object-level. Information dynamically flows between the two levels, with the meta-level monitoring and exercising control over the object level. This framework gained popularity within the cognitive psychological community because it could easily be mapped onto a process model of memory and, therefore, generated highly testable predictions examining the relationship between the meta level and the object level of memory. For example, researchers examined monitoring processes associated with acquisition (e.g., judgments-of-learning [JOL]), retention (e.g., feeling of knowing [FOK]), and retrieval (e.g., confidence). Researchers also developed methods of understanding the relationship between the operationalized monitoring judgments and control processes, such as study time allocation, study choices, and decisions to withhold responses (for a review, see Dunlosky & Tauber, 2015).

Important as this model was for Cognitive Psychologists, it served to constrain the cognitive psychological approach to understanding metacognition as it operates within a sequential process model of memory (see Figure 2), and, consistent with the cognitive psychological tradition, it stripped away non-cognitive elements (e.g., affect, motivation) that likely play a significant role in how individuals monitor and control their own cognition (but see, Dixon & Hultsch, 1983; Koriat & Goldsmith, 1996).

In parallel to the development of the cognitive psychological approach to understanding metacognition, education researchers began to incorporate affect and motivation into investigations of self-regulated learning (SRL). Researchers argued that models of self-regulated learning should include motivational constructs, specifically *goal orientation*, to

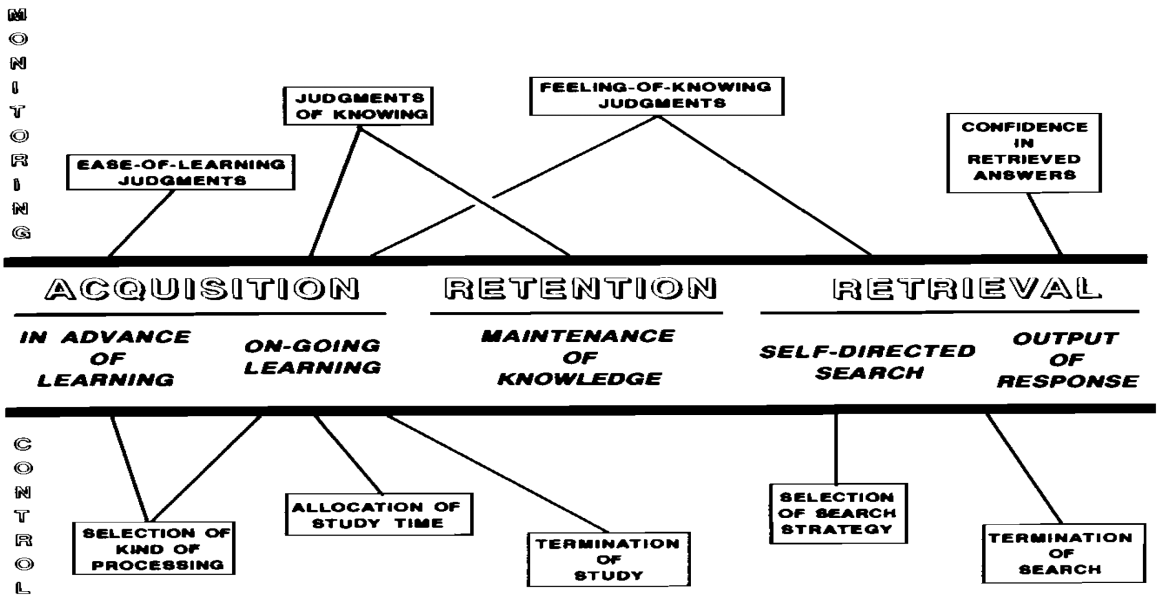

FIGURE 2 Theoretical memory framework and accompanying monitoring and control components *Source*: Reproduced from Nelson and Narens (1994)

effectively understand how individuals approach monitoring and control of learning (Pintrich, 2000; Pintrich et al., 1993; Pintrich & Schrauben, 1992; Zimmerman, 1986, 1998, 2000, 2013). Frameworks, generally coming from the education and educational psychology literature, share several basic assumptions: (1) learners are active participants in the learning process; (2) learners can monitor, control, and regulate aspects of cognition, motivation, and behavior; (3) there is some standard against which comparisons are made in order to assess whether the process should continue, change, or terminate; (4) self-regulatory activities are not directly linked to outcomes, but mediate the relationships between the learner, context of learning, and outcome (Pintrich, 2000). The general principles of these models are evident in research focused on academic and skill learning. For example, research supports the hypothesis that college students use learning and regulatory strategies when reading for learning, completing a brief essay, and studying for an exam (Hadwin et al., 2007). Cleary and Sandars (2011) demonstrated in medical students a relationship between quality of self-regulation strategies with surgical techniques and knowledge of surgical procedures. Cleary and Zimmerman (2012) also found that people can increase motor skill efficacy (e.g., shooting basketball free-throws) when they adopt the cyclical phase model of self-regulated learning (Zimmerman, 2000).

Much of what is contained in these basic assumptions aligns with what is assumed in standard metacognitive models from the Cognitive Psychological tradition. For example, the assumption of mental comparisons to some internal standard has been examined through the Cognitive Psychological perspective by examining how individuals implement metacognitive control. Research has demonstrated that a learner may choose to focus on studying items that are not known but are familiar to the learner, or within the learner's region of proximal learning (e.g., Metcalfe & Kornell, 2003). Alternatively, a learner may choose to continue to study until they have achieved some desired state of mastery (e.g., discrepancy reduction, Dunlosky & Hertzog, 1998). However, some aspects of primary assumptions from the SRL tradition are not considered in traditional Cognitive Psychological models. For example, metacognitive models have not typically integrated motivation (but see Dunlosky & Thiede, 1998). While omitted in many traditional models from Cognitive Psychology, this relationship has important practical implications. For example, a highly intelligent student may choose to not study mathematics, because participation engenders stress and anxiety (e.g., McGee & Martin, 2011).

There are numerous models that have been proposed to describe SRL. These models share a high number of constructs and processes, but at their core is metacognition (see, Panadero, 2017 for review). For example, several models propose that metacognition is the gateway to self-regulating learning (Efklides, 2011; Winne & Perry, 2000). However, comparison between the SRL models is difficult because these models frequently define metacognition differently. We suggest that metacognition is decomposed into monitoring and control, and operates dynamically with affective states, goals, and motivations, as well as cognitive resources available to the learner to foster continuous monitoring and control of, not only learning, but also emotional states and group interactions.

In addition to creating a framework that effectively integrates approaches and understanding from the SRL literature and traditional metacognition literature, we attempt to address the omission of well-studied meta-affective processes within the context of our framework. Cognitive-affective interactions, as they impact monitoring and control, have received less empirical attention within traditional models of metacognition, though they have received attention within the SRL literature (e.g., Efklides, 2011). Even within the SRL literature, how psychological and physiological components of affective states inform task engagement through meta-affective processes (e.g., how cues are weighed; how physiological factors are evaluated; how emotion regulation informs cognitive engagement) remain less well understood.

DeBellis and Goldin (2006) made important strides in bridging this gap by introducing the concept of meta-affect. Meta-affect can be thought of as the individual's monitoring of affect through cognition (thinking about the regulation of one's feelings). According to DeBellis and Goldin, cognition plays an important role in meta-affect, in that it may engender exploration of a topic (e.g., a complex math problem) or result in avoidance of the topic altogether. In our view, meta-affect shares much in common with Nelson and Narens (1994) conceptualization of metacognition as it consists of interacting meta and object levels. It also strongly aligns with research regarding emotion regulation (e.g., Gross, 2002) and affective forecasting (e.g., Gilbert et al., 2002).

According to Gross (2002), emotion regulation reflects the processes by which individuals influence what emotions they have and how they experience and express those emotions. Individuals can deploy attention toward or away from emotionally charged information (McRae & Gross, 2020). Additionally, individuals can select to engage with situations for which we can predict how we may feel based on prior experience.

As depicted in Figure 3 (adapted from McRae & Gross, 2020) individuals monitor the situation and exercise control through selection, modification, and/or engaging in cognitive reappraisal.

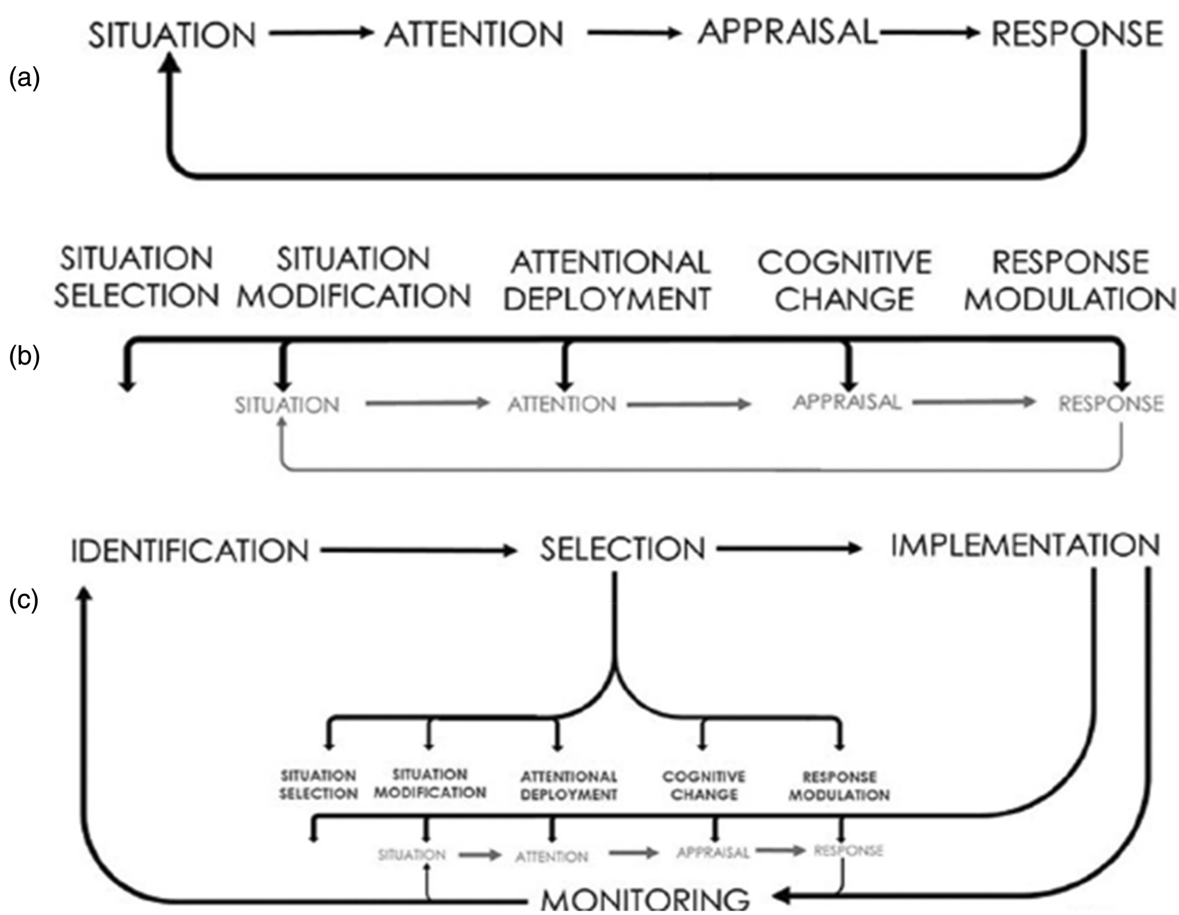

FIGURE 3 Stages of emotion regulation *Source*: Adapted from McRae and Gross (2020)

We suggest that meta-affective processes are crucial when considering all task operations that requires cognitive and emotional engagement. Educational Psychology researchers have carefully considered meta-affective processes in learning, suggesting that relevant emotional experiences can be grouped by standards and degree of implied activation. In terms of standards, positive emotions such as pleasant enjoyment can be distinguished from negative emotions such as unpleasant anxiety. These emotions are critically important for students' learning and performance (Pekrun et al., 2010; Schutz & Pekrun, 2007), particularly in problem solving (Gross et al., 2011; Isen, 2001). Meta-affective processes allow students to effectively monitor situational factors and physiological cues that may be attributed to negative emotions. In addition, meta-affective control process may result in a reappraisal of the emotional state from negative to positive. For example, a student may first experience bewilderment in problem solving as anxiety provoking but may come to re-evaluate that as a positive challenge (D'Mello et al., 2013). Although meta-affect has been widely studied within Education Psychology, research has focused mainly on the relationship between positive and negative emotions with achievement oriented self-regulation processes (D'Mello et al., 2013; Efklides, 2011). Additionally, SRL research has mostly focused on metacognitive regulation, with little consideration of meta-affective regulation (e.g., Kramarski & Mevarech, 2003; Schoenfeld, 1992). We offer a way to consider the interaction between meta-affect and metacognitive monitoring and control.

As with the SRL literature, theories of emotion regulation have much in common with models of metacognition from the cognitive perspective. It is often the case that monitoring and control of affective states are directly linked. Like the research on emotion regulation, investigations into affective forecasting—predicting emotional states in the future—suggest that prior experience and attention to internal states are necessary to engage in forecasting. That said, people seem to consistently perform poorly at predicting future emotions (Gilbert et al., 2002; Loewenstein, 2000; Wilson & Gilbert, 2005).

Each of the models that we have highlighted include some form of monitoring and control. We propose that monitoring and control should be at the heart of a modern framework of metacognition, and such a conceptualization must also account for individual goals, motivations, and constraints inherent to the individual. However, the context of an experience and the demands of the task are largely responsible for guiding these monitoring and control processes. Given that task demands are external to the individual, and can be applied to numerous contexts, we believe that they can be useful to inquiries in many psychological disciplines.

3 | MOTIVATION AND DEMANDS GUIDE MONITORING AND CONTROL

3.1 | Motivation

Although monitoring and control are central and interacting processes within our framework, we suggest that these processes cannot be initiated without *motivation* and goal setting. Therefore, a necessary construct for metacognition is motivation as established by the individual. Take for example, an eyewitness who might be motivated to be as accurate as possible. This motivational state will determine how the witness searches and evaluates accessed relevant memories. It may determine whether they volunteer or withhold some potentially relevant piece of information (e.g., Koriat & Goldsmith, 1996). For example, in a recent eyewitness memory experiment, Thomas et al. (2020) found that when motivation was not congruent with the mindset established after the activation of negative stereotype about aging older adults (>65 years old) were more likely to withhold correct *and* incorrect responses. That is, although participants in the experiment may have had an initial motivation to be helpful and provide as much correct information as possible, activation of negative stereotypes resulted in a shift in motivation. Motivated to not conform to the negative stereotype, older adults may have adopted a risk-averse approach to responding. Similarly, a student who is motivated to get a perfect score on an exam will likely approach the material differently than a student who is motivated to get a passing grade.

Research also demonstrated that motivation results in selective remembering, with better memory for information one is motivated to remember than information one is not motivated to remember (e.g., Castel et al., 2002; Halamish et al., 2019; Murphy & Castel, 2020). Research also suggests that motivation may result in selective processing during encoding (Dunlosky & Ariel, 2011) and at retrieval (Halamish & Stern, 2021).

Similar to the metacognitive and affective model of SRL (MASRL) proposed by Efklides (2011), the present model considers affect and motivation to have separate influences on task engagement. However, our conceptualization of meta-affective and affect as it impacts cognitive processes bridges directly to the emotion regulation literature and considers how both physiological and psychological cues associated with affective and emotional experiences influence task engagement. A primary difference between the present model and MASLR is that we see motivation as decoupled from self-concept. Although self-concept and affect can be related to motivation, we conceptualized self-concept as represented in MASLR, to be akin to the evaluation of resources in the present model, and as the MAMC model suggests, motivation will be influenced by task demands to impact meta-affect and metacognitive processes. The following discussion on task demands will clarify why we have established the relationship between motivation and task demands in this way. The previous discussion on selective remembering demonstrates how motivation can be considered independent of self-concept.

3.2 | Demands of the task

We further suggest that the *demands of the task* may impact the approach to the task. For example, within the Cognitive Psychological domain, a four alternative forced choice test (4AFC) demands that the learner ***selects*** the correct (or most familiar) answer from the group. A cued recall test that requires the same information would demand that the learner search their memory and ***produce*** the correct answer. Selection versus production requires different search and decision processes, and research has consistently demonstrated that production may be more cognitively demanding or effortful than selection (e.g., Bulevich & Thomas, 2012). In one study, Bulevich and Thomas found that greater task demands (as operationalized as the difference in a cued recall as compared to a recognition memory test) resulted in more effective metacognitive monitoring and control in an eyewitness memory experiment. That is, when older adult participants were asked to recall a previously witnessed event, they more effectively exercised metacognitive control to withhold suggested misinformation as compared to when the final memory test was a recognition test.

In addition to task output requirements, task instructions are included in the demands of the task, and they may interact with how individuals approach the task. As one example, Thomas and Gutchess (2020) required participants over the age of 65 to be as complete as possible in their answers to memory prompts within an eyewitness memory paradigm. Crucially, for half of these participants, a negative stereotype associated with aging (poor memory) was activated, resulting in control over what they choose to report on a final test of memory. Specifically, the participants with the activated stereotype chose to report fewer responses (correct and incorrect). In our framework, the incongruence between the control process, as instantiated by stereotype threat, and demands of the task, as instantiated by instructions for completeness, resulted in conflict that negatively impacted task output. Therefore, demands of the task resulted in a change to their approach, or the control processes selected.

As another example an eyewitness, who has been exposed to misinformation and is given a warning that the misleading information may have affected their memory (e.g., Karanian et al., 2020), may shift their approach from one that engenders a shallow search of memory to one that includes source discrimination. Thomas et al. (2010) found that when participants were explicitly told to carefully consider the accuracy of post-event information in an eyewitness experiment, participants were more accurate and better able to monitor the accuracy of their responses than when they were not given these kinds of instructions (see also, Karanian et al., 2020). These results suggest that when meta-processes are instantiated through task instructions, they can have downstream consequences on cognitive output.

Task demands that are revealed by the instructions (e.g., warnings about the deceptive nature of the misleading post event information), may result in individuals reassessing the task, and developing a new approach to evaluating retrieved memories. In this instance, we suggest that after evaluating the demands of the task, participants return to the monitoring stage to re-evaluate relevant prior knowledge and available resources. In this example, the context of the test required participants to reassess the task (monitoring) and likely altered the approach of, or controlled processes, chosen by the participants.

In addition to explicit instructions, research has consistently shown that inherent task demands will also directly impact how individuals select a strategy. For example, Finley and Benjamin (2012) demonstrated that learners will change encoding strategies to adapt to different test formats (see also, Rivers & Dunlosky, 2021). In these studies, test expectancy impacted performance as well as self-reported strategies. Importantly, understanding how one should approach a task depends on *prior experience* with that task. Therefore, explicit in our framework is how prior experience and knowledge interacts with task demands to influence metacognitive approach to a task.

Crucially, if the Task Demands are minimal, individuals may not be required to access prior experience or relevant knowledge. For example, the aforementioned eyewitness who was exposed to misleading information may not search memory for source specific cues associated with the memory for that event if the test does not require or instruct them to do so. Similarly, a student may not engage in an effortful search of their memory for a 4AFC recognition question if familiarity is sufficient to answer the question. Additionally, there may be situations where an individual may lack the relevant knowledge to meet the demands of the task. For example, effective emotion regulation may require that an individual be informed by their emotional states from previous similar situations. However, if the individual has no similar prior experiences to draw upon, then the monitoring and control process must operate without this information, likely resulting in suboptimal regulation. A new teaching assistant may be anxious about their first day with their class section and not be able to successfully regulate their emotional state. However, the seasoned instructor, knowing they do get anxious on the first day, may recognize that the demand of the situation requires them to remember successful first days from previous semesters.

Task demands can also impact motivation. For example, research has demonstrated that when participants are given specific incentives, these incentives can change motivation. Koriat and Goldsmith (1996) developed a task that de-incentivized incorrect responses. Specifically, participants were disproportionately penalized for incorrect answers as compared to rewarded for correct answers. When compared to an equated incentive group, participants who were disproportionately negatively penalized withheld more responses. They were *motivated* to reduce losses, and to do this, they changed their approach to responding. We suggest that participants may have begun the task with a motivation to do well; however, as the task instructions were made clear, their motivation state may have shifted to "avoid losses." These instructions also had measurable consequences on metacognitive control, with participants in the high penalty group withholding more incorrect *and* correct answers than participants in the equated incentive group.

3.3 | Internal and external constraints—Resources

An individual's approach may also be constrained by internal and external factors. External factors likely constrain an individual's approach and are evaluated heuristically. For example, even though it may lead to mastery of the material, a student likely will not develop an approach that requires 10 h of study per day. Similarly, one typically is not going to choose to study in a room with many distractions, because they recognize that those distractions will impact their ability to engage with the material. These examples illustrate how we consider external resource constraint evaluation as integral to our model.

Internal factors that constrain processing are similarly influential in our framework. One way that cognitive resources have been shown to impact metacognition has been to cross-sectionally compare older adults (over the age of 65) to younger adults (18–24 years old). Age differences have emerged across monitoring and control tasks (for review see, Castel et al., 2016; Hertzog, 2016). For example, Thomas et al. (2011) found that older adults demonstrated poorer metacognitive prediction accuracy than younger adults in an episodic FOK paradigm. Evidence from this study suggested that cognitive resources impacted how older adults approached the task. That is, when older adults were given external guidance as to how to weigh diagnostic cues prior to making FOKs, FOK accuracy improved.

Interestingly, although age-related changes in the brain may constrain cognitive processing (Thomas & Gutchess, 2020), there is a large body of research to suggest that older adults are better able to regulate emotions than younger adults (Gross et al., 1997). Research also suggests that older adults deploy more attention to positive than negative information as compared to younger adults (Isaacowitz et al., 2008). However, when compared to younger adults, older adults have been shown to exhibit reduced reappraisal-related activation in prefrontal regions (Opitz et al., 2014). These results suggest that older and younger adults have differences in available cognitive resources to engage in both metacognitive processes associated with cognition and with emotion regulation.

Similarly, research has demonstrated the relationship between prefrontal activation and effective metacognition. For example, Fleming et al. (2014) examined metacognitive accuracy in patients with lesions to the anterior prefrontal cortex. These patients showed a deficit in metacognitive accuracy though they performed equivalently on a memory task when compared to a healthy control group (see also, Bang & Fleming, 2018; Rounis et al., 2010).

Resource constraints seem to impact how older adults engage in emotion regulation. That is, their approaches or strategies to achieve their desired goal may be less cognitively demanding than those used by younger adults. Importantly, in the context of emotion regulation, as there are multiple possible trajectories to achieve task success, constraints on resources do not necessarily result in decrements in task performance. Resource constraints can also impact patients with prefrontal lesions and/or individuals who suffer from conditions that negatively impact prefrontal function. Importantly, individuals may be aware that their performance may be impacted by access to available processing resources and may adjust their strategy accordingly, as in the case of older adults' engaging in emotion regulation.

That said, deficits may be so severe as to result in unawareness and an inability to effectively monitor. For example, Thomas et al. (2013) found that older adults with early-stage dementia of the Alzheimer's type (DAT) were unable to accurately monitor learning in situations that required evaluation of cues associated with the to-be-learned material (see also Moulin, 2002). Consistent with this finding, people with DAT have also been shown to be less accurate than older adult controls in predicting memory performance insofar as these individuals tend to overestimate performance (Barrett et al., 2005; Moulin, 2002). This overestimation has been found for different types of memory material, such as words in episodic memory tasks and flashbulb memory (Budson et al., 2005). Our model would predict that individuals with severe deficits would demonstrate a breakdown in meta-processing because of impaired ability to engage resources.

To briefly reiterate the primary components of the proposed model, an individual approaches any given task with a specific motivation. This motivation will affect how individuals engage with the task and motivation impacts both metacognitive and meta-affective processes. Task engagement may be constrained by two additional factors. The first is resources, in that the individual will need to engage with the task in a way that can accommodate both situational (noisy environments) and internal (prefrontal cortical capacity) factors. The second is task demands, in that engagement with the task may lead to a revision to their specific motivation, either through explicit instructions or, implicitly, through ongoing experience with the task. If those task demands require additional knowledge, that information may be accessed during this stage of the model, if required by the task. Finally, the processes occurring at the meta and object level will produce output in the form of emotional experiences and objective cognitive performance. The experience from this output can feedback into and may allow for revisions to motivation.

4 | CONCLUSIONS

We should be clear that we have not directly empirically tested the pathways proposed in this framework. Rather, we present this framework as a means to spark research that integrates motivation and task demands into the general thinking of how metacognition operates across various affective and cognitive processes. Our own research, as well as the research of others discussed in this review have provided some evidence for a causal relationship between motivation and metacognition (Jang et al., 2020; Sidi et al., 2018); prior knowledge and metacognition (Mihalca & Mengelkamp, 2020; Whatley & Castel, 2021); task demands and control (Dai, 2020; Fiechter & Benjamin, 2018; Palmer et al., 2010; Toppino & Pagano, 2021); monitoring and control (DeCaro & Thomas, 2019; Efklides, 2014; Koriat et al., 2014), control and output (Bulevich & Thomas, 2012; Undorf et al., 2021), and finally between cognitive resources and metacognition (Murphy & Castel, 2020; Peng & Tullis, 2021; Thomas et al., 2011, 2013). However, additional empirical research will help to refine this framework and promote its value in uniting the presently independent fields investigating metacognition. Importantly, we propose separate but interacting mechanisms associated with meta-affect and metacognition. Although prior models have considered affect and emotion in the context of metacognition (e.g., Efklides, 2008, 2011), models have generally considered affective processes as impacting metacognition. We suggest that meta-affective processes interact with metacognitive processes. Our model provides a path forward in testing how these two mechanisms operate and interact.

Understanding the role of meta-affect and metacognition in psychological processes is a scientific problem that cuts across different disciplines focused on understanding human behavior. Although researchers across domains have approached the study of metacognition using different techniques and methods, it should be clear even from this focused review that monitoring and control of human thinking and behavior are central to Western Psychological theory. An accurate understanding of these processes requires us to look beyond discipline specific research. We are hopeful that this framework will encourage a problem-based approach to the study of metacognition that brings together traditionally isolated fields of study across psychology.

AUTHOR CONTRIBUTIONS

Ayanna Thomas: Conceptualization (lead); formal analysis (lead); project administration (lead); writing – original draft (lead); writing – review and editing (lead). **Alia Wulff:** Investigation (supporting); project administration (supporting). **Dominique Landinez:** Investigation (supporting). **John Bulevich:** Conceptualization (equal); writing – original draft (equal); writing – review and editing (equal).

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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