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Mind-Wandering When Studying Valuable Information: The Roles of Age, Dispositional Traits, and Contextual Factors

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The factors that trigger lapses of attention (e.g., mind-wandering) during new learning remain unclear. The present study investigated whether the likelihood of experiencing an attentional lapse depends on (a) the importance of the material being studied and (b) the learner's age. In two experiments, younger and older adults completed a delayed free recall task in which to-be-remembered words were paired with point values. Thought probes were embedded into the encoding phase of each list to provide an index of one's ability to maintain attention on task and prevent recurrent lapses of attention (i.e., the consistency of attention). Experiment 1 revealed all individuals better remembered high-value information at the expense of low-value information, and older adults were more frequently focused on the task than younger adults. Participants were also less likely to remember an item at test if they experienced an attentional lapse while learning said item, and they were more consistently focused on the task when studying high-value information than when studying low-value information. Age did not moderate either of these effects. Experiment 2 replicated the findings from Experiment 1 and further revealed that the positive association between age and attentional consistency was explained by age-related differences in affect, motivation, personality, and attention-deficit hyperactivity disorder symptomology. Once these factors were accounted for, older age was associated with increased attentional *inconsistency* (less on-task focus). While future replication of this finding is needed, implications for education and theories of both mind-wandering and aging are discussed.

Public Significance Statement

Discovering ways to help people stay focused while learning has posed a challenge for researchers. The present study shows that if an individual values the material they are learning, they are more likely to consistently pay attention to and remember said material, regardless of advancing age. Furthermore, while older adults generally do not remember information as well as younger adults, they are seemingly better able to stay focused on what they need to learn. However, when controlling for personality traits, attention-deficit hyperactivity disorder symptomology, affect, and task-specific motivation, the results suggest older adults may actually be *more* susceptible to various internal distractors (e.g., mind-wandering about an upcoming doctor's appointment or weekend plans) and external distractors (e.g., a stranger speaking loudly nearby) relative to younger adults. Overall, these findings highlight the multifaceted nature of one's ability to stay focused on what they are learning and offer insights for enhancing learning across different age groups.

Keywords: mind-wandering, lapses of attention, learning, episodic memory, attention control

Imagine you are at a café, catching up with a friend who is talking about a book they recently read. As your friend enthusiastically delves into the plot, your mind unintentionally begins to drift to another book you have long intended to read but have not yet acquired. The idea of visiting a nearby bookstore crosses your mind, but the thought is quickly overshadowed by the numerous errands awaiting you that afternoon. Meanwhile, as your friend has moved on to discussing a major plot twist, your attention snaps back to the

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conversation. Later, when you attempt to recall the details from your morning rendezvous, the unexpected plot twist lingers in your memory, but you struggle to recall more specific details about your friend's book. This scenario, familiar to many, demonstrates how a lapse of attention during the learning process can significantly hinder subsequent memory (Blondé et al., 2022; deBettencourt et al., 2018; Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). More specifically, this example reflects a temporary shift in attention away from the task at hand toward internal thoughts and concerns (i.e., mind-wandering/daydreaming).

Given the widespread occurrence and implications of attentional lapses in educational (Brown, 1927; Lindquist & McLean, 2011; Unsworth et al., 2012; Wammes et al., 2016) and occupational (Jones & Martin, 2003; Reason, 1990) settings, it is imperative for researchers to gain a deeper understanding of *who* is most prone to these lapses and *when* lapses most frequently occur. Regarding the former, studies have reliably shown that people with poor attention control abilities tend to experience more frequent lapses of attention when completing attentionally demanding tasks (Kane et al., 2016; McVay & Kane 2012b; Robison et al., 2020; Unsworth & McMillan, 2014; Unsworth et al., 2021). Notably, attention control is one mechanism (e.g., Head et al., 2008; McCabe et al., 2010; Nordahl et al., 2005) thought to underlie adult age-related declines in the ability to accurately remember specific experiences from one's past (i.e., episodic memories; Tulving, 2002) and performance in other cognitive domains (e.g., Braver & West, 2008; Hasher & Zacks, 1988). Yet, a perplexing negative association has been repeatedly documented between age and susceptibility to attentional lapses—leading some to suggest that age-related differences in attention control are exaggerated (Rey-Mermet & Gade, 2018; Verhaeghen, 2011). In terms of the latter, the circumstances under which lapses most frequently occur remain poorly understood, especially within a learning and memory context. With few exceptions (e.g., Xu & Metcalfe, 2016), researchers have not examined factors that could reduce lapses of attention during learning.

The present study therefore had two overarching goals. First, we aimed to advance our understanding of *who* is most susceptible to lapses of attention by focusing on the role of age. If older adults continue to experience more on-task focus and less frequent lapses of attention (high attentional consistency) during intentional learning conditions, we sought to investigate the possible reasons why. Second, we sought to advance our understanding of *when* lapses most frequently occur by testing the potential moderating influence of value. In an information-saturated world, some details are inevitably more important to remember than others. Hence, individuals may adjust the consistency of their attention (i.e., the regularity with which they allocate attention to on-task processing on an item-by-item basis over time; see Unsworth & Miller, 2021) based on the value of the information encountered. To investigate these matters, the present study adopted an interdisciplinary approach by focusing on the potential roles of dispositional factors (personality traits and attention-deficit hyperactivity disorder [ADHD] symptomology) and contextual, state-based factors (motivation, positive and negative affect, state anxiety). By exploring the interplay between age, dispositional traits, and contextual factors in value-driven learning, the present study provides important insights into the complex nature of when, and for whom, lapses of attention are most frequent. Unraveling these complexities is essential for advancing psychological theory and holds practical implications for optimizing learning across different age groups and individual learner profiles.

Lapses of Attention

A fundamental aspect of sustained attention is the notion that attention fluctuates, leading to variability in task performance. Sometimes substantial attention is devoted to a given task, resulting in high levels of task engagement and, subsequently, better performance. Other times, less attention is allocated to said task, leading to reduced levels of task engagement and decreased performance. These fluctuations in attention, whether minor (with little to no influence on performance) or more extreme (with a considerable impact on performance), can be conceptualized as lapses of attention wherein an individual temporarily disengages from the task at hand, culminating in a failure or delay to execute an intended action (Cheyne, 2010; Reason & Mycielska, 1982). Several laboratory techniques have been developed to examine one's ability to consistently maintain attention on task and, more specifically, one's ability to prevent recurrent lapses of attention. One of the most widely employed methods, adopted in the present study, is the thought probe technique (Kane et al., 2007; McVay & Kane, 2009, 2012b; Miller & Unsworth, 2021; Robison et al., 2020; Seli et al., 2015; Smallwood et al., 2003; Stawarczyk et al., 2011; Unsworth & McMillan, 2014; Unsworth et al., 2021). This technique involves intermittently pausing participants during a task and asking them to indicate whether, immediately before the probe's appearance, their attention was directed toward the task or whether they were thinking about things unrelated to the task (see Smallwood & Schooler, 2006, 2015, for review). An advantage of this technique is that it allows researchers to classify various forms of task-unrelated (off-task) thoughts that are independent of the ongoing task (Stawarczyk et al., 2011).[1] Mind-wandering is one example. Others include temporary shifts of attention away from the task toward unrelated external stimuli (i.e., external distraction) and moments of "zoning out," where attention neither adheres to specific internal thoughts nor external stimuli (i.e., mind-blanking). Indeed, mind-blanking can be thought of as the absence of thought, reflecting a more extreme form of task disengagement (Ward & Wegner, 2013). Like mind-wandering, instances of external distraction (McVay & Kane, 2012a; Robison & Unsworth, 2015; Unsworth & McMillan, 2014) and mind-blanking (Stawarczyk & D'Argembeau, 2016; Unsworth & Robison, 2016) have been associated with poor behavioral performance in attention-demanding tasks. For example, negative associations between performance and various forms of task-unrelated thought (TUT) have been observed in the sustained attention to response task (McVay & Kane, 2012a;

[1] Stawarczyk et al. (2011) characterize ongoing conscious experiences based on two key dimensions: stimulus dependency and task relatedness. Specifically, a thought can be categorized as either (a) dependent on or independent of an external task stimulus and (b) related or unrelated to the task at hand. Accordingly, a pure on-task state is when thoughts are both related to the task and are dependent on the external task stimulus, whereas a complete off-task state is both unrelated to the task and independent of the external stimulus.

Smallwood et al., 2004; Stawarczyk & D'Argembeau, 2016; Stawarczyk et al., 2011), the Stroop task (Robison & Unsworth, 2018; Unsworth & McMillan, 2014; Unsworth & Robison, 2017b), the psychomotor vigilance task (Robison & Unsworth, 2018; Unsworth & McMillan, 2014; Unsworth et al., 2020; Unsworth & Robison, 2016, 2017b), and the antisaccade task (Hutchison et al., 2020; Robison & Unsworth, 2018; Unsworth & McMillan, 2014; Unsworth & Robison, 2017b). As alluded to previously, similar findings emerge when embedding thought probes into various episodic memory tasks (Blondé et al., 2022; Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). Furthermore, the proportion of TUTs experienced during a given task correlates with other common indicators of attentional lapses, including reaction time coefficient of variation (Kane et al., 2016; Unsworth, 2015) and variation in baseline pupil diameter (Unsworth & Robison, 2017a; Unsworth et al., 2021). Hence, the thought probe technique is a valid indicator of lapses of attention in a variety of laboratory and real-world settings (e.g., Kane et al., 2007, 2017; McVay et al., 2009; Unsworth et al., 2012; Unsworth & McMillan, 2017). In terms of understanding why lapses of attention occur, and for whom lapses are most frequent, several theoretical frameworks have been proposed (e.g., McVay & Kane, 2010; Robison et al., 2020; Smallwood & Schooler, 2006). However, these theories are specific to instances of mind-wandering and not necessarily about external distraction or mind-blanking per se. Therefore, similar to McVay et al. (2013), the present study uses theories of mind-wandering as a guiding principle to understand the experience of TUTs (i.e., mind-wandering, external distraction, and mind-blanking) and attentional consistency more broadly.

One of the most prominent theories, inspired by Klinger (1971, 2009), is the *Control Failure* × *Current Concerns* account (McVay & Kane, 2010). This view suggests that the contents of TUTs are generated automatically in response to environmental cues and prominent personal concerns (e.g., resolving a conflict with one's spouse). While lapses of attention may confer some benefits (see Decker et al., 2023; Fox & Beaty, 2019), McVay and Kane (2010; see also McVay et al., 2013) suggest that lapses largely reflect unwanted breakdowns of our attention control system. Namely, attention control—commonly referred to as cognitive control (Botvinick et al., 2001), executive control (Baddeley, 1996), or executive attention (Engle, 2002)—is needed to actively maintain task-relevant information in the presence of internally or externally distracting information, enabling us to guide thought and action in accordance with task goals. Therefore, mind-wandering, in particular, is shaped by (a) an individual's ability to maintain task goals and inhibit competing task-irrelevant thoughts as well as (b) the salience of unresolved worries of the individual. When personal concerns rise to the forefront of consciousness during an ongoing task, such instances represent a failure of the attention control system to keep attention on task.

Given that people with enhanced attention control abilities are generally less susceptible to various forms of attentional lapses (Kane et al., 2016; McVay & Kane, 2012b; Robison et al., 2020; Unsworth & McMillan, 2014; Unsworth et al., 2021), and attention control abilities are impaired with advanced adult age (e.g., Braver & West, 2008; Cohn et al., 1984; Hamm & Hasher, 1992; Hartley, 1993; Hasher & Zacks, 1988; Nicosia et al., 2021; Spieler et al., 1996; West & Baylis, 1998), one would expect younger adults to be less susceptible to recurrent lapses of attention relative to older adults. However, as previously mentioned, existing research indicates that *younger* adults actually report more frequent TUTs than older adults (Bonifacci et al., 2023; Frank et al., 2015; Giambra, 1989; Jackson & Balota, 2012; Jackson et al., 2013; Krawietz et al., 2012; McVay et al., 2013; Robison et al., 2022; Seli et al., 2017; Staub et al., 2014a, 2014b, 2015; Vallesi et al., 2021; for review, see Jordão et al., 2019). This finding is inconsistent with the control failure account (McVay & Kane, 2010).

An alternative theory is that the experience of a lapse is an attentionally resource-demanding process (Smallwood & Schooler, 2006; Teasdale et al., 1995). That is, when mind-wandering, less attention is seemingly allocated to task-relevant stimuli compared to when an individual is completely focused on task, because attention is at least partially split between internal task-irrelevant information and, in the case of learning, the to-be-remembered material (i.e., perception becomes decoupled from the external task stimulus; Smallwood & Schooler, 2006; Smallwood et al., 2003). Extending this logic to cases of external distraction, attention would be split between the to-be-remembered material and the external, task-unrelated stimulus. In either event, the temporary reduction in the amount of attention devoted to the to-be-remembered material is thought to result in a weaker memory representation that is less likely to be remembered (Miller & Unsworth, 2021), akin to effects of divided attention whereby attentional resources for a secondary task compete with attentional resources for the primary task (Anderson et al., 1998; Baddeley et al., 1984).

In terms of aging and memory, researchers (Craik & Byrd, 1982) have long believed, and continue to believe (e.g., Craik & Rose, 2012; Greene & Naveh-Benjamin, 2023), that age-related deficits in episodic memory are largely attributed to a decline in attentional resources. Thus, relative to younger adults, older adults may experience fewer TUTs because most of their attentional resources are consumed by the criterion task. Accordingly, the *resource competition account* (Smallwood & Schooler, 2006) argues that TUTs enter conscious awareness when there are attentional resources to spare as opposed to when attention control fails. So, if most of their resources are allocated to learning to-be-remembered material, older adults likely lack the resources necessary to produce spontaneous instances of TUT.

If age-related differences in the ability to maintain attention on task (and prevent recurrent lapses of attention) are driven by availability of attentional resources, and availability of said resources declines with age, older adults should demonstrate larger performance decrements during an attentional lapse when compared to younger adults—assuming TUTs consume similar amounts of attentional resources across age groups. However, at least one study contradicts this prediction. McVay et al. (2013) compared sustained attention performance on trials immediately preceding TUTs to performance on trials immediately preceding on-task thoughts and found younger and older adults demonstrated the same degree of task disruption. Yet it remains to be seen whether similar results arise during intentional learning conditions on a delayed free recall (DFR) task, a task that is especially resource demanding.

Dispositional and Contextual (State-Based) Factors

One's propensity to experience lapses of attention may depend on factors other than attention control or availability of attentional resources. For example, the tendency for highly agreeable people to be cooperative and comply with directions (Costa & McCrae, 1992) could be why a recent study found a negative correlation between agreeableness and intentional mind-wandering (willfully disengaging from the task at hand in favor of thinking about other things; Robison et al., 2020). Similar results have been found for conscientiousness (Jackson & Balota, 2012; Robison et al., 2020; cf. Kane et al., 2017). If highly consciousness individuals are more focused on achieving their goals and are more diligent in their efforts to achieve said goals (Costa & McCrae, 1992), these individuals should presumably be more consistently focused on completing a given task. Several other studies have shown that susceptibility to lapses of attention also positively correlates with neuroticism (Jackson et al., 2013; Kane et al., 2017; Robison et al., 2017; Unsworth et al., 2021), which aligns with the idea that current concerns predominate our thoughts and interfere with on-task focus (McVay & Kane, 2010). That is, neuroticism is linked to self-consciousness and embodies an individual's tendency to experience anxiety, depression, and vulnerability (Costa & McCrae, 1992). People who are highly neurotic should thus focus more on negative thoughts about themselves, leading to more frequent mind-wandering due to the heightened salience of these concerns.

Critically, multiple studies have consistently demonstrated age-related increases in agreeableness and conscientiousness but age-related decreases in neuroticism (e.g., Bleidorn et al., 2009; Roberts & Mroczek, 2008; Soubelet & Salthouse, 2011; Terracciano et al., 2005). While research has yet to document a potential role of agreeableness or neuroticism in explaining the relationship between age and lapses of attention, at least two studies have revealed that older adults' increased conscientiousness may partly explain why they are less likely to experience TUTs compared to younger adults (Jackson & Balota, 2012; Nicosia & Balota, 2021). However, this result is not always found (Jackson et al., 2013; Maillet & Rajah, 2016). Nevertheless, these findings collectively suggest that age-related differences in several personality traits—agreeableness, conscientiousness, and neuroticism—could potentially explain why older adults are more consistently focused on task than are younger adults.

The dispositional traits discussed above reflect stable and enduring personality characteristics. Some mental health conditions may be viewed in a similar manner, insofar that they represent a set of relatively stable *neurodevelopmental characteristics*. That said, it should be noted that the manifestation of thoughts and behaviors relevant to clinical diagnoses can be modified and improved through psychological treatment, unlike personality. Regardless, symptoms of ADHD are a set of specific characteristics (and impairments) related to the experience of attentional lapses. Lapses of attention have been associated with impulsivity (Cheyne et al., 2009), fidgeting (Seli et al., 2014), and poor performance on measures of attention control (Kane et al., 2016; Unsworth, 2015)—all of which are features of ADHD (Barkley, 1997; Barkley et al., 1997; Hinshaw, 1994). More direct evidence comes from several studies that have revealed mind-wandering, particularly unintentional forms of mind-wandering, positively correlates with ADHD symptomology (Arabacı & Parris, 2018; Biederman et al., 2017; Mowlem et al., 2019; Seli et al., 2015). Importantly, the prevalence of ADHD seems to decline with age (Song et al., 2021; Vos & Hartman, 2022), suggesting another potential avenue by which lapses of attention become less frequent in older age (Moran et al., 2021).

Taken altogether, the research reviewed thus far has focused on cognitive and dispositional predictors of lapses of attention. However, it is also crucial to consider situational states that vary over time and in response to different circumstances (i.e., contextual factors). Two key variables to consider are *affect* and task-specific *motivation/interest*.[2] Regarding affect, Smallwood et al. (2009) induced positive, neutral, and negative moods immediately before participants completed a sustained attention task. Compared to positive mood, negative mood resulted in more frequent lapses of attention during the task (see also Jonkman et al., 2017; cf. Seibert & Ellis, 1991). In another study, Kane et al. (2017) conducted a weeklong daily life experience-sampling study and showed that younger adults mind-wandered more when they experienced negative affect, such as anxiety, sadness, confusion, and irritation (see also Kane et al., 2007; Killingsworth & Gilbert, 2010; McVay & Kane, 2009; Robison et al., 2020).

In terms of task-specific *motivation/interest*, prior work with younger adults demonstrates that those who are highly motivated to excel in a task tend to experience fewer lapses of attention during said task (Miller & Unsworth, 2021; Robison & Unsworth, 2018; Seli et al., 2015; Unsworth & McMillan, 2013). Theoretically, to optimize their performance, individuals who are more motivated to perform well should more consistently direct attention to the task at hand. By remaining consistently attentive to the task, these individuals with high motivation perform better. Furthermore, as time spent on task increases and it becomes more challenging to sustain attention across trials, TUTs become more difficult to inhibit leading to an increase in lapses and subsequent declines in performance (i.e., "time-on-task effect"; see Thomson, Seli, et al., 2014). Therefore, those who are more motivated to perform well may also be more inclined to persist in their efforts to sustain attention across the entire task, resulting in better attentional consistency on a trial-by-trial basis and overall better task performance.

Critically, older adults tend to report less negative affect (Barrick et al., 1989; Carstensen et al., 2000; Charles et al., 2001; Gross et al., 1997; Grühn et al., 2010) and more positive affect/subjective well-being (Cacioppo et al., 2008; Stawski et al., 2008) relative to younger adults. Additional studies have shown that older adults may, in some contexts, be more motivated to perform well on a variety of laboratory tasks (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Ryan & Campbell, 2021; Seli et al., 2017, 2021). Accordingly, older adults' heightened motivation, greater positive affect (Frank et al., 2015), and lower levels of anxiety (Moran et al., 2021) have each been shown to explain part of the association between age and TUTs. However, it

[2] In a prior study (Robison & Unsworth, 2018), task interest and task-specific motivation were nearly perfectly correlated. Given intrinsic motivation may be defined as liking specific tasks simply because the activity brings one pleasure (traditionally referred to as interests; see Locke & Schattke, 2019), it is not entirely surprising that asking participants to rate their interest in, and motivation to perform well on, a given task produces redundant results. For these reasons, the present study solely focuses on motivation, but we note other studies in the cognitive aging literature focused on interest instead of motivation (Jackson & Balota, 2012; Krawietz et al., 2012).

remains unclear whether similar outcomes emerge within a learning and memory context and whether older adults can flexibly adjust the consistency of on-task focus based on the perceived value of the to-be-remembered material.

The Potential Role of Value in Lapses and Learning

Several studies have suggested that motivation manipulations can reduce the frequency of attentional lapses in younger adults (Mrazek et al., 2012; Seli et al., 2019; Unsworth et al., 2022). Mrazek et al. (2012) found that monetary incentives reduced TUTs during a working memory task, whereas Seli et al. (2019) discovered that TUTs were reduced when participants were told they could leave the experiment early if they performed well on a sustained attention task (cf. Robison et al., 2021). Unsworth et al. (2022) also had participants complete a sustained attention task, but half of the participants were assigned to a condition in which they were instructed to "Try Hard" on a subset (20%) of trials. Participants in the "Try Hard" condition displayed larger task-evoked changes in pupillary responses before and after stimulus onset (an indicator of effort expenditure), fewer TUTs, and better performance when compared to participants in the control condition. These results are consistent with the idea that effort mobilization can reduce the occurrence of lapses of attention (e.g., Botvinick & Braver, 2015; Westbrook & Braver, 2015). That is, when motivated, participants mobilize effort to increase the amount of attention allocated to the task, resulting in better overall task performance and a reduction in lapses of attention (Unsworth et al., 2022).

Research has yet to examine whether motivation manipulations similarly promote on-task focus during new learning, but motivational manipulations have been shown to influence episodic memory performance (e.g., Castel, 2024; Knowlton & Castel, 2022; Watkins & Bloom, 1999). For example, Adcock et al. (2006; see also Shohamy & Adcock, 2010) required participants to study a series of pictures. Each picture was associated with a specific monetary amount, and participants were awarded that amount if they correctly recalled the corresponding image at test. Results revealed subsequent memory was best for pictures that were worth more money. Earlier studies manipulated the value of the to-be-remembered material by using points. Namely, Castel et al. (2002) asked participants to study multiple lists of words, and each word within a list was paired with a point value. Points were awarded to the participant if the accompanying word was correctly recalled at test, and participants were instructed to score as many points as possible. Results revealed superior recall for high-point words compared to low-point words (i.e., value-directed remembering [VDR]).

Ensuing research corroborated Castel et al.'s (2002) findings, suggesting that enhanced memory for important information is largely achieved through differential encoding. For instance, both younger and older adults spent more time studying items paired with higher point values when study time was under their direct control (Castel et al., 2013). Other investigations experimentally controlled study time while simultaneously recording pupil dilation, a commonly used indicator of attentional effort (see Kahneman, 1973; Unsworth & Miller, 2021). In each of these experiments (Ariel & Castel, 2014; Kahneman & Peavler, 1969; Miller et al., 2019), high-value items were associated with larger pupillary responses at encoding relative to low-value items. These findings collectively suggest that learners flexibly allocate more attentional effort to the most important information. Therefore, if information importance, as determined by point values, is construed as motivating, it seems possible that individuals may similarly modulate the consistency of attention according to the importance of the to-be-remembered material. In other words, individuals may be more consistently focused on task (i.e., less susceptible to TUTs) when studying valuable information.

The Present Study

Previous research indicates there are many potential reasons why increased age is associated with less frequent TUTs (high attentional consistency). Predominate theories highlight the roles of attentional resources (Smallwood & Schooler, 2006); failures of attention control (McVay & Kane, 2010); the salience of competing personal concerns (Klinger, 1971, 2009); and a variety of dispositional factors, such as personality traits (Jackson & Balota, 2012; Nicosia & Balota, 2021) or neurodevelopmental conditions like ADHD (Moran et al., 2021). Other theories highlight the role of state-based factors, including task-specific motivation/interest (Frank et al., 2015; Jackson & Balota, 2012; Krawietz et al., 2012, Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021) and affect (Frank et al., 2015; Moran et al., 2021). Note, however, that each of these studies examined age differences in TUTs while participants performed monotonous sustained attention tasks (Giambra, 1989; Jackson et al., 2013; McVay et al., 2013; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021; Staub et al., 2014a, 2014b, 2015; Vallesi et al., 2021) or reading comprehension tasks (Bonifacci et al., 2023; Frank et al., 2015; Jackson & Balota, 2012; Krawietz et al., 2012).

There are a few reasons to suspect different results may arise during intentional learning conditions common to episodic memory tasks. First, older adults tend to maintain relatively strong reading comprehension skills (De Beni et al., 2007; Radvansky & Curiel, 1998). Similarly, older adults appear to commit fewer errors in sustained attention tasks than younger adults (Carriere et al., 2010)—owing to a more strategic response style favoring accuracy over speed (see also Vallesi et al., 2021). Conversely, research consistently demonstrates that increased age is associated with more negative change in episodic memory (Craik, 1994), especially when study and test conditions require self-initiated controlled processing (Craik, 1977; Craik, 2022; Craik & McDowd, 1987; Craik & Simon, 1980).

It thus seems possible that intentional learning conditions common to episodic memory paradigms may be more challenging for older adults than standard sustained attention tasks or reading comprehension tasks, resulting in a reduced (null) effect of age on attentional lapses or an opposite (positive) effect of age on attentional lapses. This prediction is based off a refined version of the resource competition framework (Smallwood & Schooler, 2006) discussed earlier. Namely, Smallwood and Andrews-Hanna (2013) proposed the *context regulation hypothesis*, suggesting individuals adaptively adjust control processes and, by extension, the occurrence of attentional lapses, based off task demands. When a task is attentionally demanding, control needs to be exerted to prevent the occurrence of TUTs since their incidence could have adverse outcomes on performance. When relatively few demands are necessitated by the task, though, TUTs may not impair performance and may even allow individuals to be more productive with their excess attentional capacity (see also Baird et al., 2011; Rummel & Boywitt, 2014).

In support of this view, Robison et al. (2020) demonstrated that younger adults with enhanced attention control ability reported more frequent lapses of attention than those with inferior attention control ability when task demand was low. When task demand was high, however, individuals with high attention control ability reported fewer lapses of attention than those with low attention control ability. The tendency for older adults to experience fewer lapses of attention (relative to younger adults) may, therefore, be more pronounced in less demanding tasks than more demanding tasks. That said, it is important to acknowledge that at least one study suggests this may not be the case. McVay et al. (2013; see Experiment 2) administered younger and older adults a common measure of working memory with varying cognitive load—working memory generally declines in older age (Salthouse, 1990). Results from McVay et al. (2013) revealed the expected age deficits in working memory performance at high levels of cognitive load, but older adults still reported fewer TUTs than younger adults. So, it is entirely possible that older adults may continue to experience enhanced attentional consistency during an episodic memory task with intentional learning conditions. The present study sought to provide further insight into these matters.

Considering younger adults tend to report lower task-specific motivation than older adults (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021), it also seems plausible that value of the to-be-remembered material may moderate the effect of age on susceptibility to attentional lapses during learning. Findings from Seli et al. (2021) offer some support for this idea, insofar that experimentally increasing motivation (via monetary incentive) served to reduce age-related differences in lapses of attention while participants performed a sustained attention task. More specifically, incentives reduced TUTs (and increased motivation) among younger adults, whereas incentives had little effect among older adults since they were highly motivated to begin with.

Extending Seli et al.'s (2021) findings to VDR, perhaps age-related differences in indices of attentional consistency (e.g., TUTs) become *smaller* with increasing value. On the surface, such a finding aligns with work demonstrating reduced age-related differences in recall performance for high-value information (Castel et al., 2002, 2007, 2013). Note, however, the theoretical interpretations of these findings are somewhat at odds with each other. Specifically, the findings from Seli et al. (2021) imply value primarily serves to reduce TUTs for younger adults by increasing their motivation. Older adults are highly motivated and experience fewer TUTs to begin with. The findings from Castel et al. (2002, 2007, 2013), on the other hand, imply value primarily helps older adults distribute their attentional resources more efficiently, allowing them to compensate for existing memory limitations. Current theorizing further suggests that motivational (e.g., intrinsic motivation, reward sensitivity) and emotional processes (e.g., emotion regulation) may help older adults selectively attend to the most important information (Knowlton & Castel, 2022; Swirsky & Spaniol, 2019). Indeed, the age-related differences in positive and negative affect described previously have been attributed to older adults' use of more effective emotion regulation strategies (e.g., Urry & Gross, 2010). By employing such strategies, older adults may be less affected by the stress and frustration that often accompanies demanding memory tasks. This, in addition to their enhanced motivation, may make it easier for older adults to focus on task and allocate most of their available resources to what is most essential. Thus, it also seems possible that age-related differences in on-task focus may become *larger* with increasing value.

Complicating matters further, it is important to acknowledge that the interaction between value and age is not always found when examining memory performance in VDR tasks (Ariel et al., 2015; Castel et al., 2009; Murphy & Castel, 2022). Given the link between one's attentional state and subsequent memory at the within- and between-subjects levels (Blondé et al., 2022; deBettencourt et al., 2018; Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016), the presence of an interaction (when examining indices of attentional consistency) seems as likely to occur as the interaction for memory performance.

The present study provides the first critical test of the ideas outlined above, whereby we monitor lapses of attention during learning—for younger and older adults—while manipulating the value of the to-be-remembered material. Specifically, in two experiments, participants completed a DFR task with a VDR manipulation at encoding. During this task, participants studied a series of words paired with point values (ranging from 1 to 10 points) and were asked to maximize their point total on each list. Points were awarded to participants at test if the corresponding word was accurately recalled. Participants completed multiple study-test blocks (i.e., lists), and each list contained 30 unique to-be-remembered words. Thought probes were embedded throughout the study phase of each list to provide an index of one's ability to consistently keep attention focused on task. We also included a control condition without thought probes in our first experiment. In doing so, we aimed to clarify whether the thought probes themselves influenced the encoding process.

Taken altogether, it is clear that lapses of attention frequently occur in many learning tasks and, when they occur, are associated with poorer subsequent memory compared to when individuals report being on task (Blondé et al., 2022; deBettencourt et al., 2018; Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). Therefore, to foster successful learning among all individuals—the young and old alike—it is crucial that researchers develop a better understanding of which factors reduce their negative influence. The present study sought to fill in this gap while providing a more nuanced understanding of how age, dispositional traits, and contextual factors together explain aspects of attentional consistency during goal-based learning. To do so, we also included measures of motivation (Experiment 1 and Experiment 2), affect (Experiment 2), personality (Experiment 2), and ADHD symptomology (Experiment 2).

Experiment 1

The first goal of Experiment 1 was to test whether individuals can modulate the consistency of attention based on the importance (value) of the to-be-remembered material. As previously mentioned, prior research suggests that learners flexibly allocate more attentional effort to the most important information (Ariel & Castel, 2014; Castel et al., 2013; Kahneman & Peavler, 1969; Miller et al., 2019). Therefore, we expected TUTs to be most frequent when participants studied low-value information and on-task thoughts to be most frequent when participants studied high-value information. We were also interested in examining whether age (younger vs. relatively healthy older adults) moderated this effect, although we had no specific hypothesis about whether an interaction between age and value would emerge. Some may predict *reduced* age-related differences in attentional consistency with increasing value (Seli et al., 2021), whereas others might predict *larger* age-related differences with increasing value insofar that attentional consistency could act as a compensatory mechanism supporting intact (or superior) memory selectivity in older age (e.g., Knowlton & Castel, 2022). And yet other studies suggest the presence of an interaction between age and value is unlikely (Ariel et al., 2015; Castel et al., 2009; Murphy & Castel, 2022).

Accordingly, the second goal of Experiment 1 was to investigate whether older adults, in comparison to their younger counterparts, are generally better able to consistently focus on the to-be-remembered material during intentional learning conditions. Based on the context regulation hypothesis (Smallwood & Andrews-Hanna, 2013), it seems possible that older age may be associated with more frequent lapses and less on task focus when trying to learn new information (cf. McVay et al., 2013). This result would also be consistent with control failure accounts of mind-wandering (McVay & Kane, 2010) and the notion that attention control abilities are impaired in older age (Braver & West, 2008; Hasher & Zacks, 1988).

If, however, older age continues to be associated with enhanced attentional consistency, this result would most align with resource theories (Smallwood & Schooler, 2006). To further probe the potential role of attentional resources in effects of age on lapses, we sought to examine whether the detrimental effect of TUTs on subsequent memory is similar for younger and older adults. If younger adults have more attentional resources available to divide (between on-task processing and off-task processing), then resource theories predict that memory performance for younger adults should be less affected by an attentional lapse than is the case for older adults. Previous work (Maillet & Rajah, 2016; McVay et al., 2013) suggests the within-subject effect of on-task versus off-task thought (TUT) on performance is invariant to age, but it remains to be seen whether similar results arise during intentional learning conditions in episodic memory tasks.

Of course, a positive association between age and attentional consistency could also be explained by dispositional or situational factors. Given existing research has reliably demonstrated age-related differences in motivation (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021), our third goal was to assess whether motivation mediates age-related differences in on-task focus. Most existing studies (Jackson & Balota, 2012; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021) measured one's motivation to perform well (i.e., task-specific motivation; see Kanfer, 1987) by having participants self-report their motivation levels either before and/or after task completion. We adopted a similar procedure here and expected older adults to be more motivated than younger adults to complete the memory task. We also expected a positive correlation to arise between motivation and attentional consistency, regardless of age differences. Individuals who are more motivated to perform well tend to more consistently focus on the task at hand and report fewer TUTs (Miller & Unsworth, 2021; Robison & Unsworth, 2018; Seli et al., 2015; Unsworth & McMillan, 2013). Thus, motivation should mediate the effect of age on attentional consistency. Note, however, that prior studies (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2021) suggest motivation alone does not fully account for the association between age and indices of attentional consistency; hence, we expected partial mediation to occur.

Finally, as noted previously, we sought to alleviate concerns that the mere presence of thought probes could interfere with how individuals—older adults, in particular—process items during encoding. Existing research embedding thought probes into episodic memory tasks has mostly relied on measures where the to-be-remembered material is processed at an item-by-item level (e.g., associative learning; Garlitch & Wahlheim, 2020; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Xu & Metcalfe, 2016). To the authors' knowledge, research has yet to embed thought probes into the encoding phase of a standard list-learning task, such as DFR. In these tasks, a series of to-be-remembered stimuli are presented one at time within a list (shoe, dog, castle). Under intentional learning conditions with *no* value manipulation, participants tend to incorporate each newly presented item into an ongoing rehearsal strategy (e.g., Miller et al., 2019). However, this appears to be less so the case when individuals study long lists of words, like the lists used in the present study (see Unsworth & Miller, 2021). In any case, it is possible that the presence of periodic thought probes during the encoding phase of a DFR task may interfere with cumulative maintenance rehearsal and ensuing subsequent memory. Therefore, we included a control condition with no thought probes. A critical point of analysis was to determine whether condition (control vs. probe) altered any of the effects of interest.

Method

Participants

The sample included 130 younger adults and 128 older adults who were randomly assigned to one of two conditions: a control condition with no thought probes ($N_{\text{younger}} = 66$, $N_{\text{older}} = 64$) and a probe condition in which thought probes were present ($N_{\text{younger}} = 64$, $N_{\text{older}} = 64$). Our sample size was selected based on the primary analysis of interest, the Age × Value interaction with indices of attentional consistency as the dependent variable. A power analysis indicated that 54 participants per age group would be needed to detect a small to moderate effect (Cohen's f = .175) with a 2 (between-subjects factor of age group) × 3 (within-subjects factor of value: low vs. mid vs. high) repeated measures analysis of variance (ANOVA). These calculations assumed $\alpha = .05$, power = .80, an average correlation of $r = .50$ between repeated measures, and a nonsphericity correction of $\varepsilon = 1$ (the default settings in G*Power Version 3.1.9.6). Given data collection occurred online, we aimed for at least 60 participants per age group.

All participants were recruited using Prolific and were paid for their participation ($10/hr). To participate in the study, younger adults had to be no more than 34 years old, and older adults had to be at least 64 years old. All participants were required to be fluent speakers of English, and all data were collected online. A total of six younger adults (final $N = 124$, $N_{\text{control}} = 61$, $N_{\text{probe}} = 63$) and seven older adults (final $N = 121$, $N_{\text{control}} = 60$, $N_{\text{probe}} = 61$) were excluded from analyses. Two older adults were excluded for not meeting the age criteria described above (i.e., both participants were in their mid-50s). On a posttask survey, a variety of additional participants indicated their data should be dropped from analyses. Participants who were excluded admitted to cheating ($n_{\text{younger}} = 3$, $n_{\text{older}} = 1$); taking a prolonged break during the task ($n_{\text{younger}} = 1$); and completing the study in an unexpectedly distracting environment (e.g., "my room had some unexpected distractions," $n_{\text{younger}} = 1$). Another person was excluded because their internet disconnected for 5 min during the study phase of the third list ($n_{\text{older}} = 1$). Given the online nature of the study, we also erred on the side of caution and removed individuals flagged as outliers (3 *SDs* above the mean) when inspecting boxplots and histograms of recall accuracy scores as a function of age group ($n_{\text{younger}} = 1$, $n_{\text{older}} = 3$). Like Schwartz et al. (2023), we reasoned that perfect- or near-perfect recall accuracy scores across lists indicated likely use of an external aid. After data exclusions, a sensitivity analysis with similar assumptions to those outlined above indicated that a repeated measures ANOVA with two groups (young vs. old), 61 participants per group (see Table 1), and three measurements (value: low vs. mid vs. high) could reliably detect small effects amounting to Cohen's $f = .115$ (partial $\eta^2 = .013$ and Cohen's $d = .23$).

Next, we analyzed participant demographics. Demographic information for each participant was collected at the beginning of the experiment, before reading the task instructions. Participants were asked to report their age (free response), gender (Female, Male, Nonbinary, or Other), highest achieved education level (Some High School, High School Graduate, Some College, No Degree, Associate Degree, Bachelor's Degree, Professional/Graduate Degree), current state of health (Poor, Fair, OK, Good, Excellent), and racial/ethnic background (American Indian or Alaskan Native, Native Hawaiian or Other Pacific Islander, Hispanic or Latino/a/x, Asian, Black, White, Other or Unknown). Most participants reported themselves to be in good health ($M = 3.64$ out of 5, $SD = 1.00$) and to have obtained an associate or bachelor's degree ($M = 3.20$ out of 5, $SD = 1.38$). A Mann–Whitney U test revealed no significant age differences in current health quality ($z = -.31$, $p = .757$), but older adults had significantly higher levels of education than younger adults, $z = -3.68$, $p < .001$.

Procedure

All participants first provided informed consent and demographic information. Participants reported their age, gender, racial/ethnic background, current health quality, and highest level of education (see Table 1). Participants then completed a DFR task with a VDR manipulation. That is, each to-be-remembered word was paired with a point value. The goal of the task was to remember as many of the words in each list as possible while achieving a maximal score, a sum of the points associated with each word that was accurately recalled. In the probe condition, thought probes were embedded throughout the encoding phase of each list. The control condition did *not* administer thought probes during the encoding phase of each list. All other features of the task were identical between conditions. Upon completion of the DFR task, participants were asked to report how motivated they were to perform well on the task. Next,

Table 1
Participant Demographics for Each Age Group and Condition in Experiment 1

	Younger adult		Older adult	
Demographic variable	Control ($N = 61$)	Probe ($N = 63$)	Control ($N = 60$)	Probe ($N = 61$)
Mean age (*SD* age)	25.46 (3.25)	24.84 (3.27)	68.87 (4.28)	69.34 (4.58)
Gender				
Female	42.6%	46.0%	60.0%	55.7%
Male	52.5%	52.4%	40.0%	44.3%
Nonbinary or other	4.9%	1.6%	.0%	.0%
Race				
Asian	19.7%	3.2%	.0%	1.6%
White	52.5%	61.9%	90.0%	91.8%
Hispanic or Latino/a/x	11.5%	14.3%	.0%	.0%
Black	13.1%	15.9%	10.0%	4.9%
American Indian or Alaskan Native	.0%	.0%	.0%	1.6%
Other or Unknown	3.3%	4.8%	.0%	.0%
Health				
Excellent	19.7%	15.9%	23.3%	21.3%
Good	39.3%	44.4%	35.0%	42.6%
OK	34.4%	22.2%	28.3%	16.4%
Fair	4.9%	14.3%	11.7%	18.0%
Poor	1.6%	3.2%	1.7%	1.6%
Education				
High school graduate	16.4%	22.2%	13.3%	9.8%
Some college, no degree	27.9%	25.4%	10.0%	24.6%
Associate degree	6.6%	9.5%	8.3%	8.2%
Bachelor's degree	41.0%	33.3%	41.7%	26.2%
Professional degree (Master's, PhD, etc.)	8.2%	9.5%	26.7%	31.1%

Note. All participants were recruited from Prolific.

participants were asked a few questions about potential experimental issues (e.g., whether there were problems with the task loading), cheating, or other reasons for which their data should be excluded from analyses. Participants were reassured that, regardless of their response to these questions, they would be compensated for their time. The procedure was approved by the Institutional Review Board of the University of California, Los Angeles (UCLA). All participants were treated according to the ethical standards of the American Psychological Association and were debriefed following the session. The entire online session lasted approximately 30 min.

Materials

DFR With VDR Manipulation. Participants were administered a DFR task with a VDR manipulation, which began with a single practice list containing 10 words. The experimental trials consisted of four lists, each containing 30 unique words (i.e., words did not repeat within or across lists). Word lists were initially composed of randomized nouns selected from the Toronto word pool (Friendly et al., 1982), and all words ranged in length from four to six letters (mean word length varied from 4.53 letters to 4.67 letters across lists). Each word was paired with a point value between 1 and 10, indicating how much the word was "worth." Each point value appeared three times within an experimental list, and the order of point values within lists was pseudorandomized. Stimulus words appeared onscreen for 3 s each with a 500 ms interstimulus interval.

Following presentation of the last word within each list, a 20 s distractor task began, during which a series of three-digit numbers appeared simultaneously onscreen. Each three-digit string appeared for 2.5 s. During this time, participants had to indicate which digit—the first digit (on the left) or the last digit (on the right)—within the sequence was the largest. Participants were instructed to respond via key press as quickly and accurately as possible. After the distractor task, participants were prompted to recall as many words as possible from the corresponding list. Participants typed their answers into a response field at the center of the screen (participants could see all typed responses). After 2 min elapsed, the screen automatically advanced, but participants were allowed to proceed on their own after 1 min elapsed. Following the recall period, participants were told their point score for that list but were not given feedback about specific items or the number of words recalled.

Participants were informed that they would be presented with four lists of to-be-remembered words and that each word would appear alongside a number. Participants were told that the number represented the value of remembering said word, of which would be awarded to the participant if the accompanying word was correctly recalled at test. For example, a participant may have studied "apple: 2" followed by "track: 9." If the participant remembered "apple" at test, then they would receive 2 points. If the participant also remembered "track" at test, then they would receive an additional 9 points (yielding 11 points total). Participants were told that the goal of the task was to remember as many of the words in each list as possible while achieving a maximal score, a sum of the points associated with each word that was accurately recalled.

Thought Probes. For individuals in the probe condition, thought probes pseudorandomly appeared during the encoding phase of each word list. Similar to Miller and Unsworth (2021), four probes appeared in the odd numbered lists (probe frequency = 13.3%), and five probes appeared in the even numbered lists (probe frequency = 16.7%), yielding 18 total probes. For each block in the experiment (e.g., block 1 = list 1 and list 2, block 2 = list 3 and list 4), we ensured three probes appeared following low-, mid-, and high-value words. Thus, each value category consisted of six total observations. Points 1–3 were considered low value, points 4–7 were considered mid value, and points 8–10 were considered high value.

Probes asked participants to report the current contents of their thoughts. The response options for the probes were based on prior investigations of mind-wandering and other thought content (Robison & Unsworth, 2018; Stawarczyk et al., 2011; Unsworth & Robison, 2016, 2017b; Ward & Wegner, 2013). Specifically, a screen appeared instructing participants to "Please characterize your current conscious experience." Response options were (a) I am totally focused on the current task, (b) I am thinking about my performance on the task or how long it is taking, (c) I am distracted by sights/sounds/temperature in my environment or by physical sensations (hunger/thirst/pain), (d) I am daydreaming/my mind is wandering about things unrelated to the task, and (e) I am not very alert/my mind is blank. Response 1 was considered as on task, whereas response 2 was considered task-related interference (TRI)—instances in which thoughts are focused internally but are related to the appraisal of the current task (i.e., TRI is stimulus independent, whereas on-task processing is stimulus dependent; Stawarczyk et al., 2011). Finally, responses 3–5 were considered task-unrelated/off-task thoughts (external distraction, mind-wandering, and mind-blanking), aka lapses of attention.

Task-Specific Motivation. Upon completion of the DFR-VDR task, participants were asked about their motivation to perform well on said task (see Experiment 1 in Miller & Unsworth, 2021; Robison & Unsworth, 2018; Robison et al., 2020). Specifically, participants were asked, "How motivated were you to perform well on the memory task?" Participants responded on a 7-point scale (1 = *not at all motivated*, 7 = *extremely motivated*).

Results and Discussion

Descriptive statistics for each age group are listed in Table 2 and visualized in Figure 1. All measures were approximately normally distributed (i.e., skewness < 2; kurtosis < 4; Kline, 2016), except for motivation and TUTs. Proportions of TUT were near floor (under 10%) for both age groups, whereas task-specific motivation scores for older adults were especially highly negatively skewed and leptokurtic. A normal distribution was obtained for motivation with a log10 transformation, but rerunning the analyses with the transformed data did not alter the interpretation of our results. All effects that were nonsignificant with the raw data remained nonsignificant with the transformed data, and all effects that were significant with the raw data remained significant with the transformed data. Therefore, we opted to report analyses using the raw data instead of the transformed data. Table 3 lists reliability estimates for all measures.

We first sought to examine whether the presence of thought probes would interfere with how individuals—older adults, in particular—encode to-be-remembered material in a DFR task. Prior research using list-learning paradigms, in the absence of a value manipulation, suggests participants engage in self-initiated cumulative maintenance rehearsal until working memory becomes overloaded (e.g., Miller et al., 2019). Cumulative maintenance rehearsal

Table 2
Descriptive Statistics for All Measures in Experiment 1

Measure	Age group	*M*	*SD*	Min	Max	Skew	Kurtosis
Control condition							
Recall acc	Young	0.34	0.16	.11	.81	.78	.41
	Old	0.29	0.13	.09	.61	1.02	.35
Motivation	Young	6.03	1.00	1.00	7.00	−2.14	9.32
	Old	6.52	0.95	1.00	7.00	−3.70	18.96
Probe condition							
Recall acc	Young	0.38	0.16	.07	.81	.61	−.30
	Old	0.29	0.12	.08	.64	.79	.46
Motivation	Young	5.63	1.27	2.00	7.00	−.92	.61
	Old	6.77	0.53	4.00	7.00	−2.99	11.65
Prop on task	Young	0.65	0.35	.00	1.00	−.57	−1.04
	Old	0.80	0.27	.06	1.00	−1.16	.18
Prop TRI	Young	0.27	0.27	.00	1.00	.84	.04
	Old	0.16	0.23	.00	.78	1.40	.91
Prop TUT	Young	0.08	0.13	.00	.50	1.58	1.58
	Old	0.05	0.10	.00	.44	2.59	6.51

Note. Recall acc = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; Motivation = self-reported motivation (posttask). While older adults demonstrated higher motivation than younger adults in both conditions, age-related differences in motivation were larger in the probe condition than the control condition, $F(1, 241) = 6.80$, $p = .010$, $MSE = .96$, partial $\eta^2 = .03$. Min = minimum; Max = maximum; *MSE* = mean square error.

is thought to underlie the primacy effect (e.g., Rundus, 1971). The first few items within a list tend to receive the most rehearsals, resulting in superior recall for these items. In the present study, the first thought probe appeared, on average, following serial position 6, and the earliest a thought probe could appear was following serial position 4. So, the worry was that, if a probe were to appear following a primacy item, the probe could potentially disrupt the cumulative rehearsal strategy and reduce the primacy effect.

A related concern was that thought probes could encourage participants to essentially restart an ongoing rehearsal strategy. For example, if a probe appeared at serial position 19, a person could treat serial position 19 as the new starting point in said strategy. In which case, serial position 19 and the following items could receive more rehearsals (resulting in better recall) compared to a condition in which no probes appear; hence, we were interested in examining potential effects of condition across all serial positions. To assess these possibilities, we submitted mean recall accuracy to a repeated measures ANOVA with serial position (1–30) as a within-subjects factor and condition (control vs. probe) as a between-subjects factor. A main effect of serial position arose, $F(29, 7047) = 32.37$, $p < .001$, $MSE = .05$, partial $\eta^2 = .12$, which was predominately characterized by a primacy effect, negative linear trend: $F(1, 243) = 83.03$, $p < .001$, $MSE = .15$, partial $\eta^2 = .26$. As demonstrated in Figure 2, words presented at the beginning of a list tended to be better remembered than words presented at the end of a list. Critically, the main effect of condition ($F = .88$, $p = .35$) and the Condition × Serial Position interaction ($F = 1.36$, $p = .10$) were both nonsignificant.

We proceeded to add age as a between-subjects factor to ensure the presence of thought probes had a similar, null effect on recall for both age groups. The Condition × Age Group interaction ($F = 1.05$, $p = .31$) and the Condition × Age Group × Serial Position interaction ($F = 1.01$, $p = .46$) were both nonsignificant. Collectively, these results suggest embedding thought probes into the encoding phase of a DFR task, with a VDR component, likely did not meaningfully alter the way individuals processed, and remembered, the to-be-remembered material. Given the absence of any condition-related effects on the primary variables of interest, we dropped condition as a factor and collapsed across conditions when data from both conditions were available. Analyses examining potential probe reactivity effects at the trial level (e.g., comparisons of memory for words before vs. after thought probes) are reported in Appendix A. In general, compared to words that were not probed, subsequent memory was worse for words that appeared directly *before* a probe. Importantly, these item-specific effects did not significantly vary across age groups.

Attentional State as a Function of Value, List, and Age

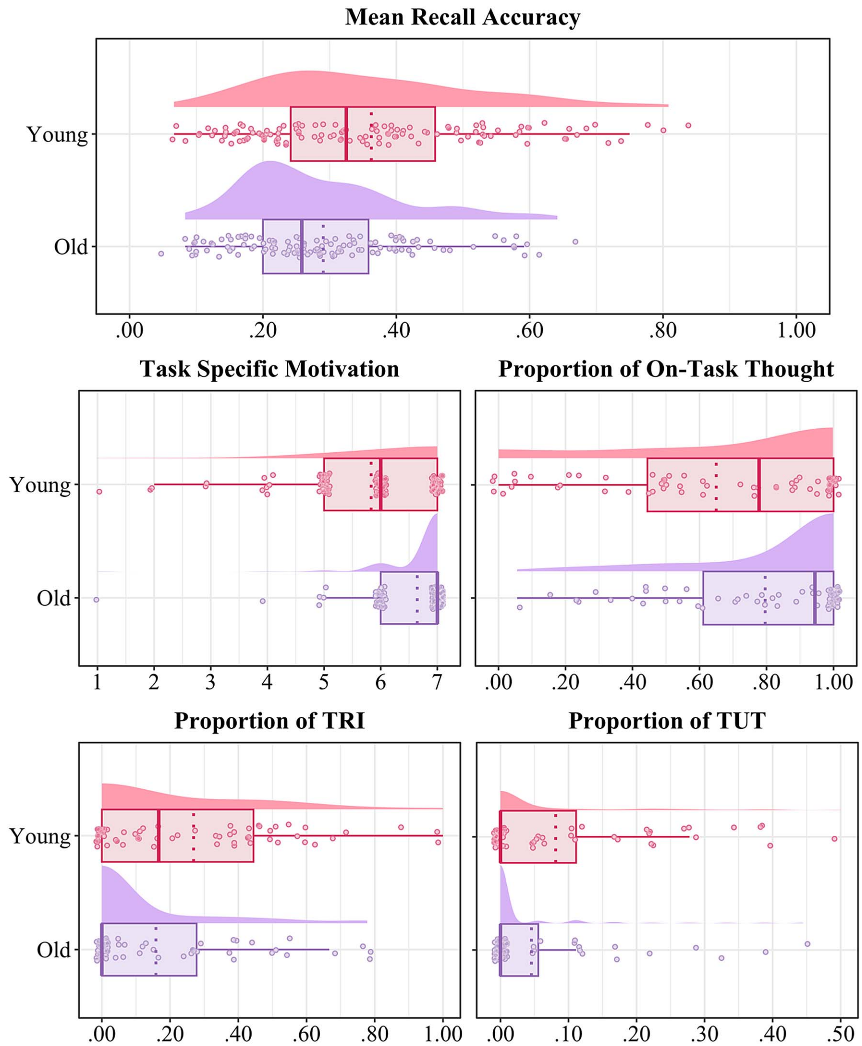
A goal of Experiment 1 was to investigate whether older adults, in comparison to their younger counterparts, are generally better able to consistently focus on the to-be-remembered material during intentional learning conditions. Overall, participants were on task 72% of the time and experienced TUTs 6% of the time. The remaining time was spent thinking about their performance or how long the task was taking to complete (TRI). Note 6% is substantially smaller than proportions of TUT observed in other learning and memory tasks—which generally show estimates around 30%–40% (e.g., Garlitch & Wahlheim, 2020; Miller & Unsworth, 2021)—and may be due to the presence of point values. This possibility will be revisited in the General Discussion. Nevertheless, Figure 3 reveals older adults were more consistently focused on task during learning ($M = .80$, $SE = .03$) than were younger adults ($M = .65$, $SE = .04$), $t(122) = 2.62$, $p = .010$, 95% CI [.04, .26], Cohen's $d = .47$. Younger adults, on the other hand, reported higher rates of TRI ($M = .27$, $SE = .03$) relative to older adults ($M = .16$, $SE = .03$), $t(122) = 2.44$, $p = .016$, 95% CI [.02, .20], Cohen's $d = .44$. Rates of TUT did not significantly differ among younger ($M = .08$, $SE = .02$) and older ($M = .05$, $SE = .01$) adults, $t(122) = 1.73$, $p = .086$, 95% CI [−.01, .08], Cohen's $d = .31$. Taken altogether, these results are most consistent with resource theories (Smallwood & Schooler, 2006), insofar that older adults demonstrated intact, if not superior, attentional consistency.

Another goal of Experiment 1 was to examine whether individuals can modulate the consistency of attention based on the importance (value) of the to-be-remembered material. Given the clear presence of a floor effect in proportions of TUT, we submitted proportions of on-task thought[3] to a repeated measures ANOVA with value (low vs. mid vs. high) and list (1–4) as within-subject factors. Value was treated as a categorical variable because we administered six thought probes per value category across the entire task. Words worth 1–3 points were classified as low value, words worth 4–7 points were classified as mid value, and words worth 8–10 points were classified as high value. There were simply not enough observations per point value to treat value as a continuous variable. Critically, the analysis revealed a main effect of value, $F(2, 246) = 4.93$, $p = .008$, $MSE = .08$, partial $\eta^2 = .04$. As demonstrated in Figure 4, people were more

[3] Proportions of on-task thought were highly correlated with proportions of TUT (Spearman's $\rho = -.70$; Pearson's $r = .66$, $ps < .001$).

Figure 1

Boxplots With Jittered Individual Participant Scores for All Variables in Experiment 1



Note. Dotted lines within each boxplot reflect the corresponding group's mean. Data for mean recall accuracy and task-specific motivation are collapsed across conditions (no probe vs. probe). TRI = task-related interference; TUT = task-unrelated thought (mind-wandering, external distraction, and mind-blanking). See the online article for the color version of this figure.

consistently focused on the task at hand as value of the to-be-remembered material increased, positive linear trend: $F(1, 123) = 9.08$, $p = .003$, $MSE = .08$, partial $\eta^2 = .07$. Pairwise comparisons (Fisher's least significant difference) revealed that rates of on-task thought were significantly lower when participants studied low-value words ($M = .69$, $SE = .033$) than when they studied high-value words ($M = .75$, $SE = .027$), $p = .003$. Rates of on-task thought during study of mid-value words ($M = .72$, $SE = .031$) did not significantly differ from rates of on-task thought during study of low ($p = .132$) or high ($p = .09$) value words.

The analysis further revealed no significant effect of list ($F = 1.32$, $p = .267$), suggesting time spent on task or task experience did not influence participants' ability to keep attention focused on task. The interaction between value and list was likewise nonsignificant ($F = 1.93$, $p = .073$), suggesting the ability to modulate attentional consistency according to value was unaffected by time-on-task or task experience. To investigate whether the effect of value on attentional consistency (as indexed by proportions of on-task thought) varied as a function of age, we reran the analysis with age group as a between-subjects factor. All age-related interactions were nonsignificant ($ps > .51$). Thus, both younger and older adults selectively modulated the consistency with which attention was directed to on-task processing during learning.

Recall Accuracy as a Function of Value, List, and Age

Next, we sought to replicate established effects of value and age on recall performance. We submitted recall accuracy to a repeated measures ANOVA with value (1–10) and list (1–4) as within-subject factors. The analysis revealed a significant main effect of

Table 3
Reliability Estimates for All Measures in Experiment 1

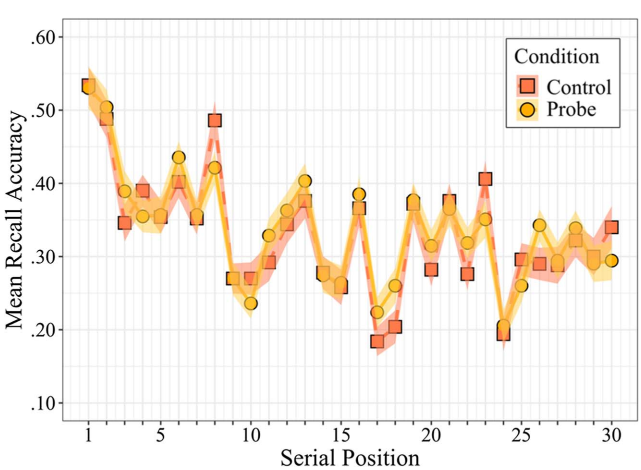
Measure	Reliability (Cronbach's α)
Recall acc	.92
Motivation	
Prop on task	.92
Prop TRI	.89
Prop TUT	.76

Note. The posttask motivation scale consists of a single item and thus has no estimated internal consistency. Recall acc = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study.

value, $F(9, 2196) = 183.29$, $p < .001$, $MSE = .11$, partial $\eta^2 = .43$, indicating words associated with higher values were best remembered, positive linear trend: $F(1, 244) = 408.64$, $p < .001$, $MSE = .43$, partial $\eta^2 = .63$. For instance, words worth 1 point were remembered worse than all other point values, whereas words worth 10 points were remembered better than all other point values. In terms of nonsignificant pairwise comparisons, memory for words worth 2 points did not significantly differ from memory for words worth 3 points ($p = .133$). Memory performance was similarly equivalent when comparing points 4 and 5 ($p = .105$).

The analysis further revealed a significant main effect of list, $F(3, 732) = 7.01$, $p < .001$, $MSE = .07$, partial $\eta^2 = .03$, suggesting individuals were able to remember slightly more words on each list—irrespective of value—with increased task-experience, positive linear trend: $F(1, 244) = 12.07$, $p < .001$, $MSE = .10$, partial $\eta^2 = .05$. Recall accuracy on list 1 ($M = .31$, $SE = .01$) was significantly lower than recall accuracy on list 2 ($M = .33$, $SE = .01$), list 3 ($M = .34$, $SE = .01$), and list 4 ($M = .34$, $SE = .01$). All other comparisons were nonsignificant ($ps > .29$).

Figure 2
Proportion of Words Correctly Recalled (Mean Recall Accuracy) as a Function of Serial Position (1–30) and Condition (Control Vs. Probe)



Note. Shaded regions represent one standard error of the mean. See the online article for the color version of this figure.

An interaction between value and list also emerged, $F(27, 6588) = 16.26$, $p < .001$, $MSE = .05$, partial $\eta^2 = .06$. Note that all omnibus tests treated value as a continuous variable with 10 levels (points 1–10). To simplify the interpretation of complex interaction terms such as this, we report pairwise comparisons obtained after rerunning the corresponding analysis with a categorical value variable. Points 1–3 were considered low value, points 4–7 were considered mid value, and points 8–10 were considered high value.

When examining the least valuable words, a significant negative linear effect of list emerged, $F(1, 244) = 15.90$, $p < .001$, $MSE = .02$, partial $\eta^2 = .06$. Recall accuracy for low-value words was higher on the first list ($M = .23$, $SE = .01$) than the second ($M = .16$, $SE = .01$), third ($M = .18$, $SE = .01$), and fourth ($M = .17$, $SE = .01$) lists, $ps < .001$. Recall accuracy for low-value words did not significantly differ across lists 2–4, $ps > .24$. Turning to words of moderate value, a significant main effect of list emerged that was quadratic, $F(1, 244) = 7.01$, $p = .009$, $MSE = .02$, partial $\eta^2 = .03$, and cubic, $F(1, 244) = 15.17$, $p < .001$, $MSE = .01$, partial $\eta^2 = .06$, in nature. Recall accuracy for mid-value words was higher on the second list ($M = .32$, $SE = .01$) than the first ($M = .27$, $SE = .01$), third ($M = .28$, $SE = .02$), and fourth ($M = .29$, $SE = .02$) lists, $ps < .023$. All other comparisons were nonsignificant, $ps > .07$. Finally, examining recall accuracy for the most valuable words revealed a significant main effect of list that was predominately characterized by a positive linear trend, $F(1, 244) = 98.11$, $p < .001$, $MSE = .03$, partial $\eta^2 = .29$, and, to a lesser extent, a quadratic trend, $F(1, 244) = 20.73$, $p < .001$, $MSE = .02$, partial $\eta^2 = .08$. Namely, recall accuracy for high-value words was lower on the first list ($M = .43$, $SE = .01$) than all other lists, $ps < .001$. Recall accuracy for high-value words was likewise significantly lower on the second list ($M = .51$, $SE = .02$) than the third ($M = .57$, $SE = .02$) and fourth ($M = .56$, $SE = .02$) lists, $ps < .001$. The third and fourth lists did not significantly differ from each other ($p = .671$). These results, shown in Figure 5, are consistent with the idea that participants were increasingly able to prioritize high-value words at the expense of low-value words with additional task experience (Castel et al., 2002, 2007).

Adding age group as a between-subjects factor to the repeated measures ANOVA described above yielded a significant main effect of age, $F(1, 243) = 14.48$, $p < .001$, $MSE = .81$, partial $\eta^2 = .06$. Overall, older adults displayed impaired mean DFR accuracy ($M = .29$, $SE = .01$) relative to younger adults ($M = .36$, $SE = .01$). The only other effect to approach conventional levels of significance was an interaction between age and list,[4] $F = 2.36$, $p = .071$ (all other $ps > .30$). Taken altogether, advanced age seemingly led to a decline in the amount of information that could be remembered overall. But, all individuals, regardless of age, displayed enhanced memory for high-value information at the expense of memory for low-value information; hence, the ability to prioritize valuable information increased as a function of task experience for all participants.

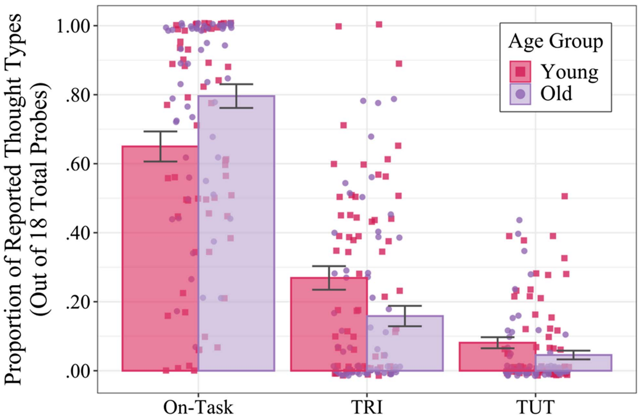
Recall Accuracy as a Function of Attentional State

We next sought to investigate predictions made by resource-based theories of age differences in TUTs. These accounts suggest the detrimental effect of TUTs on subsequent memory should

[4] The only significant condition-related effect to emerge was a three-way interaction between condition, age, and list, $F(3, 723) = 3.13$, $p = .025$, $MSE = .07$, partial $\eta^2 = .01$, suggesting recall performance for young adults in the probe condition benefitted most from increased task experience.

Figure 3

Proportions of On-Task Thought, TRI, and TUT Reported During the Study Phase as a Function of Age Group



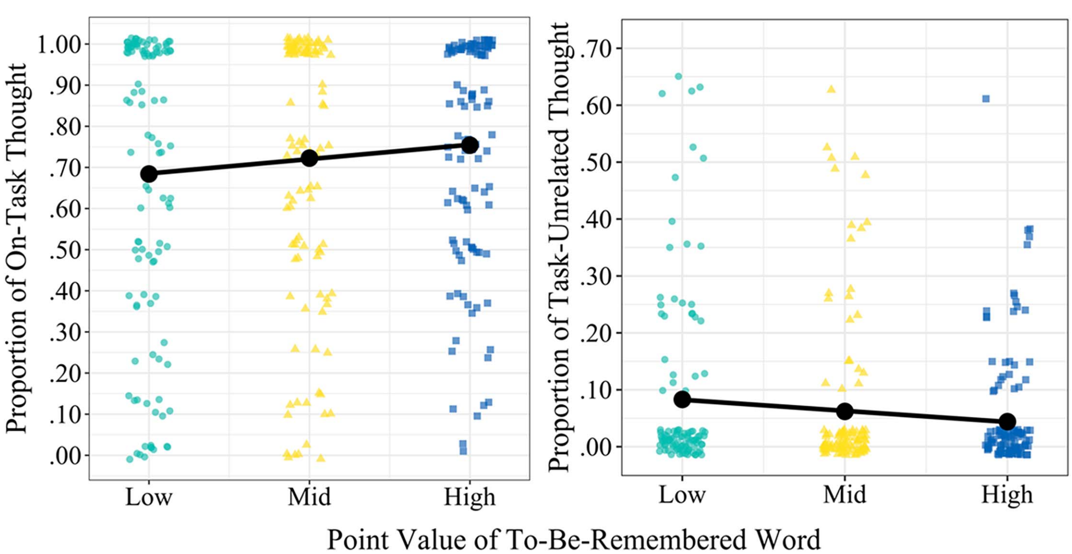
Note. Error bars represent one standard error of the mean. The jittered points reflect individual participant scores for a given thought category. Pink squares represent younger adults, whereas purple circles represent older adults. TRI = task-related interference; TUT = task-unrelated thought. See the online article for the color version of this figure.

be smaller for younger adults than older adults. To examine this possibility, we used logistic multilevel modeling (MLM). A mean-based analytic technique, such as repeated measures ANOVA, would have reduced the sample size to 37 participants (24 younger adults and 13 older adults). Using MLM, we were able to leverage observations from participants that would have been excluded, meaning the MLM technique was better suited for testing a potential interaction between age group and attentional state. Like Miller and Unsworth (2021), to-be-remembered words were nested within probe number (18 total thought probes, each corresponding to a specific to-be-remembered word) and subjects (N = 124). In other words, 18 outcomes per subject were included in the analysis, and the outcome reflects recall (forgotten vs. recalled) of the word immediately preceding each thought probe. Probe number and subject were specified as random effects (i.e., intercepts were allowed to vary across subjects and probes). Attentional state (on task vs. TRI vs. TUT) was added as a fixed effect. We tested two models: one with an interaction between attentional state and age group (plus their corresponding main effects) and another with just the main effects of attentional state and age group as predictors. Model comparisons revealed the addition of the interaction term did not significantly improve model fit, $\chi^2(2) = .24$, $p = .887$. Neither main effect of attentional state, elaborated upon below, significantly varied as a function of age group ($ps > .69$). Older adults demonstrated worse subsequent memory than younger adults regardless of attentional state ($\gamma = -.67$, $SE = .18$, $z = -3.69$, $p < .001$). Therefore, we retained the model without the interaction term but note the effects that reached significance in the retained model were likewise significant in the rejected model.

Consistent with previous research, results revealed that the odds of a participant correctly recalling an item were 1.72 ($e^{.54}$) times greater when they reported being focused on task compared to when they were distracted by internal or external sources ($\gamma = .54$, $SE = .25$, $z = 2.17$, $p = .030$). Put more simply, participants were less likely to remember an item if their attention lapsed during learning (Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). Results further revealed, inconsistent with Miller and Unsworth (2021), that TRI ($\gamma = .30$, $SE = .26$, $z = 1.17$, $p = .241$) was *not* associated with better subsequent memory relative to TUT. Nor was TRI associated with

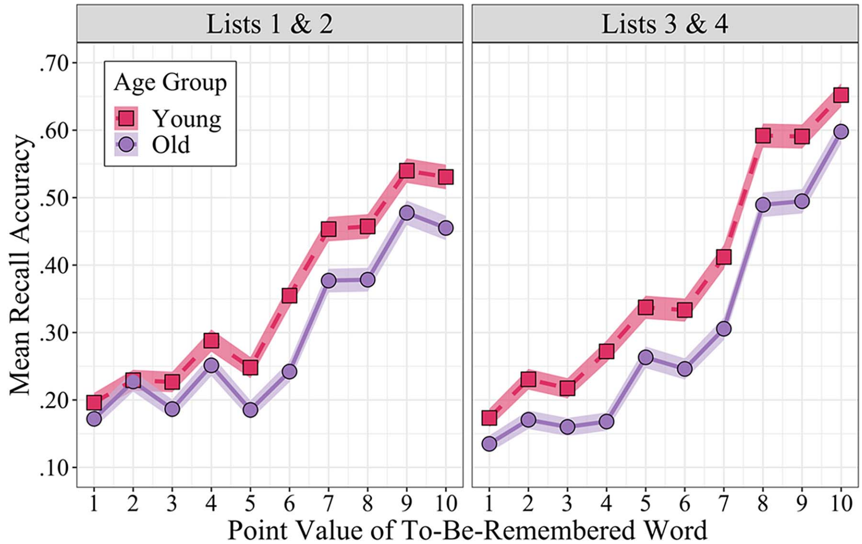
Figure 4

Proportion of On-Task Thought (Left) and Task-Unrelated Thought (Right) as a Function of Value



Note. Low value = points 1–3; middle value = points 4–7; high value = points 8–10. The jittered points reflect individual participant scores for a given value category. Task-unrelated thought refers to instances of mind-wandering, external distraction, and mind-blanking. See the online article for the color version of this figure.

Figure 5
Recall Accuracy as a Function of Point Value, Age Group, and List in Experiment 1



Note. List was treated continuously (ranging from 1 to 4) in all analyses. We collapsed lists into blocks (each containing two lists) for visualization purposes only. Shaded regions represent one standard error of the mean. See the online article for the color version of this figure.

worse subsequent memory relative to instances of on-task thought ($\gamma = -.24$, $SE = .15$, $z = -1.57$, $p = .117$).[5] Nevertheless, these results suggest that when individuals experience TUTs during study, they are less likely to remember that information at test. Critically, though, the detrimental effect of these attentional diversions on memory did not vary across age groups—a result at odds with the idea that reduced resources explain why older adults are more consistently focused on task than younger adults.

Task-Specific Motivation

The final goal of Experiment 1 was to examine whether task-specific motivation mediates age-related differences in on-task focus. An independent samples *t* test revealed that older adults were significantly more motivated than younger adults, $t(243) = 6.45$, $p < .001$, 95% CI [.57, 1.06], Cohen's $d = .82$. Table 2 provides the means and standard deviations for each age group. Since those who were highly motivated to perform well, like older adults, tended to report a greater proportion of on-task thought ($r = .24$, $p = .007$, $N = 124$), we specified a path model in which age group had a direct effect on proportions of on-task thought and an indirect effect through motivation. Age was recoded so that younger adults were 0 and older adults were 1. The indirect effect of motivation was nonsignificant, $\beta = .08$, $SE = .05$, $p = .099$, 95% CI [−.02, .19]. The absence of an effect was seemingly due to a nonsignificant effect of motivation on proportions of on-task thought when controlling for age ($\beta = .17$, $SE = .10$, $p = .103$, 95% CI [−.03, .37]), since the effect of age on motivation was highly significant, $\beta = .50$, $SE = .06$, $p < .001$, 95% CI [.39, .62]. Thus, older adults were more motivated to perform well on the memory task than younger adults. But task-specific motivation did not appear to explain why older adults in Experiment 1 were more consistently focused on task than were younger adults.

Experiment 2

Experiment 1 demonstrated that the importance of the to-be-remembered material moderated the occurrence of on-task focus during study. Participants were most consistently focused on the task when studying information high in value and least consistently focused on the task when studying information low in value. This tendency to modulate the consistency of attention based on value did not differ between younger and older adults. Nor did it depend on time on task (list). In fact, no effect of time on task on attentional consistency emerged at all, which is inconsistent with typical findings in the sustained attention literature. That is, sustained attention tasks (e.g., the psychomotor vigilance task and the sustained attention to response task) generally give rise to a vigilance decrement, whereby a person's ability (or willingness) to maintain consistent, high levels of attentional effort deteriorates over time.

Evidence for the vigilance decrement comes from studies demonstrating a decline in performance (e.g., mean reaction time becomes slower and more variable) and a decrease in task-evoked pupillary responses as time on task increases (Beatty, 1982; Parasuraman, 1986; Unsworth & Robison, 2016). Critically, these decreases in performance (and pupil dilation) are accompanied by an *increase* in lapses of attention (Cunningham et al., 2000; Smallwood et al., 2004; Thomson, Seli, et al., 2014; Unsworth & Robison, 2016). Unsworth et al. (2020) further demonstrated that these vigilance

[5] A repeated measures ANOVA similarly revealed a significant main effect of attentional state, $F(2, 72) = 6.19$, $p = .003$, $MSE = .06$, partial $\eta^2 = .15$. The primary difference between analyses was that the repeated measures analysis suggested on-task thought was associated with significantly better recall accuracy ($M = .40$, $SE = .05$) than TRI ($M = .28$, $SE = .05$), $p = .031$. Consistent with the MLM, TRI was *not* associated with better recall accuracy than TUT ($M = .21$, $SE = .05$), $p = .141$.

decrements in psychomotor vigilance tasks are reliably observed in sessions as brief as 10 min. Not only that, but individuals most susceptible to lapses of attention struggled to sustain attention over a time course as short as 10 s. Thus, maintaining attention on task—even if only for a few seconds—can be an effortful and difficult process. In tasks that require continuous allocations of attentional effort, attentional focus increasingly wanes and becomes less consistent as time elapses. Given the repetitive and monotonous nature of sustained attention tasks, it seems possible that intentional learning conditions (in a memory context) may be more engaging for participants, resulting in little to no time-on-task effect. That said, Garlitch and Wahlheim (2020) found a vigilance decrement in an episodic memory task with a longer study phase than what was used in Experiment 1. To clarify these matters, Experiment 2 attempted to replicate the effect of value on proportions of on-task thought while increasing demands on sustained attention. To do so, we introduced two additional lists to the learning session, bringing the total to six lists instead of four lists.

Consistent with research adopting incidental learning conditions, Experiment 1 also found no age-related differences in susceptibility to lapses of attention (Maillet & Rajah, 2016). Yet younger adults reported being focused on task less than older adults, and younger adults also reported more TRI (Maillet & Rajah, 2013). Collectively, these results support the idea that, relative to younger adults, older adults were better able to consistently allocate their attention to on-task processing. These findings align most with the resource competition framework (Smallwood & Schooler, 2006), which suggests older adults lack the attentional resources necessary to experience TUTs while performing an attentionally demanding task.

However, Experiment 1 revealed that instances of TUT had the same detrimental effect on younger and older adults' subsequent memory performance, consistent with previous work that measured lapses of attention in other tasks (Maillet & Rajah, 2016; McVay et al., 2013). If the age-related decline in lapses is driven by a reduction in attentional resources, older adults should have demonstrated larger performance decrements compared to younger adults—so long as we assume TUTs for older adults are as resource intensive as TUTs for younger adults. Furthermore, age was largely associated with increased motivation to perform well on the memory task. But, contrary to previous work (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021), motivation did not account for the relationship between age and proportions of on-task thought (attentional consistency) in Experiment 1. Since our sample size in Experiment 1 was similar to those reported in prior aging work (e.g., Robison et al., 2022), a potential reason for the discrepancy in results could be that our younger adult sample, recruited through Prolific, was more highly motivated than prior younger adult samples who were obtained through university human subject pools (Frank et al., 2015; McVay et al., 2013; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022). In other words, motivation's ability to explain age-related reductions in lapses of attention may depend on how individuals are recruited and compensated. Experiment 2 sought to test this notion by examining the relationship between motivation and attentional consistency in a younger adult sample recruited through the human subject pool at a large public university in the United States.

Given the lack of support for the control failure (McVay & Kane, 2010), resource competition (Smallwood & Schooler, 2006), and motivation (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021) based accounts of age differences in attentional consistency, Experiment 2 conducted a more comprehensive examination of the influence of dispositional and situational factors on the occurrence of attentional lapses and any age-related differences therein. As outlined in the Introduction, it is possible that affective (Frank et al., 2015; Moran et al., 2021), personality (Jackson & Balota, 2012; Nicosia & Balota, 2021), and neurodevelopmental (Moran et al., 2021) factors may also explain why younger adults tend to be less consistently focused on task than older adults. Experiment 2 investigated these matters by including measures of positive and negative affect, state anxiety, the Big 5 personality traits, and ADHD symptomology.

In sum, Experiment 2 had four primary aims. First, we sought to replicate the effect of value on proportions of on-task thought. Both younger and older adults in Experiment 1 modulated the consistency of attention based on the importance of the to-be-remembered material, and the ability (or willingness) to do so did not significantly vary with increased time on task. Note, however, that the learning task used in Experiment 1 was relatively short in duration (less than 30 min long). This raises the possibility that the task may not have been long enough to sufficiently challenge one's ability to selectively allocate high levels of attentional effort to the task at hand. Accordingly, we modified the experimental design for Experiment 2 in an attempt to increase demands on sustained attention. If successful in our attempts to increase time-on-task effects, we were interested in examining whether age-related differences in these effects would emerge. Second, we were interested in examining whether a larger performance decrement (during an attentional lapse) would arise for older adults than younger adults with a larger sample size. Third, we sought to examine whether the relationship between age and attentional consistency (proportions of on-task thought) is explained by motivation when recruiting a sample of younger adults from the human subject pool at a public university (as opposed to Prolific). Fourth, we wanted to conduct a more comprehensive analysis of potential mediators, focusing not only on motivation but on affect, personality, and ADHD symptomology as well.

Method

Participants

The sample included 123 younger adults and 119 older adults. We were interested in examining a complex mediation model and correlations within age groups. Updated effect size guidelines for individual differences research suggest $r = .10$ indicates a small effect; $r = .20$ indicates a medium effect; and $r = .30$ indicates a large effect (see Funder & Ozer, 2019; Gignac & Szodorai, 2016). Operating under the assumption that the largest effect we could find within an age group would be equivalent to $r = .30$, we wanted enough participants to reliably detect moderate to large correlations (e.g., $rs \geq .25$) with power = .80 and $\alpha = .05$. Therefore, our goal was to obtain data from 120 participants per age group. Younger adults were recruited using the undergraduate human subject pool at UCLA and were awarded partial course research credit for their participation. Older adults were recruited using Prolific and were paid for their participation ($10/hr). To participate in the study, all participants had to be fluent speakers of English. Younger adults had to be less than 35 years old, and older adults had to be at least 64 years old. Like Experiment 1, all data were collected online because it would take much longer to do in person.

A total of 15 participants were excluded in the younger adult sample (final N = 108, 82 female, 25 male, 1 nonbinary/other, M_{age} = 20.31, SD_{age} = 1.45), and a total of 11 participants were excluded in the older adult sample (final N = 108, 73 female, 35 male, M_{age} = 67.44, SD_{age} = 4.38). Individuals were excluded if they did not meet the age criteria specified above (n_{older} = 1) and if they were unable to recall a single word (out of the 30 possible) on more than one list in the DFR task ($n_{younger}$ = 2, n_{older} = 1).[6] Additional participants were excluded for completing the study on a cell phone ($n_{younger}$ = 1), for skipping all questionnaires ($n_{younger}$ = 1), and for taking a 37-min break when presented with a thought probe midway through the task ($n_{younger}$ = 1). On a posttask survey, a variety of participants indicated their data should be dropped from analyses. Participants who were excluded admitted to cheating ($n_{younger}$ = 2, n_{older} = 3); giving up partway through the task ($n_{younger}$ = 2); repeatedly falling asleep during the task ($n_{younger}$ = 1); taking a prolonged break during the task ($n_{younger}$ = 2); and completing the study in an exceptionally distracting environment (e.g., "in a room with 10 people who would come in and out or have loud conversations that were distracting," $n_{younger}$ = 3). Another person was excluded because their internet disconnected during the recall phase of the second list (n_{older} = 1). Finally, consistent with Experiment 1 and Schwartz et al. (2023), we erred on the side of caution and removed individuals flagged as outliers (3 *SDs* above the mean) when inspecting boxplots and histograms of recall accuracy scores as a function of age group (n_{older} = 5). We reasoned that perfect- or near-perfect recall accuracy scores across lists indicated likely use of an external aid.

On average, participants in the final sample reported themselves to be in good health (M = 3.89 out of 5, SD = .83) and having obtained an associate degree (M = 3.83 out of 6, SD = 1.25). Younger adults reported being in significantly better health than older adults (z = 3.27, p = .001), and older adults had significantly higher levels of education than younger adults, z = 6.96, p < .001. Characteristics for each age group are summarized in Table 4.

Table 4
Participant Demographics for Each Age Group in Experiment 2

Demographic variable	Younger adult	Older adult
Mean age (*SD* age)	20.31 (1.45)	67.44 (4.38)
Gender		
Female	75.9%	67.6%
Male	23.1%	32.4%
Nonbinary or other	.9%	.0%
Race		
Asian	46.3%	1.9%
White	25.9%	84.3%
Hispanic or Latino/a/x	14.8%	3.7%
Black	4.6%	8.3%
Native Hawaiian or Other Pacific Islander	.9%	.0%
American Indian or Alaskan Native	.9%	.0%
Other or Unknown	6.5%	1.9%
Health		
Excellent	27.8%	13.0%
Good	56.5%	57.4%
OK	11.1%	17.6%
Fair	4.6%	11.1%
Poor	.0%	.9%
Education		
Some high school	.0%	.9%
High school diploma	17.6%	8.3%
Some college, no degree	52.8%	18.5%
Associate degree	18.5%	12.0%
Bachelor's degree	11.1%	39.8%
Professional degree (Master's, PhD, MD, etc.)	.0%	20.4%

Note. All younger adult participants were recruited through the human subject pool at the University of California, Los Angeles, using Sona Systems. All older adult participants were recruited through Prolific.

Procedure

Participants first provided informed consent and demographic information, in which they reported their age, gender, racial/ethnic background, current health quality, and highest level of education. Immediately following the demographics, participants completed a DFR-VDR task. Thought probes were embedded throughout the encoding phase of each list for all participants. The DFR-VDR task began and ended with a question asking participants to report their motivation to do well on the task. We included a pretask measure of motivation since performance and/or attentional lapse rates during the task may reactively influence posttask assessments (e.g., Miller & Unsworth, 2021, Experiment 2). Next, additional questions appeared probing participants' encoding strategy use. Some research suggests younger adults may employ more effective encoding strategies than older adults (Hertzog et al., 1998; Zivian & Darjes, 1983), which could explain their superior recall performance. However, this association between age and effective strategy use is not always found (Ariel et al., 2015; Bailey et al., 2009). The present study sought to add to this literature.

Following the strategy questionnaire, participants completed the following: the Spielberger State-Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992), the Positive and Negative Affectivity Scale (PANAS; Watson et al., 1988), the Big Five Inventory-2 Short Form (Soto & John, 2017a, 2017b), and the short-form screener of the Adult ADHD Self-Report Scale v1.1 (Adler et al., 2019; Kessler et al., 2005). Participants were then asked a few questions inquiring about potential experimental issues (e.g., whether there were problems with the task loading), cheating, or other reasons for which their data should be excluded from analyses. Participants were reassured that, regardless of their response to these questions, they would be compensated for their time. The Institutional Review Board of UCLA approved the procedure. All participants were treated in accordance with ethical standards of the American Psychological Association and were debriefed following the session. The entire session lasted about 1 hr.

Materials

DFR With VDR Manipulation. The materials in Experiment 2 were the same as those in Experiment 1, except (a) all participants

[6] No participants in Experiment 1 met this exclusionary criterion.

were administered thought probes, (b) the experimental trials now consisted of six lists, and (c) participants were unaware of the number of lists they would be administered.

Thought Probes. Same as Experiment 1, except 27 total probes were administered (four probes in each odd numbered list and five probes in each even numbered list).

Task-Specific Motivation. Like Experiment 1, except participants were now asked about their level of motivation twice during the task (Experiment 2, Miller & Unsworth, 2021; Experiment 2, Seli et al., 2017). The first self-report item appeared after completing the practice trials, directly before beginning the real trials of the DFR-VDR task. Specifically, participants were asked, "How motivated are you to perform well on the memory task?" The second self-report item appeared immediately upon completion of the DFR-VDR task. Participants were now asked, "How motivated were to perform well on the last few lists of the memory task?" The two measures of motivation were highly correlated ($r = .55$, $p < .001$), so we used the mean of these reports for our regression analyses. See Experiment 1 for more details.

Encoding Strategy Use. After the assessment of posttask motivation, participants indicated whether they used any encoding strategies to help better remember the words. We probed for strategy use following task completion to avoid potential reactivity effects associated with concurrent (list by list) strategy reports (see Dunlosky & Hertzog, 2001). Participants were asked, "What strategy (or strategies) did you use to remember the words?" The following options appeared onscreen: (a) I read each word to myself as it appeared onscreen, (b) I repeated the words to myself as much as possible, (c) I generated a sentence to link the words together, (d) I developed mental images of the words, (e) I grouped the words in a meaningful way, and (f) I did something other than the options included here. Participants were allowed to select more than one response. Consistent with prior work (Bailey et al., 2008; Miller et al., 2019; Unsworth, 2016), responses 1 (passive reading) and 2 (rehearsal) were considered ineffective strategies. Responses 3 (sentence/story generation), 4 (mental imagery), and 5 (grouping) were considered effective strategies. For analyses, we computed the proportion of effective strategies used.

Questionnaires.

State Anxiety. Participants completed the STAI (Marteau & Bekker, 1992). A series of six adjectives appeared onscreen (e.g., worried, relaxed). Since we were primarily interested in *state* anxiety, participants were instructed to "select the option that best describes how you feel right now." Participants responded on a 4-point scale (1 = *not at all*, 4 = *very much*). We computed the average rating across all items.

Affect. Participants were administered the PANAS (Watson et al., 1988). Ten items assessed positive affect, whereas another 10 items assessed negative affect. For instance, participants viewed an adjective (e.g., proud, irritable) and were asked "to what extent do you feel this way right now, at the present moment?" Participants responded with a 5-point scale (1 = *not at all*, 5 = *extremely*). For each subscale, we computed the average rating across all items.

Personality. Participants completed the 30-item Big Five Inventory-2 Short Form (Soto & John, 2017a, 2017b). The Big Five Inventory-2 Short Form includes six items for each facet of personality (extraversion, agreeableness, conscientiousness, neuroticism, and openness). Participants rated how well each item (e.g., "I am persistent, work until the task is finished") described them on a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*). For each subscale, we computed the average rating across all items.

ADHD Symptomatology. We assessed ADHD symptomology with the short-form screener of the Adult ADHD Self-Report Scale-v1.1 (Adler et al., 2019; Kessler et al., 2005). The complete Adult ADHD Self-Report Scale-v1.1 scale consists of 18 items. The short-form screener (Part A) merely consists of the six items that are most predictive of an ADHD diagnosis in adults. Participants read each item (e.g., "When you have a task that requires a lot of thought, how often do you avoid or delay getting started?"; "How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?") and were asked to select the answer that best describes how they have felt and conducted themselves over the past 6 months. Participants responded on a 5-point scale (1 = *never*, 5 = *very often*). The present study adopted a similar approach to Seli et al. (2015) and computed the average rating across all items.

Results and Discussion

Descriptive statistics for all cognitive measures are listed in Table 5, whereas descriptive statistics for all state-based measures are listed in Table 6. Descriptive statistics for all dispositional trait measures can be found in Table 7. All variables were approximately normally distributed, and all measures had generally acceptable values of reliability (see Table 8).

Attentional State as a Function of Value, List, and Age

Participants reported being on task 56% of the time and experienced TUTs 18% of the time. The remaining 26% of the time was spent thinking about their performance or how long the task was taking to complete (TRI). While a rate of 18% for attentional lapses is still lower than what is typically observed in other learning and memory tasks (e.g., Garlitch & Wahlheim, 2020;

Table 5
Descriptive Statistics for All Cognitive Measures in Experiment 2

Measure	Age group	*M*	*SD*	Min	Max	Skew	Kurtosis
Recall acc	Young	.39	.15	.13	.83	.79	.06
	Old	.33	.14	.15	.73	1.11	.79
Prop on task	Young	.50	.35	.00	1.00	.07	−1.44
	Old	.62	.32	.00	1.00	−.49	−1.00
Prop TRI	Young	.24	.23	.00	.89	.94	.09
	Old	.28	.24	.00	.96	.79	.01
Prop TUT	Young	.25	.28	.00	1.00	1.02	.08
	Old	.10	.16	.00	.67	1.67	1.79
Strategy use	Young	.59	.32	.00	1.00	−.31	−.85
	Old	.52	.30	.00	1.00	.06	−.73

Note. Recall acc = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; Strategy use = proportion of effective strategies used (out of three total: sentence generation, mental imagery, and grouping). Younger adults did *not* use a significantly greater proportion of effective encoding strategies than older adults ($p = .068$). Min = minimum; Max = maximum.

Table 6
Descriptive Statistics for All State-Based, Contextual Measures in Experiment 2

Measure	Age group	*M*	*SD*	Min	Max	Skew	Kurtosis
PreMotiv	Young	5.00	1.35	1.00	7.00	−.55	−.11
	Old	6.49	0.88	3.00	7.00	−1.90	3.19
PostMotiv	Young	4.51	1.60	1.00	7.00	−.26	−.79
	Old	5.95	1.36	1.00	7.00	−1.65	2.50
Anxiety	Young	2.09	0.60	1.00	3.83	.44	.21
	Old	1.85	0.62	1.00	3.67	.77	.30
NegAffect	Young	1.50	0.64	1.00	4.00	1.98	4.11
	Old	1.19	0.34	1.00	2.90	2.70	7.86
PosAffect	Young	2.28	0.77	1.10	4.20	.72	−.09
	Old	3.34	0.89	1.00	5.00	−.04	−.59

Note. PreMotiv = task-specific motivation before beginning the experimental trials; PostMotiv = task-specific motivation upon completion of all experimental trials; Anxiety = Spielberger State-Trait Anxiety Inventory-state score; NegAffect = Positive and Negative Affectivity Scale (PANAS) negative affect score; PosAffect = PANAS positive affect score; Min = minimum; Max = maximum.

Miller & Unsworth, 2021), our efforts to increase lapses of attention (relative to Experiment 1, $M = 6\%$) were successful. In terms of age differences, older adults were again more frequently focused on task during learning ($M = .62$, $SE = .03$) than were younger adults ($M = .50$, $SE = .03$), $t(214) = 2.60$, $p = .010$, 95% CI [.03, .21], Cohen's $d = .35$. Older adults ($M = .28$, $SE = .02$) did not significantly differ from younger adults ($M = .24$, $SE = .02$) when examining rates of TRI ($t = 1.17$, $p = .242$), but younger adults reported significantly higher rates of TUT ($M = .25$, $SE = .03$) than older adults ($M = .10$, $SE = .02$), $t(214) = 5.03$, $p < .001$, 95% CI [.09, .22], Cohen's $d = .68$. These results broadly replicate Experiment 1 insofar that they support the idea that younger adults are more prone to attentional *inconsistency* during intentional learning conditions (relative to older adults).

Next, we sought to replicate the effect of value on attentional state. In accord with Experiment 1,[7] we submitted proportions of on-task thought to a repeated measures ANOVA with value (low vs. mid vs. high) and list (1–6) as within-subject factors. Value was again treated as a categorical variable because each list consisted of one to two thought probes per value category. Words worth 1–3 points were classified as low value, words worth 4–7 points were classified as mid value, and words worth 8–10 points were classified as high value. There were simply not enough observations per point value in each list to reliably treat value as a continuous variable. Critically, results aligned with Experiment 1 insofar that a main effect of value arose, $F(2, 430) = 16.26$, $p < .001$, $MSE = .08$, partial $\eta^2 = .07$. Rates of on-task thought tended to increase as value increased, positive linear trend: $F(1, 215) = 24.94$, $p < .001$, $MSE = .09$, partial $\eta^2 = .10$. Specifically, rates of on-task thought were significantly lower when individuals studied low-value words ($M = .52$, $SE = .03$) than when they studied mid-value ($M = .58$, $SE = .02$) and high-value ($M = .58$, $SE = .02$) words, all $ps < .001$. The comparison between mid- and high-value words was nonsignificant, $p = .40$.

Unlike Experiment 1, results also revealed a significant main effect of list, $F(5, 1075) = 14.45$, $p < .001$, $MSE = .18$, partial $\eta^2 = .06$. As demonstrated in Figure 6, proportions of on-task thought did not significantly change across lists 1–3 ($ps > .76$). But, beginning with list 4, rates of on-task thought were significantly lower than all preceding lists ($ps < .016$). Proportions of on-task thought continued to decline until the sixth list, which did not significantly differ from the fifth list ($p = .664$). Thus, a typical time-on-task effect arose in Experiment 2, whereby individuals became less focused on task as time ensued, negative linear trend: $F(1, 215) = 32.44$, $p < .001$, $MSE = .33$, partial $\eta^2 = .13$.

Notably, a significant interaction between value and list also emerged, $F(10, 2150) = 4.44$, $p < .001$, $MSE = .08$, partial $\eta^2 = .02$. Pairwise comparisons revealed that, on the first list, people were less consistently focused on task when studying low-value words compared to when they studied mid- and high-value words ($ps < .004$). As shown in Figure 7, the difference between mid- and high-value words was not significant ($p = .588$). On the second list, no significant effects of value were observed (all $ps > .10$). But, on the third list, people were significantly more focused on task when they studied high-value words than when they studied mid- or low-value words ($ps < .001$). Low- and mid-value words did not differ from each other ($p = .425$). On the fourth list, proportions of on-task thought did not differ between mid- and high-value words ($p = .568$), but on-task thought was significantly lower when studying low-value words than when studying mid- and high-value words ($ps < .005$). On the fifth list, individuals were more focused on task when studying mid-value words than when studying low-value words ($p = .006$). All other comparisons were nonsignificant ($ps > .08$).

Taken altogether, these results seem to suggest that individuals were least susceptible to time-on-task effects when studying high-value information—initially. That is, steady, modest declines in on-task focus occurred after the second list when participants studied low- and mid-value words. When participants studied high-value words, no consistent decline in on-task thought was observed until after the third list. Thus, when restricting the analysis to lists 3–6, significant declines in on-task thought occurred during study for all words regardless of their point value. But, during this period,

Table 7
Descriptive Statistics for All Dispositional Trait Measures in Experiment 2

Measure	Age group	*M*	*SD*	Min	Max	Skew	Kurtosis
Extraversion	Young	3.23	0.75	1.33	4.83	−.21	−.34
	Old	3.34	0.84	1.17	5.00	−.38	.03
Agreeableness	Young	3.79	0.66	2.17	5.00	−.24	−.50
	Old	4.25	0.65	2.00	5.00	−.87	.33
Conscientiousness	Young	3.50	0.69	1.83	4.83	−.12	−.31
	Old	4.07	0.84	1.50	5.00	−.78	−.18
Neuroticism	Young	2.92	0.87	1.00	5.00	−.08	−.14
	Old	2.01	0.85	1.00	4.83	1.09	1.25
Openness	Young	3.56	0.66	2.17	5.00	.14	−.56
	Old	3.84	0.87	1.17	5.00	−.63	−.21
ADHD	Young	2.84	0.66	1.00	4.50	−.10	.06
	Old	2.12	0.64	1.00	5.00	1.09	3.07

Note. Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener; Min = minimum; Max = maximum.

[7] Proportions of task-unrelated (off-task) thought continued to be at or near floor for older adults. See Table 5. Despite the presence of a floor effect, proportions of TUT were still highly correlated with proportions of on-task thought (Spearman's $\rho = -.75$; Pearson's $r = -.72$, $ps < .001$).

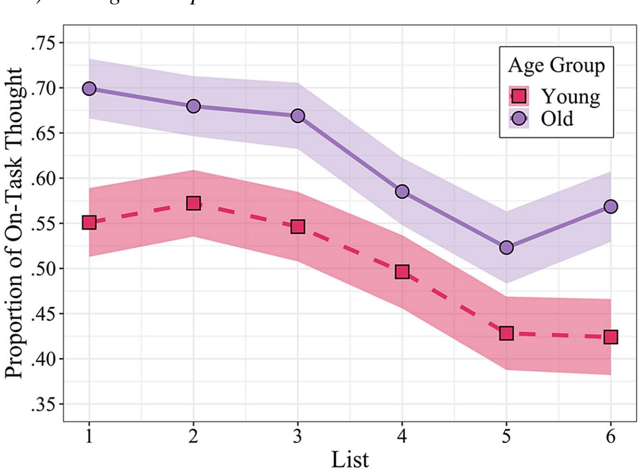
Table 8
Reliability Estimates for All Measures in Experiment 2

Measure	Reliability (Cronbach's α)
Cognitive measures	
Recall acc	.94
Prop on task	.92
Prop TRI	.83
Prop TUT	.89
Strategy use	
State-based, contextual measures	
PreMotiv	
PostMotiv	
Anxiety	.83
NegAffect	.87
PosAffect	.93
Dispositional trait measures	
Extraversion	.75
Agreeableness	.78
Conscientiousness	.82
Neuroticism	.86
Openness	.76
ADHD	.76

Note. Computing a split-half reliability for mean task-specific motivation (using pre- and postscores) produces an estimate of .71. Recall acc = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; PreMotiv = task-specific motivation before beginning the experimental trials; PostMotiv = task-specific motivation upon completion of all experimental trials; Anxiety = Spielberger State-Trait Anxiety Inventory-state score; NegAffect = Positive and Negative Affectivity Scale (PANAS) negative affect score; PosAffect = PANAS positive affect score; Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener.

high-value information was more strongly affected by time-on-task, negative linear effect of list: $F(1, 215) = 34.05$, $p < .001$, $MSE = .13$, partial $\eta^2 = .14$, than mid-value information, negative linear effect of list: $F(1, 215) = 13.24$, $p < .001$, $MSE = .10$, partial $\eta^2 = .06$, and

Figure 6
Proportions of On-Task Thought as a Function of Time on Task (i.e., List) and Age in Experiment 2



Note. Shaded regions represent one standard error of the mean. See the online article for the color version of this figure.

low-value information, negative linear effect of list: $F(1, 215) = 7.48$, $p = .007$, $MSE = .14$, partial $\eta^2 = .03$. Consequently, there was no longer a significant main effect of value on proportions of on-task thought on the sixth and final list, omnibus test: $F(2, 430) = 1.72$, $MSE = .05$, $p = .180$, partial $\eta^2 = .01$.

To examine whether the effects of value and time on task varied across age groups, we next added age as a between-subjects factor to the repeated measures ANOVA described above. Results revealed all age-related interactions were nonsignificant (*ps* > .10). Thus, consistent with Experiment 1, individuals—regardless of age—were increasingly focused on learning when the to-be-remembered material was more important.

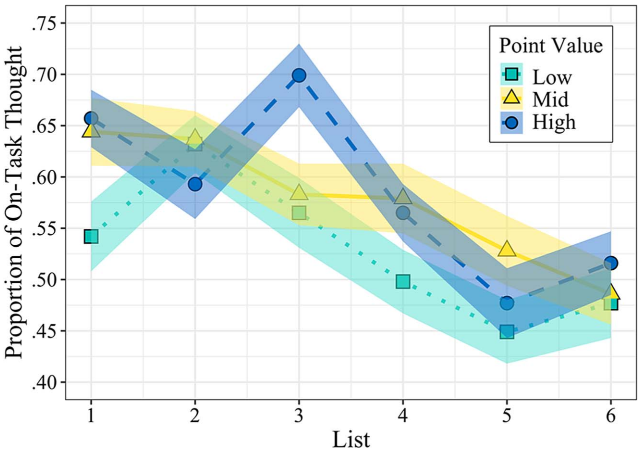
Overall, unlike Experiment 1, TUTs and TRI-type thoughts seemingly became more difficult to inhibit for all individuals, leading to a decrease in on-task focus as time elapsed. This finding is consistent with Garlitch and Wahlheim (2020) and suggests that the lack of any time-on-task effect (vigilance decrement) in Experiment 1 was partly due to the relatively short task duration. Indeed, declines in on-task focus were not observed until the fourth list in Experiment 2, which was the max number of lists administered in Experiment 1. Critically, though, these time-on-task effects were moderated by value and did not vary across age groups. Little to no vigilance decrement occurred over the first half of the task when studying high-value information, suggesting the importance of the to-be-remembered material may act as a buffer against these time-on-task effects. That said, participants soon became unable (or unwilling) to sustain high levels of effort expenditure across the remainder of the task. By the fourth list (approximately 25 min into the task), individuals especially struggled to keep attention focused on task when studying high-value information.

Recall Accuracy as a Function of Value, List, and Age

Next, we submitted recall accuracy to a repeated measures ANOVA with value (1–10) and list (1–6) as within-subject factors. A significant main effect of value arose, $F(9, 1935) = 139.71$, $p < .001$, $MSE = .14$, partial $\eta^2 = .39$. Consistent with Experiment 1, memory for words worth 2 points did not significantly differ from memory for words worth 3 points ($p = .709$). Memory for words worth 4 points did not significantly differ from memory for words worth 5 points ($p = .509$), and memory for words worth 5 points did not significantly differ from memory for words worth 6 points ($p = .069$). All other pairwise comparisons were significant (*ps* < .05), indicating higher value words were better remembered than lower value words, positive linear trend: $F(1, 215) = 261.68$, $p < .001$, $MSE = .65$, partial $\eta^2 = .55$.

The analysis further revealed a significant main effect of list, $F(5, 1075) = 5.79$, $p < .001$, $MSE = .08$, partial $\eta^2 = .03$, suggesting individuals were able to remember a greater proportion of words on each list—irrespective of value—across the first four lists. That is, recall accuracy on list 1 ($M = .34$, $SE = .01$) was significantly lower than recall accuracy on lists 2–4 (*ps* < .001), but recall accuracy on these latter lists did not significantly differ from each other (*ps* > .13). Following list 4 ($M = .38$, $SE = .01$), recall performance declined and reached asymptote across lists 5 ($M = .35$, $SE = .01$) and 6 ($M = .35$, $SE = .01$); hence, recall accuracy on lists 5 and 6 did not significantly differ from recall accuracy on lists 1 and 3 (*ps* > .08). Recall accuracy on lists 5 and 6 was also significantly worse than recall accuracy on lists 2 (*ps* < .036) and 4 (*ps* < .001). In sum,

Figure 7
Effects of Value and Time on Task (i.e., List) on Proportions of On-Task Thought During Study



Note. Point value was treated *categorically* (low = points 1–3; middle = points 4–7; high = points 8–10). Each individual list consisted of 1–2 observations per value category. Shaded regions represent one standard error of the mean. See the online article for the color version of this figure.

the main effect of list was largely characterized by a quadratic trend: $F(1, 215) = 19.62$, $p < .001$, $MSE = .08$, partial $\eta^2 = .08$.

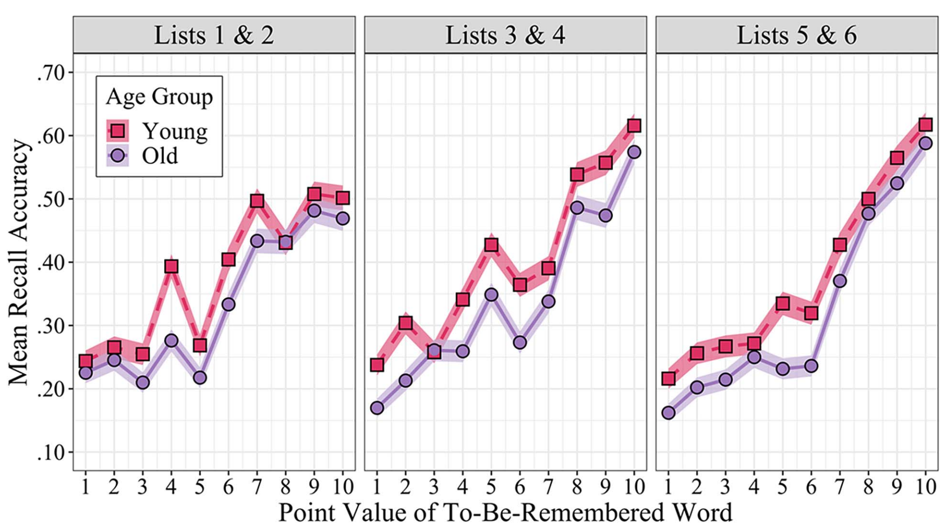
The main effect of list was qualified by an interaction with value, $F(45, 9675) = 11.95$, $p < .001$, $MSE = .06$, partial $\eta^2 = .05$. Consistent with Experiment 1, we reran the analysis replacing the continuous (10-level) value variable with a three-level value variable (low = points 1–3; mid = points 4–7; high = points 8–10) to help decompose the interaction. When examining the least valuable words, a significant negative linear effect of list emerged, $F(1, 215) = 4.21$, $p = .041$, $MSE = .03$, partial $\eta^2 = .02$. Recall accuracy for *low*-value words was higher on the first list ($M = .26$, $SE = .02$) than the second ($M = .23$, $SE = .02$), fifth ($M = .22$, $SE = .02$), and sixth ($M = .22$, $SE = .02$) lists, *ps* < .025. All other comparisons were nonsignificant (*ps* > .052).

Turning to words of moderate value, a significant main effect of list emerged that was both linear, $F(1, 215) = 14.48$, $p < .001$, $MSE = .02$, partial $\eta^2 = .06$, and quadratic, $F(1, 215) = 11.48$, $p < .001$, $MSE = .02$, partial $\eta^2 = .05$, in nature. That is, recall accuracy for *mid*-value words was lower on the first list ($M = .33$, $SE = .01$) than the second list ($M = .37$, $SE = .01$), but recall accuracy for mid-value words was lower on the third list ($M = .33$, $SE = .02$) than the second list, *ps* < .001. Lists 1 and 3 did not differ from each other ($p = .953$). However, following the fourth list ($M = .35$, $SE = .02$), recall accuracy for mid-value words declined and became significantly worse on the final list ($M = .30$, $SE = .02$) relative to all other lists (*ps* < .02)—except for the fifth list ($p = .354$). Recall accuracy for mid-value words on the fifth list ($M = .31$, $SE = .02$) was significantly lower than recall accuracy on the second and fourth lists (*ps* < .001).

Examining recall accuracy for the most valuable words revealed a significant main effect of list that was largely characterized by a positive linear trend, $F(1, 215) = 35.85$, $p < .001$, $MSE = .04$, partial $\eta^2 = .14$, and a quadratic trend, $F(1, 215) = 21.65$, $p < .001$, $MSE = .03$, partial $\eta^2 = .09$. Recall accuracy for *high*-value words was lower on the first list ($M = .43$, $SE = .02$) than all other lists, *ps* < .001. Similarly, recall accuracy for high-value words was significantly lower on the second list ($M = .51$, $SE = .02$) than the fourth list ($M = .55$, $SE = .02$) and sixth list ($M = .55$, $SE = .02$), *ps* < .031. All other comparisons were nonsignificant, *ps* > .16. Collectively, these results are consistent with Experiment 1 in suggesting that participants increasingly prioritized recall of high-value words at the expense of low- (and mid-) value words with additional task experience (see Figure 8).

When adding age as a between-subjects factor, the analysis further revealed a significant main effect of age, $F(1, 214) = 7.13$,

Figure 8
Mean Recall Accuracy as a Function of Point Value, Age Group, and List in Experiment 2



Note. List was treated continuously (ranging from 1 to 6) in all analyses. We collapsed lists into blocks (block 1 = lists 1–2; block 2 = lists 3–4; block 3 = lists 5–6) for visualization purposes only. Shaded regions represent one standard error of the mean. See the online article for the color version of this figure.

p = .008, MSE = 1.29, partial η^2 = .03. Like Experiment 1, older adults displayed impaired DFR accuracy overall (M = .33, SE = .01) when compared to younger adults (M = .39, SE = .01). The only other significant effect to arise was a three-way interaction between age, value, and list, $F(45, 9{,}630) = 1.82$, $p < .001$, MSE = .06, partial η^2 = .01 (all other ps > .15). Follow-up analyses suggested this three-way interaction was driven by the presence of an Age × List interaction among low-value words (points 1–3). Namely, when rerunning the analysis with the categorical value variable, older adults appeared to remember fewer low-value words across lists, negative linear trend: $F(1, 107) = 4.21$, p = .043, MSE = .03, partial η^2 = .04. Pairwise comparisons suggested that older adults remembered significantly more low-value words on the first list (M = .26, SE = .02) than the second (M = .20, SE = .02), third (M = .20, SE = .02), fifth (M = .19, SE = .02), and sixth (M = .20, SE = .02) lists, all ps < .014. The first list did not significantly differ from the fourth list (M = .23, SE = .02), p = .160. Recall accuracy for low-value words among younger adults, on the other hand, demonstrated no significant changes across lists (F = .936, p = .457). Thus, age differences in recall arose for low-value words only on the third and fifth lists (ps < .05). No age-related differences in recall emerged for low-value words on the other lists (ps > .06). These results broadly suggest that younger and older adults both prioritized study and subsequent recollection of the most valuable information, but this increased selectivity among older adults was partly achieved by their tendency to increasingly deemphasize words associated with the lowest values.

Recall Accuracy as a Function of Attentional State

Next, we sought to examine the within-subject effect of attentional state on subsequent memory performance using logistic MLM. All model parameters were identical to those used in Experiment 1, but the analysis now contained 27 thought probes per person and 216 participants total. We initially compared a model with an interaction term between attentional state and age group (plus their corresponding main effects) to a similar model with just the main effects as predictors. Like Experiment 1, model comparisons revealed the addition of the interaction term did not significantly improve model fit, $\chi^2(2) = 3.09$, p = .213. Neither main effect of attentional state, discussed below, significantly varied as a function of age group (ps > .12). Older adults demonstrated worse subsequent memory than younger adults irrespective of attentional state ($\gamma = -.46$, SE = .13, $z = -3.56$, $p < .001$). Given the lack of a significant interaction, we dropped the interaction term from the model but note significant effects in the retained model were likewise significant in the rejected model.

Consistent with Experiment 1, results revealed on-task thought was associated with better subsequent memory relative to TUT (γ = .80, SE = .11, z = 7.31, p < .001). Namely, the odds of a participant correctly recalling an item were 2.23 ($e^{.80}$) times greater when they reported being on task compared to when they were distracted by internal (e.g., mind-wandering) or external sources. Unlike Experiment 1, but consistent with Miller and Unsworth (2021), results further indicated that TRI (γ = .37, SE = .11, z = 3.23, p = .001) was associated with significantly better subsequent memory relative to TUT. TRI was also associated with significantly worse subsequent memory relative to instances of on-task thought ($\gamma = -.44$, SE = .09, $z = -5.08$, $p < .001$).[8]

Collectively, these results corroborate the findings of Experiment 1 using a larger sample and suggest that performance decrements during periods of TUT were similar across age groups. For all individuals, items studied during TUTs—and, to a lesser extent, during instances of TRI—were less likely to be recalled than when full attention was given to the task (Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Metcalfe & Xu, 2016; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). As previously mentioned, the lack of an interaction is somewhat at odds with resource theories, which suggest memory performance for older adults should be more impaired by TUTs than younger adults.

State-Based Variables and Dispositional Traits

We next sought to test the notion that the Prolific sample in Experiment 1 may have been more motivated than the typical undergraduate sample used in aging studies, resulting in reduced age-related differences in task-specific motivation. Indeed, posttask motivation scores for younger adults in Experiment 1 were significantly higher than posttask motivation scores in Experiment 2, $t(230) = 7.27$, $p < .001$, 95% CI [.96, 1.68], Cohen's d = .96. However, a reduction in motivation was similarly observed when examining posttask motivation scores for older adults in Experiment 1 and Experiment 2, $t(227) = 4.78$, $p < .001$, 95% CI [.41, .98], Cohen's d = .63, suggesting that increasing the time spent on task in Experiment 2 likely reduced motivation for all individuals. That said, a 2 (Young vs. Old) × 2 (Experiment 1 vs. Experiment 2) ANOVA indicated that the decline in motivation across experiments was larger for younger than older adults, $F(1, 457) = 7.35$, p = .007, partial η^2 = .02. While the effect is small, it does suggest that age-related differences in motivation were larger in Experiment 2 than Experiment 1.

We next submitted motivation scores (in Experiment 2) to a repeated measures ANOVA with time (pre vs. post) as a within-subjects factor. The analysis revealed a significant main effect of time, $F(1, 215) = 27.38$, $p < .001$, MSE = 1.04, partial η^2 = .11, suggesting motivation to perform well on the memory task was higher at the beginning of the task than at the end of the task. Adding age group as a between-subjects factor revealed a significant main effect of age, $F(1, 214) = 94.49$, $p < .001$, MSE = 2.46, partial η^2 = .31. Like Experiment 1, older adults were significantly more motivated overall (M = 6.22, SE = .11) relative to younger adults (M = 4.76, SE = .11). Age-related differences in motivation did not vary as a function of time (F = .06, p = .814).

In terms of other state-based variables, older adults in Experiment 2 reported more positive affect, $t(214) = 9.35$, $p < .001$, 95% CI [.83, 1.28], Cohen's d = 1.27, less negative affect, $t(214) = 4.46$, p < .001, 95% CI [.17, .45], Cohen's d = .61, and less anxiety, $t(214)$ = 2.86, p = .005, 95% CI [.07, .40], Cohen's d = .39, immediately upon completion of the DFR-VDR task. In regard to dispositional traits, older adults were also more agreeable, $t(214) = 5.14$, $p < .001$,

[8] A significant main effect of attentional state similarly arose when running the analysis as a repeated measures ANOVA, $F(2, 210) = 20.98$, p < .001, MSE = .04, partial η^2 = .17. On-task thought was associated with significantly better recall accuracy (M = .40, SE = .02) than TRI (M = .29, SE = .02), and TRI was associated with significantly better recall accuracy than TUT (M = .22, SE = .03). All ps < .016.

95% CI [.28, .63], Cohen's $d = .70$, more conscientious, $t(214) = 5.54$, $p < .001$, 95% CI [.37, .78], Cohen's $d = .75$, and less neurotic, $t(214) = 7.76$, $p < .001$, 95% CI [.68, 1.14], Cohen's $d = 1.06$. As expected, older adults did not differ from younger adults when examining extraversion ($p = .312$), but an unexpected finding was that older adults in the present study were more open-minded, $t(214) = 2.68$, $p = .008$, 95% CI [.07, .49], Cohen's $d = .36$. Younger adults, on the other hand, reported more pronounced ADHD symptomology than older adults, $t(213) = 8.17$, $p < .001$, 95% CI [.55, .90], Cohen's $d = 1.11$. Tables 5–7 provide the means and standard deviations for these variables broken down by age group, whereas Table 9 provides correlations with age (recoded so that younger adults were 0 and older adults were 1) and all other variables. For an examination of individual differences within each age group, please refer to Appendix B.

Mediation of Age-Related Differences in Attentional Consistency

As noted previously, older adults were less susceptible to lapses of attention during learning, enabling them to focus their attention more consistently on the task at hand relative to younger adults. The ability to keep attention consistently focused on task was, like age, associated with increased motivation to perform well ($r = .51$, $p < .001$), more positive affect ($r = .46$, $p < .001$), less negative affect ($r = -.19$, $p = .006$), lower state anxiety ($r = -.26$, $p < .001$), less ADHD symptomology ($r = -.19$, $p = .006$), higher agreeableness ($r = .27$, $p < .001$), higher conscientiousness ($r = .22$, $p < .001$), more openness to new experiences ($r = .20$, $p = .003$), and lower neuroticism ($r = -.26$, $p < .001$). Thus, we next sought to examine whether age-related differences in attentional consistency could be explained by these factors.

To do so, we first created a negative affect factor composite score for each participant by entering scores from the STAI and PANAS into a factor analysis using principal component analysis. Factor loadings were as follows: STAI state anxiety (.91), PANAS negative affect (.84), and PANAS positive affect (−.53). Using an aggregation of these measures is consistent with Robison et al. (2020) and allows us to better assess the role of a negative affect construct (see Salthouse, 2017, for a more elaborate discussion on the advantages of such a procedure). We next specified a path model in which age group had a direct effect on proportions of on-task thought and indirect effects through the following: mean motivation, negative affect composite scores, ADHD symptomology, agreeableness, conscientiousness, neuroticism, and openness. Each of the mediators was allowed to covary with each other. The resulting model is depicted in Figure 9.

Both task-specific motivation (indirect effect: $\beta = .28$, $SE = .05$, $p < .001$, 95% CI [.19, .37]) and the negative affect composite (indirect effect: $\beta = .08$, $SE = .03$, $p = .011$, 95% CI [.02, .13]) significantly explained the effect of age on proportions of on-task thought. The indirect effects for the other variables were nonsignificant (*p*s > .10), largely owing to their substantial shared variance with, not only each other (e.g., r between conscientiousness and neuroticism = −.40; r between conscientiousness and ADHD symptomology = −.52) but with motivation and/or negative affect. For example, ADHD symptomology and neuroticism were highly positively correlated with the negative affect composite (r with ADHD = .25; r with neuroticism = .48). See Appendix C for correlations among all variables when controlling for age differences.

Critically, though, with all these predictors accounted for, the relationship between age and proportions of on-task thought became larger in magnitude and changed sign,[9] direct effect: $\beta = -.26$, $SE = .08$, $p = .001$, 95% CI [−.41, −.11]. This represents a case of negative statistical suppression, which will be elaborated upon in the General Discussion. In any case, motivational, affective, and (to a lesser extent) dispositional factors explained why older adults were more consistently focused on the task at hand. But, when controlling for the influence of these multiple "third variables," results indicate that older adults actually experienced more attentional *inconsistency* relative to younger adults. This finding supports the notion that attention control abilities play a fundamental role in explaining age-related declines in cognitive functioning (Hasher & Zacks, 1988) as well as control failure accounts of mind-wandering (McVay & Kane, 2010).

Transparency and Openness

The data, analysis scripts, and task stimuli are all publicly available on the Open Science Framework (https://osf.io/8u6jp/). All figures were created in *R* using the *tidyverse* (Wickham, 2017). Path models were analyzed using the *lavaan* package in *R* (Rosseel, 2012), and logistic multilevel models were similarly analyzed in *R* using lme4 (Bates et al., 2015). All other analyses were conducted in IBM SPSS Statistics (Version 29). In accord with Journal Article Reporting Standards (Appelbaum et al., 2018), we report how we determined our sample sizes, all data exclusions, all manipulations, and all measures throughout the present study. The experiments' designs and their analyses were not formally preregistered.

General Discussion

Understanding one's ability to consistently keep attention focused on task during learning is crucial for both educational and applied settings, as lapses of attention (and, to a lesser extent, TRI-type thoughts) can profoundly impact the acquisition of new knowledge and skill mastery. The present study sought to address two interrelated questions that are central to this understanding: (1) Which learning conditions promote more on-task focus? (2) Which individuals are best able to consistently maintain attention on task, and why? To address the first question, the present study focused on the possible influence of value, the importance of the information to be remembered. In a world inundated with information, discerning between what is essential and what is not becomes a crucial skill. Value-driven attention and memory processes are therefore of paramount importance, as value may guide learners in allocating their attentional resources more efficiently.

In terms of our second question, age-related declines in susceptibility to attentional lapses have long perplexed the field. The experience of an attentional lapse (McVay & Kane, 2009, 2010, 2012b) and aging (Braver & West, 2008; Hasher & Zacks, 1988; Zacks & Hasher, 1994) are both associated with poor attention control. Yet healthy older adults report fewer TUTs (and more on-task focus) than younger adults when completing various measures of sustained attention (Giambra, 1989; Jackson et al., 2013; McVay et al., 2013; Moran et al., 2021; Nicosia & Balota, 2021; Robison

[9] When not taking these other variables into account, the direct effect of age on proportions of on-task thought is the following: $\beta = .18$, $SE = .07$, $p = .009$.

Table 9
Correlations Among All Measures in Experiment 2 (Total N = 216; $N_{Younger}$ = 108; N_{Older} = 108)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	—													
2. Recall acc	**−.18**	—												
3. Prop on task	**.18**	**.25**	—											
4. Prop TRI	.08	**−.20**	**−.71**	—										
5. Prop TUT	**−.33**	**−.15**	**−.72**	.01	—									
6. Motivation	**.55**	.06	**.51**	**−.14**	**−.58**	—								
7. Strategy use	−.13	**.35**	.13	−.09	−.09	.10	—							
8. Negative affect	**−.39**	−.13	**−.35**	.11	**.39**	**−.37**	−.02	—						
9. ADHD	**−.49**	.02	**−.19**	.04	**.23**	**−.29**	.11	**.39**	—					
10. Extraversion	.07	.10	.13	−.10	−.08	**.15**	.09	−.10	**−.18**	—				
11. Agreeableness	**.33**	.00	**.27**	**−.15**	**−.24**	**.32**	.02	**−.27**	**−.43**	**.15**	—			
12. Conscientiousness	**.35**	.02	**.22**	−.05	**−.26**	**.35**	−.04	**−.35**	**−.59**	**.28**	**.42**	—		
13. Neuroticism	**−.47**	−.04	**−.26**	.08	**.29**	**−.33**	.01	**.57**	**.55**	**−.22**	**−.32**	**−.50**	—	
14. Openness	**.18**	.13	**.20**	−.04	**−.25**	**.23**	**.25**	−.10	−.09	**.29**	.08	.12	**−.19**	—

Note. Values in bold indicate statistical significance: $rs > .14$ are significant at $p < .05$; $rs > .175$ are significant at $p < .01$; $rs > .22$ are significant at $p < .001$. Recall acc = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; Motivation = mean task-specific motivation (average of pre- and posttask ratings); Strategy use = proportion of effective strategies used (out of three total: sentence generation, mental imagery, and grouping); Negative affect = negative affect factor composite score (using scores from Spielberger State-Trait Anxiety Inventory and Positive and Negative Affectivity Scale); Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener.

et al., 2022; Seli et al., 2017, 2021; Staub et al., 2014a, 2014b, 2015; Vallesi et al., 2021) and reading comprehension (Bonifacci et al., 2023; Frank et al., 2015; Jackson & Balota, 2012; Krawietz et al., 2012). However, behavioral performance in these tasks is largely unaffected by older age (Carriere et al., 2010; De Beni et al., 2007; Radvansky & Curiel, 1998; Vallesi et al., 2021), whereas older age has been consistently associated with impaired episodic memory performance (Craik, 1977, 1994; Craik, 2022; Craik & McDowd, 1987; Nyberg & Pudas, 2019; Park & Festini, 2017). Accordingly, we sought to investigate whether results similar to those described above arise during intentional learning conditions in an episodic memory task. If older adults continue to display an enhanced ability to keep attention consistently focused on task, we sought to advance the literature's understanding of why.

The Role of Value in Attentional Consistency and Sustained Attention During Learning

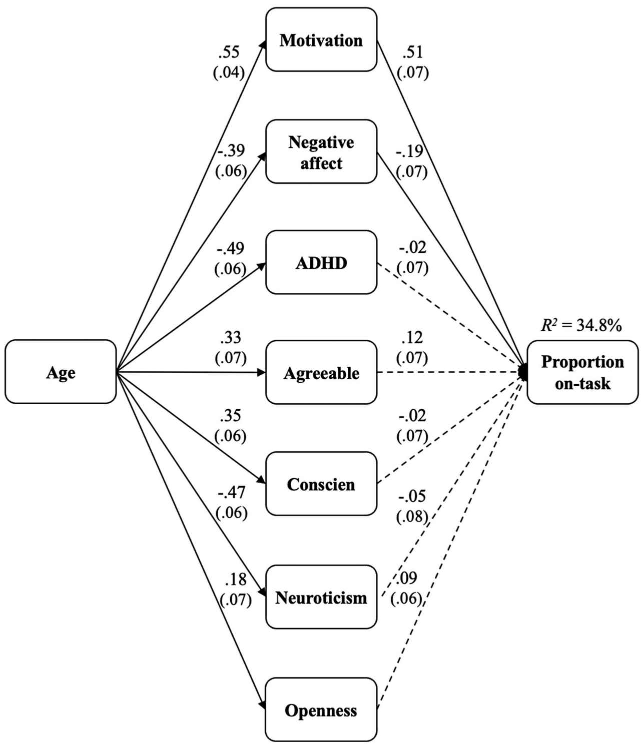
Research has long suggested that individuals seldom commit their full attentional capacity to a given task (Hockey, 1997; Kalsbeek, 1968; Kanfer & Ackerman, 1989; Schmidtke, 1976). Instead, people seem to allocate an initial proportion of their attention to a given task, with some attention being spared (Ackerman, 2011; Hockey, 1997, 2013; Kalsbeek, 1968; Kanfer & Ackerman, 1989; Schmidtke, 1976). Put differently, individuals are inclined to conserve some resources for later use. Based on these accounts, individuals have the potential to mobilize additional attentional resources when needed, resulting in enhanced task performance. In support of these ideas, both experiments revealed an effect of value on proportions of on-task thought as well as recall accuracy. Participants were more consistently focused on task when studying information that was more important, and important (high-value) information was also the best remembered.

Our results align with prior work demonstrating motivation and effort manipulations can reduce the experience of attentional lapses (Mrazek et al., 2012; Seli et al., 2019; Unsworth et al., 2022). Notably, the present study extends these findings to a learning and memory context and provides evidence for transient trial-by-trial modulations of effort based on the value of the information being studied. That is, participants seemingly allocated a greater proportion of their available attentional resources to high-value items (Ariel & Castel, 2014; Kahneman & Peavler, 1969; Miller et al., 2019). Increasing the amount of attention devoted to these items may have bolstered one's resistance to competing thoughts (Unsworth & Miller, 2021). Consequently, by optimally allocating attentional effort to high-value items, the propensity for distractions (i.e., TUTs and TRI-type thoughts) was diminished, resulting in enhanced memory for critical information.

Given a large body of work suggests that this ability to sustain high levels of effort expenditure decreases as a function of time (Beatty, 1982; Parasuraman, 1986; Unsworth & Robison, 2016), we were surprised no effects of time on task (i.e., list) on proportions of on-task thought emerged in Experiment 1. So, in Experiment 2, we increased demands on sustained attention by increasing the amount of time participants spent completing the task. An effect of list on proportions of on-task thought now arose, which revealed a steady decline in on-task thought midway through the DFR task. Interestingly, mean recall accuracy and task-specific motivation both demonstrated significant declines across task duration. Although the decline in accuracy was quite small and occurred after an initial, modest increase in performance (corresponding to the period in which proportions of on-task thought were unaffected by time), this pattern of results is broadly consistent with findings in the sustained attention literature demonstrating less attentional consistency as time on task ensues (Cunningham et al., 2000; Smallwood et al., 2004; Thomson, Seli, et al., 2014; Unsworth & Robison, 2016). Therefore, the ability (or willingness) to maintain consistent, high levels of attentional effort seemingly deteriorated over time.

Critically, though, an interaction between list and value arose, suggesting a person's ability to sustain attention throughout the

Figure 9
Path Model Predicting Proportion of On-Task Thought (Attentional Consistency)



Note. When not taking any mediators into account, the effect of age on attentional consistency (proportion of on-task thought) was β = .18, *SE* = .07, *p* = .009. Once all the variables were accounted for, the effect of age on attentional consistency became larger in magnitude and changed sign, β = −.26, *SE* = .08, *p* = .001, 95% CI [−.41, −.11]. Solid lines indicate significant paths at $p < .05$; dashed lines represent nonsignificant paths. Age is treated as a binary variable (younger adults = 0, older adults = 1). Proportion on task = proportion of on-task thought reported during study; Motivation = mean task-specific motivation (average of pre- and posttask ratings); Negative affect = negative affect factor composite score; Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener; Agreeable = agreeableness; Conscien = conscientiousness; *SE* = standard error.

course of learning depended on the importance (value) of the to-be-remembered material. Time-on-task effects (i.e., declines in on-task thought) were observed earlier for low- and mid-value items than was the case for high-value items, suggesting a protective function of value against these time-on-task effects. That said, about midway through the task, declines in on-task thought began to emerge when participants studied the most important (high-value) items. In fact, across the final lists, the strongest time-on-task effects were observed for these high-value items. Thus, by the end of the task, there was little to no benefit of value on proportions of on-task thought remaining. As previously mentioned, learners allocate attention differently to items as a function of their value (e.g., Ariel & Castel, 2014; Castel et al., 2013; Kahneman & Peavler, 1969; Miller et al., 2019), insofar that people tend to devote more attentional effort (and more study time) to more important information—likely in the form of more effective encoding strategies (M. S. Cohen et al., 2016; Hennessee et al., 2019; Miller & Unsworth, 2020). However, with increased time on task, arousal declines, and it becomes more challenging to sustain high levels of effort expenditure (Beatty, 1982; Parasuraman, 1986; Unsworth & Robison, 2016). Thus, if participants are continually mobilizing effort to prioritize high-value information, it is these high-value items that stand to be most impacted by the effects of time on task.

One issue with this interpretation, however, is the finding that recall accuracy for high-value items was superior on the final couple of lists, that is, when the benefits of value on attentional consistency (proportions of on-task thought) were reduced or eliminated. Note, this is also when recall for low- and mid-value items was lowest. Perhaps participants, aware of their declining attentional state and the limitations of their memory capacity, become more efficient in their approach to learning, selectively allocating fewer and fewer attentional resources to low- and mid-value items. An additional possibility proposed by Knowlton and Castel (2022) is that, over the course of learning, the ability to prioritize encoding of high-value information becomes more automatic and reliant on dopaminergic firing—at least for younger adults. Older adults may engage in other strategic regulatory behaviors not examined in the present study that allow them to focus on higher value items at the expense of lower value items. Future research should seek to test these notions more directly.

Overall, the present study is the first to demonstrate that both younger and older adults can selectively modulate the consistency of attention on a trial-by-trial basis during intentional learning conditions. Not only that, but the present study also showed that participants of all ages (in adulthood) were least resistant to time-on-task effects when studying important information, at least initially (for approximately 25 min). These results could have important implications for educators. For example, the present study suggests highlighting the importance and relevance of each topic discussed in class could be a promising strategy to keep students engaged with the material trying to be learned. Perhaps this could be achieved by connecting learning materials to real-world applications, having students reflect on the utility value of course content (Hulleman et al., 2010), or aligning course material with students' interests and core values (G. L. Cohen et al., 2006; Miyake et al., 2010). Educators might also find it beneficial to intersperse high-value content throughout their lessons. These approaches leverage the protective effect of value to combat potential declines in sustained attention.

Understanding Age-Related Differences in Attentional Consistency During Learning

In terms of understanding who is best able to consistently keep attention focused on task, results from both experiments support the notion that older adults display enhanced attentional consistency relative to younger adults. In Experiment 1, older adults reported more on-task focus and less TRI. No significant age differences emerged in TUTs, likely due to the presence of a floor effect in each age group. Indeed, increasing the time individuals spent on task in Experiment 2 increased TUTs relative to Experiment 1, and older adults again reported more on-task focus but also fewer TUTs. These findings are broadly consistent with the resource competition framework proposed by Smallwood and Schooler (2006), which posits that older adults, who presumably have fewer attentional resources than younger adults, tend to channel all of their available attentional resources toward the primary task. This deliberate allocation of limited resources to the primary task leaves older adults with minimal resources to allocate to TUTs. Younger adults, with their larger attentional resource capacity, can devote the same level of attention to the task at hand but still have resources available for TUTs to consume consciousness.

Note, however, a few aging studies have found a different pattern of results when examining instances of TRI—thoughts related to the appraisal of the current task, such as thinking about one's overall performance or wondering when the task will end (Stawarczyk et al., 2011; see also Smallwood et al., 2003). That is, while Experiment 1 suggested younger adults experience more TRI than older adults (Maillet & Rajah, 2013) and Experiment 2 suggested no age differences in TRI (like the control conditions in Jordano & Touron, 2017; Robison et al., 2022), other researchers have found more frequent TRI-type thoughts in older adults than younger adults (Frank et al., 2015; Krawietz et al., 2012; McVay et al., 2013; Zavagnin et al., 2014). Apart from Zavagnin et al. (2014), these latter studies adopted a narrower definition of TRI (i.e., evaluative thoughts about task performance) and go on to suggest that the fear and biases surrounding cognitive aging may cause older adults to dwell on their lab-task performance (i.e., stereotype threat; Hess et al., 2003). Ryan and Campbell (2021) further suggest that the increased motivation characteristic of older adult samples may amplify these effects. Thus, discrepancies across studies might stem from the varied ways in which different age groups experience TRI as well as the different approaches to measuring TRI. Specifically, lower task-specific motivation in younger adults likely contributes to their tendency to think more about task duration (they would rather be doing something else). In contrast, increased task-specific motivation and activation of aging stereotypes may encourage older adults to think more about their ongoing performance. To more directly examine this possibility, we suggest future research employing the thought probe technique incorporate two separate TRI categories as response options.

Importantly, McVay et al. (2013) suggest that "if older adults' reduced TUT rate is due to deficient resources, then they ought to engage in little TRI-type thinking as well." In other words, higher instances of TRI among older adults (compared to younger adults) are incompatible with a resource view that assumes older adults simply lack sufficient attentional resources to experience TUTs or TRI during ongoing tasks (Smallwood & Schooler, 2006). However, we propose that the increased prevalence of TRI among older adults is not incompatible with the idea of *differential* resource allocation between age groups. For example, consider two individuals: Person A, a younger adult with more attentional resources at their disposal, and Person B, an older adult with fewer attentional resources. Person A has an attentional resource capacity of 100 arbitrary units (AUs), whereas Person B has an attentional resource capacity of 85 AUs. During a learning task, Person A might allocate 40 AUs to the to-be-remembered material, 25 AUs to TRI, and 35 AUs to TUTs. Person B, on the other hand, may allocate 45 AUs (52.9% of their available capacity) to the to-be-remembered material, 30 AUs (35% of their available capacity) to TRI, and 10 AUs (11.8%) to TUTs. Thus, despite having fewer attentional resources overall, older adults may prioritize the primary task (and, to a less extent, TRI), resulting in more on-task thought, more TRI, and fewer TUTs compared to younger adults. This pattern does not undermine resource theories per se but instead highlights a strategic redistribution of attentional resources with age.

That said, other aspects of our results are more at odds with the idea that a lack of attentional resources prevents older adults from experiencing TUTs. Namely, both experiments revealed that subsequent memory was poorer on trials in which participants reported experiencing TUTs compared to trials where participants reported being completely focused on task. In Experiment 2, subsequent memory was similarly worse on trials in which participants reported instances of TRI (relative to trials where participants reported being completely focused on task), but these TRI trials were associated with better subsequent memory than when participants reported experiencing TUTs. Therefore, memory performance tended to get worse as attention became increasingly decoupled from the task (for similar results using pupil dilation as an index of attention allocation, see Miller & Unsworth, 2021). However, both experiments in the present study failed to detect a significant effect of age on the level of task disruption associated with these attentional diversions. Instances of TUT and TRI had similar detrimental effects on younger and older adults' subsequent memory performance, consistent with some previous work examining age differences in TUTs using other tasks (Maillet & Rajah, 2016; McVay et al., 2013).

According to the resource competition framework (Smallwood & Schooler, 2006), memory performance for younger adults should be less affected by TUTs than is the case for older adults. That is, if age differences in lapses of attention are driven by differences in the availability of attentional resources, then younger adults should be able to better afford some degree of TUT without significantly compromising task performance. Of course, this argument hinges on the assumption that lapses of attention consume a similar amount of resources for younger and older adults. It is possible that people differ in not only how frequently they experience lapses but also in how intensely attention is absorbed by their lapses. Future studies could investigate this possibility by examining whether the reduction in pupil dilation during lapse trials is significantly larger for younger adults than older adults. Although we are aware of one study who investigated this very question (Robison et al., 2022), and they found no significant age-related differences in pupillary responses when participants reported TUTs during a sustained attention task. Therefore, evidence is lacking regarding the role of attentional resource capacity in explaining the effects of age on attentional consistency.

An alternative explanation supported by our results is that older adults display enhanced attentional consistency because of a variety of dispositional and contextual factors. The present study examined this hypothesis by including measures of motivation, affect, personality, and ADHD symptomology. Consistent with previous research, results from both experiments demonstrated that older adults were more motivated to perform well than younger adults (Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022; Seli et al., 2017, 2021). Experiment 2 further revealed that, relative to younger adults, older adults experienced more positive affect (Cacioppo et al., 2008; Stawski et al., 2008), less negative affect (Barrick et al., 1989; Carstensen et al., 2000; Charles et al., 2001; Gross et al., 1997; Grühn et al., 2010), and less state anxiety (Moran et al., 2021). Increased motivation, more positive affect, less negative affect, and less anxiety were each associated with more consistent on-task focus.

In terms of dispositional traits and neurodevelopmental characteristics, older adults reported less ADHD symptomology than younger adults (Song et al., 2021; Vos & Hartman, 2022). Older adults were likewise more conscientious, more agreeable, and less neurotic (Bleidorn et al., 2009; Roberts & Mroczek, 2008; Soubelet & Salthouse, 2011; Terracciano et al., 2005). An unexpected age difference also arose for openness, with older adults scoring higher than younger adults. While openness has been associated with more frequent lapses of attention in daily life (Kane et al., 2017), most research suggests that younger adults are more open to new experiences (Allemand et al., 2007; Donnellan & Lucas, 2008; Mroczek & Spiro, 2003; Small et al., 2003). Nonetheless, conscientiousness, agreeableness, and openness were all associated with more consistent on-task focus during study, whereas increased neuroticism and ADHD symptomology were associated with less consistent on-task focus. With each of these associations in mind, we specified a path model in Experiment 2 where age predicted motivation, a negative affect composite, ADHD symptomology, agreeableness, conscientiousness, neuroticism, and openness. Each of these state and trait variables all predicted proportions of on-task thought.

The path model revealed two significant indirect effects, one for motivation and the other for negative affect. Therefore, the inclination of older adults to focus more consistently on the to-be-remembered material was explained by their heightened motivation to perform well and their lower levels of negative affect. Note the directionality specified in our path analysis implies higher motivation and less negative affect each led to fewer TUTs (high attentional consistency), but the reverse could also be true. Experiencing TUT may produce changes in affect (Kane et al., 2017; Killingsworth & Gilbert, 2010). Similarly, experiencing more attentional inconsistency during learning could contribute to reduced motivation as learning ensues. Thus, these associations are likely bidirectional and dynamically evolve throughout a task. Initial high levels of negative affect and low task-specific motivation (characteristic of younger adults) may lead to less consistent on-task focus, which, in turn, could reinforce negative affect and reduced motivation.

The remaining indirect effects specified in the path analysis were nonsignificant, largely due to significant overlapping sources of variance. For example, neuroticism and ADHD symptomology highly correlated with increased negative affect. Neuroticism and ADHD symptomology highly correlated with each other. Taken altogether, these findings provide compelling evidence supporting both dispositional and situational explanations for age differences in attentional consistency. Note others have reached similar conclusions (e.g., Frank et al., 2015; Jackson & Balota, 2012; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022), but the present study distinguishes itself through its larger sample size and the wide range of theoretically meaningful variables considered (particularly in Experiment 2). Previous research has focused only on a subset of these variables. For instance, two studies (Frank et al., 2015; Moran et al., 2021) focused on the mediating influence of motivation/interest and affect (situational factors), while another two studies concentrated on motivation/interest and conscientiousness (Jackson & Balota, 2012; Nicosia & Balota, 2021). To the authors' knowledge, no one has considered all of these important factors in tandem when modeling age-related differences in indices of attentional consistency. This narrow focus is problematic, as relying on a limited set of variables to predict an indicator of attentional consistency results in a construct that is narrowly defined and overlooks many of its more nuanced features. Most constructs are influenced by several underlying factors, some of which may account for the variance explained by a single construct in question. This highlights the importance of regression analyses that incorporate multiple predictors.

Accordingly, one of the most crucial findings of the present study arose when inspecting the path between age and on-task thought (consistency) after controlling for the various state and trait variables. With all the predictors accounted for, the relationship between age and proportions of *on-task thought* became larger in magnitude and changed sign ($\beta = -.26$). This phenomenon indicates the presence of a suppression effect, which implies that the inclusion of the other predictors in the model served to clarify the relationship between age and attentional consistency by controlling for variance that is not relevant to the primary relationship of interest (Horst, 1941; Paulhus et al., 2004; Watson et al., 2013). In other words, the suppressor variables isolated the unique variance in attentional consistency that is directly related to age, revealing a more accurate depiction of their relationship. The change in the sign and magnitude of the β coefficient for age further suggests that the true relationship between age and attentional consistency may be masked or distorted when not accounting for the influence of other interrelated predictors.

We emphasize that future research must replicate the suppressor effect using high powered designs to affirm its significance, as it unveils more nuanced insights into the relationship between age and attention throughout the learning process. For instance, the revelation of a suppression effect—uncovering a negative relationship between age and on-task thought (attentional consistency)—aligns with and fortifies several theoretical perspectives on lapses of attention and aging. First, it supports the idea that older adults experience a decline in attention control abilities (e.g., Braver & West, 2008; Hasher & Zacks, 1988; Nicosia et al., 2021). Specifically, a negative correlation between proportions of on-task thought and age is consistent with predictions made by both the Control Failures × Current Concerns account (McVay & Kane, 2010) and the context regulation hypothesis (Smallwood & Andrews-Hanna, 2013). The former account suggests that the increased tendency for older adults to experience attentional *inconsistency* stems from an inability to inhibit salient personal concerns from entering consciousness, diverting attention away from the task at hand (McVay & Kane, 2010; McVay et al., 2013). According to the latter hypothesis, attention control serves not only to inhibit the occurrence of TUTs but also to manage the contexts in which they occur. In situations where a task is attentionally demanding (e.g., intentional learning conditions), people with superior attention control abilities (e.g., younger adults) should be more successful in exerting control over TUTs, given their detrimental impact on performance. But, in less demanding situations, TUTs may enable individuals to utilize their excess attentional capacity more productively; thus, in these contexts, those with superior attention control abilities (e.g., young adults) might be less inclined to employ control over competing TUTs, leading to more attentional inconsistency. Unfortunately, in the absence of an active manipulation targeting attentional demands (e.g., comparing incidental vs. intentional learning), discerning evidence that favors one hypothesis over the other remains elusive.

Limitations and Future Directions

There are, of course, several limitations of the present study that are worth mentioning. The first concerns the discrepancy in results regarding task-specific motivation. As previously mentioned, motivation did not significantly account for the relationship between age and proportions of on-task thought in Experiment 1. But, in Experiment 2, motivation explained a significant (and large) portion of this variance. Younger adults in Experiment 1 were recruited from Prolific and paid for their time, just like older adults. Younger adults in Experiment 2 were recruited through the human subject pool at a public university and were compensated with course credit necessary for their grade. We reasoned that the Prolific sample in Experiment 1 may have been more motivated than the typical undergraduate sample used in aging studies (e.g., Frank et al., 2015; McVay et al., 2013; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022), resulting in reduced age-related differences in motivation. Indeed, analyses revealed that age-related differences in motivation were larger in our second experiment. Therefore, age-related differences in task-specific motivation, and motivation's ability to account for effects of age on attentional consistency, may depend on how younger and older adults are recruited and/or compensated.

Since most prior studies exploring the impact of motivation on the effects of aging and attentional lapses suffer from a similar confounding effect of compensation method (Frank et al., 2015; McVay et al., 2013; Moran et al., 2021; Nicosia & Balota, 2021; Robison et al., 2022), the results from the present study suggest the role of motivation in these relationships may potentially be overestimated. While at least two studies demonstrated results similar to Experiment 2 when younger and older adult samples were both recruited and compensated through Amazon Mechanical Turk (Seli et al., 2017, 2021), future aging research (and individual differences research, more broadly) should be mindful of the pros and cons of using different compensation methods and online samples (see Greene & Naveh-Benjamin, 2022). We suspect that individuals who participate in research for monetary compensation are likely more motivated to perform well on (or interested in) scientific research. When individuals are compensated via other methods (e.g., course credit), we suspect participants will be less motivated/interested in general and more variability in motivation/interest levels may arise (for related discussion focusing on aging, see Ryan & Campbell, 2021). Future research is needed to verify these claims and to examine whether differences in compensation method relate to variability (both related and unrelated to age) in other variables.

A related issue is that recruiting older adults through online platforms like Prolific may underestimate age-related differences in broader cognitive functioning, such as episodic memory ability. Individuals in their 70s and 80s who are comfortable participating on such platforms are likely more highly functioning than older adults who do not actively participate on said platforms. Similarly, said platforms may naturally attract more participation from individuals with certain personality traits (e.g., openness to new experiences).

Another limitation of the present study is the noticeable floor effects observed for TUTs. In Experiment 1, TUTs constituted only 8% of responses to the thought probes. Although we managed to increase the rate to 18% in Experiment 2, it remains substantially lower than the 30%–45% typically observed in associative learning tasks (e.g., Garlitch & Wahlheim, 2020; Miller & Unsworth, 2021) and video-recorded lectures (Kane et al., 2017; Risko et al., 2012; Szpunar et al., 2013). Given the presence of a floor effect, we used proportions of on-task thought as our primary indicator of attentional consistency due to its more normal distribution (rates of on-task thought had more room for growth compared to the capacity of off-task thought to decline). Aside from Robison et al. (2022), the majority of previous aging studies have not analyzed proportions of on-task thought as a dependent variable.

We do not anticipate that analyzing proportions of on-task thought would yield significantly different results compared to examining proportions of TUT, had TUTs been more normally distributed. Even with the presence of a floor effect, the two were highly correlated across both experiments and produced similar patterns of results (e.g., see Table 9 and Appendix C). Nevertheless, the low rates of attentional lapses in the present study raise some intriguing questions. Is there something inherently more engaging about free recall paradigms than associative learning paradigms? Or, more intuitively, did the mere presence of point values essentially serve to gamify the task, resulting in reduced lapses of attention relative to what would be the case if no point values were present (similar to Unsworth et al., 2022)? Future research would benefit from more thoroughly testing these possibilities.

An additional consideration for future research is the inherent complexity in categorizing thoughts as strictly on task or off task. Our definition of off-task (task-unrelated) thinking draws heavily from the framework established by Stawarczyk et al. (2011), who characterize ongoing conscious experiences based on two key dimensions: stimulus dependency and task relatedness. These distinctions between stimulus dependency and task relatedness exist on a continuum and are not always clear-cut. Thus, it is possible that some individuals may consider themselves to be "off task" when they are not. As an example, consider instances in which an external task stimulus activates semantically associated thoughts not directly linked to the stimulus itself. Older adults in our sample would have lived through the Apollo 11 mission—the first manned moon landing. So, studying the word "moon" might evoke personal memories of witnessing the lunar landing live on television (among older adults), a semantically related but tangentially connected thought to the task at hand. To the extent that these thoughts occur when "moon" is presented onscreen, we would consider this on-task processing, as these thoughts serve to enrich the encoding of the external stimulus by connecting it to something of meaning in one's life (i.e., semantic reference, an effective memory strategy; see Hertzog & Dunlosky, 2004).

However, if these thoughts persist after "moon" is replaced with a new to-be-remembered word (e.g., "purse"), then we would now categorize said thoughts as off task since they are independent of the current external stimulus. Unfortunately, it remains unclear whether younger and older adults would internally classify their thoughts in the same manner. Therefore, future research is needed to delve deeper into how thoughts are categorized from the perspective of the participant, especially in scenarios where the line between task-related and unrelated thoughts is blurred.

Finally, the present study was largely concerned with developing a better understanding of how lapses of attention (e.g., TUTs) impact learning of new information that varies in value. Existing research has consistently shown that when individuals experience TUTs while learning new material, their ability to remember this material later is significantly impaired (Blondé et al., 2022; deBettencourt et al., 2018; Garlitch & Wahlheim, 2020; Maillet & Rajah, 2013, 2014; Miller & Unsworth, 2021; Seibert & Ellis, 1991; Smallwood et al., 2003; Thomson, Smilek, & Besner, 2014; Wahlheim et al., 2023; Xu & Metcalfe, 2016). However, the effects of these attentional diversions on memory for content that is revisited across multiple study sessions remain less clear (but see Metcalfe & Xu, 2016). For instance, if a motivated individual notices that their mind is wandering when reviewing to-be-remembered material, they could potentially use this realization as a cue to adjust both their overall level of task engagement (i.e., intensity of attention, see Unsworth & Miller, 2021) and their future learning strategies.

Another possibility is that—if material has already been learned—allowing oneself to think about other matters may not influence an existing memory representation and may even promote further learning. For example, by drawing connections between the learning material and unrelated thoughts or experiences, learners could potentially form more elaborate memory traces or recontextualize the information in a manner that aids subsequent retrieval. Alternatively, these thoughts could increase interference. Therefore, while attentional lapses during the initial study of new material are detrimental to memory formation, future research should further examine their impact on learning outcomes across multiple study sessions.

Conclusion

The present study had two overarching aims. First, we sought to advance our understanding of *when* lapses of attention are most likely to occur by testing the potential moderating influence of value (information importance) on the experience of attentional lapses during learning. While value did not moderate the association between age and attentional consistency (as indexed by proportions of on-task thought), results indicated that both younger and older adults modulated the consistency of attention based on the importance of the to-be-remembered material. Namely, individuals were more consistently focused on the to-be-remembered material when studying important (high-value) information, leading to enhanced retention of said information. Critically, participants were also more resistant to effects of time on task—the tendency to become less focused on task over time—when studying important information.

Second, we sought to advance our understanding of *who* is most susceptible to attentional lapses. The present study offers a comprehensive, interdisciplinary perspective on the mechanisms underlying age-related differences in the ability to consistently keep attention focused on task (and prevent recurring lapses of attention) during learning. Specifically, relative to younger adults, older adults' increased task-specific motivation and decreased negative affect largely accounted for their tendency to report more on-task focus and fewer instances of TUT (mind-wandering, external distraction, and mind-blanking) and TRI-type thought. Various facets of personality (e.g., conscientiousness, agreeableness, and neuroticism) and neurodevelopmental characteristics (e.g., ADHD symptomology) also contributed to this association. Importantly, though, once these dispositional and state-based variables were controlled for, the results depicted a contrasting scenario: Older adults exhibited more attentional *inconsistency* (less on-task focus) compared to their younger counterparts. Thus, the frequently observed negative association between age and TUTs might well be a classic instance of statistical suppression.

Taken altogether, age plays a critical role in one's ability to consistently keep attention focused on task, but its relationship with indices of attentional consistency is more nuanced than traditionally perceived. Moreover, the value ascribed to the material one studies emerges as a pivotal force, reliably shaping the consistency of attention during learning for both younger and older adults. By investigating the confluence of age, dispositional traits, and contextual factors within value-driven learning, our study uncovers significant insights into the multifaceted nature of attentional lapses. This understanding, while enriching our theoretical framework, may pave the way for more tailored learning approaches suitable for various age groups and learner profiles.

Constraints on Generality

The present study highlights how value impacts (a) the occurrence of TUTs during learning and (b) memory performance for both younger and older adults. We assessed memory using a DFR task, where participants memorized lists of words. We investigated the effects of value by assigning point values (ranging from 1 to 10) to each word. Points were awarded to participants if the accompanying word was correctly recalled at test, and participants were instructed to score as many points as possible.

Previous research has demonstrated effects of value on memory using recognition tasks with both word (e.g., Elliott & Brewer, 2019; Elliott et al., 2020) and picture stimuli (Adcock et al., 2006) as well as through use of other value manipulations (e.g., monetary incentives, see Adcock et al., 2006)—predominantly in younger adult samples. Considering age-related declines in episodic memory performance are more pronounced in tasks requiring maximal self-initiated processing (e.g., DFR, see Craik, 2022), we do not believe the effects (or lack thereof) for older adults observed in the present study are specific to our paradigm. Nonetheless, future work would benefit from determining whether our results generalize to other episodic memory tasks that pose similar challenges for older adults, such as associative memory (see Ariel et al., 2015). Future work will likewise need to examine whether the influence of value on TUTs (and corresponding age-related effects) generalize to different memory paradigms and more naturalistic learning environments.

It is also important to keep in mind that our older adult participants were recruited from Prolific. Online platforms such as this may attract more higher functioning and intrinsically motivated older adults. Therefore, future work should strive to replicate the age-related findings observed herein using a more diverse and representative sample. Moreover, our study used correlational data to support hypothesized causal pathways (e.g., the relationships between age, affect, and lapses of attention), but such data cannot conclusively establish causality. Future research should integrate experimental and differential approaches to ascertain causal relationships more effectively.

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(*Appendices follow*)

Appendix A

Item-Level Probe Reactivity Effects

Experiment 1

For the probe condition ($N = 124$), we submitted recall accuracy to a repeated measures ANOVA with Item Type (no probe vs. word before probe vs. word after probe) as a within-subjects factor. The analysis revealed a significant main effect of Item Type, $F(2, 246) = 17.42$, $p < .001$, $MSE = .01$, partial $\eta^2 = .12$, suggesting the appearance of a thought probe during study impaired ensuing recall for the word immediately preceding said probe. That is, subsequent memory for words immediately following thought probes ($M = .34$, $SE = .02$) was similar to subsequent memory for words that were not probed ($M = .35$, $SE = .01$), $p = .665$. But subsequent memory was worse for words that appeared directly before a thought probe ($M = .29$, $SE = .02$) relative to words that appeared after a thought probe and words that were not probed, $ps < .001$. Adding age as a between-subject factor revealed no significant interaction between Item Type and Age ($F = 1.46$, $p = .235$).

Experiment 2

We repeated the analysis described above, which again revealed a significant main effect of Item Type, $F(2, 430) = 17.73$, $p < .001$, $MSE = .01$, partial = .08. Compared to words that were not probed ($M = .37$, $SE = .01$), subsequent memory was worse for words immediately preceding ($M = .33$, $SE = .01$) and following ($M = .34$, $SE = .01$) thought probes, $ps < .001$. Memory for words preceding probes did not significantly differ from memory for words following probes, $p = .141$. Adding age as a between-subject factor revealed no significant interaction between Item Type and Age ($F = 2.62$, $p = .074$).

Appendix B

Individual Differences Within Age Groups in Experiment 2

A primary goal of Experiment 2 was to better understand age-related differences in the consistency of attention during learning (and their implications for recall performance). Here we report between-subject differences *within* a given age group. After data exclusions, each individual age group had 108 participants. So, we could reliably detect $rs \geq .26$ with 80% power ($\alpha = .05$). Tables B1–B3 list reliability estimates for each measure as a function of age group. Table B4 provides the correlations among all measures for each age group separately.

Individual Differences in Younger Adults

Younger adults who were more consistently focused on the to-be-remembered material during study tended to be those who were most motivated to perform well ($r = .49$, $p < .001$). These individuals also reported experiencing less negative affect ($r = -.30$, $p < .001$), were more agreeable ($r = .27$, $p = .005$), and were more open to new experiences ($r = .27$, $p = .005$). Altogether, these variables explained 37.9% of the variability in proportions of on-task thought among younger adults, $F(4, 103) = 15.71$, $p < .001$, $MSE = .08$, and each predictor accounted for unique variance when entered into a simultaneous linear regression (see Table B5).

Critically, younger adults who were better able to keep attention focused on task during learning also tended to recall a greater proportion of to-be-remembered material at test ($r = .33$, $p < .001$). In terms of variation in recall accuracy, the best performers, among the younger adult sample, were similarly more motivated to perform well ($r = .30$, $p = .002$). These high performers also experienced less negative affect ($r = -.25$, $p = .009$) and were more open to new experiences ($r = .21$, $p = .029$). Younger adults who recalled a greater proportion of the to-be-remembered material also tended to use more effective encoding strategies ($r = .43$, $p < .001$). These variables together explained 28.2% of the variability in overall recall accuracy among younger adults, $F(5, 102) = 8.02$, $p < .001$, $MSE = .02$. When taking these additional variables into account, proportions

Table B1
Reliability Estimates for All Cognitive Measures Across Age Groups

Measure	Reliability: Young	Reliability: Old
Recall accuracy	.94	.94
Prop on task	.91	.91
Prop TRI	.83	.83
Prop TUT	.91	.78
Strategy use		

Note. Recall accuracy = proportion of correctly recalled words; Prop on task = proportion of on-task thought reported during study; Prop TRI = proportion of task-related interference reported during study; Prop TUT = proportion of task-unrelated thought reported during study; Strategy use = proportion of effective strategies used (out of three total: sentence generation, mental imagery, and grouping).

Table B2
Reliability Estimates for All State-Based, Contextual Measures Across Age Groups

Measure	Reliability: Young	Reliability: Old
Premotivation		
Postmotivation		
Anxiety	.79	.85
Negative affect	.88	.80
Positive affect	.90	.92

Note. Premotivation = task-specific motivation before beginning the experimental trials; Postmotivation = task-specific motivation upon completion of all experimental trials; Anxiety = Spielberger State-Trait Anxiety Inventory-state score; Negative affect = Positive and Negative Affectivity Scale (PANAS) negative affect score; Positive affect = PANAS positive affect score.

(*Appendices continue*)

Table B3
Reliability Estimates for All Dispositional Trait Measures Across Age Groups

Measure	Reliability	
	Young	Old
Extraversion	.72	.77
Agreeableness	.73	.78
Conscientiousness	.72	.86
Neuroticism	.81	.83
Openness	.65	.82
ADHD	.72	.69

Note. Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener.

Table B4
Correlations Among All Variables in Younger (Below the Diagonal, N = 108) and Older (Above the Diagonal, N = 108) Adults

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Recall accuracy	—	−.06	**.23**	−.15	**−.24**	.03	**.22**	−.17	−.15	**.31**	.16	**.22**	−.17	.13
2. Selectivity index	**−.32**	—	.05	.02	−.06	.03	.12	.07	.11	.03	.00	−.11	.00	.16
3. Proportion on task	**.33**	−.04	—	**−.88**	**−.68**	**.53**	.11	**−.33**	−.19	.19	.18	.19	**−.27**	.10
4. Proportion TRI	**−.23**	.16	**−.60**	—	**.24**	**−.36**	−.13	**.25**	.06	−.14	−.13	−.10	.18	−.02
5. Proportion TUT	**−.23**	−.08	**−.75**	−.08	—	**−.51**	−.02	**.29**	**.28**	−.17	−.17	**−.23**	**.27**	−.16
6. Motivation	**.30**	−.03	**.49**	−.14	**−.50**	—	.16	**−.33**	**−.29**	.10	**.27**	**.32**	**−.27**	.17
7. Strategy use	**.43**	−.16	.19	−.04	**−.20**	**.24**	—	−.09	−.01	.16	.04	.10	−.18	**.23**
8. Negative affect	**−.25**	−.14	**−.30**	.07	**.32**	−.13	−.06	—	**.34**	**−.24**	**−.28**	**−.36**	**.56**	−.08
9. ADHD	−.02	.06	−.06	.13	−.03	.16	.12	.18	—	**−.22**	**−.44**	**−.56**	**.46**	−.06
10. Extraversion	−.08	.00	.05	−.06	−.01	.16	.04	.08	−.12	—	.12	**.39**	**−.38**	**.26**
11. Agreeableness	−.02	−.04	**.27**	**−.25**	−.13	.10	.08	−.07	**−.21**	.15	—	**.41**	**−.27**	−.02
12. Conscientiousness	−.06	.01	.17	−.08	−.14	.10	−.11	−.12	**−.47**	.12	**.28**	—	**−.49**	.08
13. Neuroticism	−.12	**−.27**	−.14	.07	.12	.02	.06	**.40**	**.37**	−.03	−.14	**−.29**	—	**−.22**
14. Openness	**.21**	**−.20**	**.27**	−.09	**−.26**	.17	**.34**	.01	.06	**.32**	.08	.02	.01	—

Note. Values in bold indicate statistical significance: rs > .19 are significant at $p < .05$; rs > .24 are significant at $p < .01$; rs > .31 are significant at $p < .001$; Recall accuracy = proportion of correctly recalled words; Proportion on task = proportion of on-task thought reported during study; Proportion TRI = proportion of task-related interference reported during study; Proportion TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; Motivation = mean task-specific motivation (average of pre- and posttask ratings); Strategy use = proportion of effective encoding strategies used (out of three total: sentence generation, mental imagery, and grouping); Negative affect = negative affect factor composite score (using scores from Spielberger State-Trait Anxiety Inventory and Positive and Negative Affectivity Scale); Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener.

Table B5
Predicting the Proportion of On-Task Thought During the Encoding Phase of a DFR-VDR Task for Younger Adults

Variable	β	t	sr^2	R^2	F
Mean motivation	.41	5.17***	.16		
Negative affect	−.24	−3.04**	.06		
Agreeableness	.20	2.49*	.04		
Openness	.19	2.38*	.03	.38	15.71

Note. DFR = delayed free recall; VDR = value-directed remembering.
* $p < .05$. ** $p < .01$. *** $p < .001$.

(*Appendices continue*)

Table B6
Predicting the Proportion of Words Correctly Recalled (Mean Recall Accuracy) on a DFR-VDR Task for Younger Adults

Variable	β	*t*	sr^2	R^2	*F*
Proportion on task	.15	1.44	.01		
Mean motivation	.12	1.19	.01		
Negative affect	−.17	−1.91	.03		
Openness	.03	.36	.00		
Strategy use	.35	3.81***	.10	.28	8.02

Note. DFR = delayed free recall; VDR = value-directed remembering.
*** $p < .001$.

Table B7
Predicting the Proportion of On-Task Thought During the Encoding Phase of a DFR-VDR Task for Older Adults

Variable	β	*t*	sr^2	R^2	*F*
Mean motivation	.46	5.33***	.19		
Negative affect	−.14	−1.40	.01		
Neuroticism	−.07	−.65	.00	.31	15.46

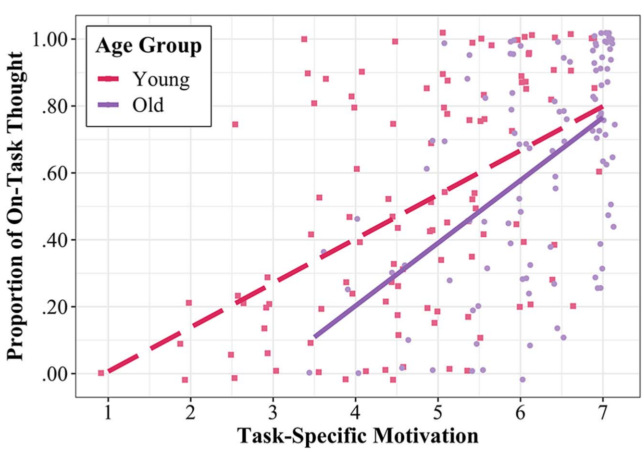
Note. DFR = delayed free recall; VDR = value-directed remembering.
*** $p < .001$.

of on-task thought no longer accounted for significant unique variance in mean recall accuracy. As demonstrated in Table B6, the only variable that continued to explain unique variance in performance was effective strategy use (β = .35, $p < .001$).

Individual Differences in Older Adults

As demonstrated in Figure B1, older adults who were more consistently focused on the to-be-remembered material during study tended to be those who were most motivated to perform well ($r = .53$, $p < .001$). Older adults with high attentional consistency also tended to experience less negative affect ($r = -.33$, $p < .001$) and were less neurotic ($r = -.27$, $p = .005$). These variables collectively explained 30.8% of the variability in proportions of on-task thought among older adults, $F(3, 104) = 15.46$, $p < .001$, $MSE = .07$. Table B7 shows motivation to perform well was the only variable that accounted for significant unique variance in proportions of on-task thought (β = .46, $p < .001$) when all predictors were accounted for in a simultaneous linear regression.

Figure B1
The Association Between Attentional Consistency (Proportion of On-Task Thought) and Mean Task-Specific Motivation as a Function of Age Group



Note. Pink long-dashed line represents regression line for younger adults, whereas solid purple line represents regression line for older adults. See the online article for the color version of this figure.

Notably, older adults who were best able to regularly keep attention focused on task during study also tended to display the best memory performance at test ($r = .23$, $p = .015$). Older adults with enhanced recall abilities were more also more conscientious ($r = .22$, $p = .023$), more extraverted ($r = .31$, $p = .001$), and reported using more effective encoding strategies ($r = .22$, $p = .026$). Altogether, these variables explained just 15.7% of the variability in overall recall accuracy among older adults, $F(4, 103) = 4.80$, $p = .001$, $MSE = .02$. As was the case for younger adults, proportions of on-task thought no longer explained significant unique variance in overall recall accuracy when accounting for the variance shared with the other predictors (see Table B8). Interestingly, extraversion was the only unique predictor of mean recall accuracy (β = .22, $p = .030$).

Table B8
Predicting the Proportion of Words Correctly Recalled (Mean Recall Accuracy) on a DFR-VDR Task for Older Adults

Variable	β	*t*	sr^2	R^2	*F*
Proportion on task	.16	1.72	.02		
Extraversion	.22	2.20*	.04		
Conscientiousness	.09	.87	.01		
Strategy use	.15	1.67	.02	.16	4.80

Note. DFR = delayed free recall; VDR = value-directed remembering.
* $p < .05$.

(*Appendices continue*)

Appendix C

Correlations Controlling for Age Group in Experiment 2

See Table C1 for correlations among all measures in Experiment 2 when controlling for age (recoded so that younger adults were 0 and older adults were 1).

Table C1

Correlations Among All Measures in Experiment 2 Controlling for Age Group (Total N = 216; $N_{Younger}$ = 108; N_{Older} = 108)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Recall accuracy	—												
2. Proportion on task	**.29**	—											
3. Proportion TRI	**−.19**	**−.73**	—										
4. Proportion TUT	**−.23**	**−.71**	.04	—									
5. Motivation	**.19**	**.50**	**−.23**	**−.50**	—								
6. Strategy use	**.33**	**.15**	−.08	**−.14**	**.21**	—							
7. Negative affect	**−.22**	**−.32**	**.16**	**.30**	**−.20**	−.08	—						
8. ADHD	−.08	−.12	.09	.08	−.02	.06	**.25**	—					
9. Extraversion	.11	.12	−.10	−.07	.13	.10	−.08	**−.17**	—				
10. Agreeableness	.06	**.23**	**−.18**	**−.14**	**.17**	.06	**−.17**	**−.32**	**.14**	—			
11. Conscientiousness	.09	**.18**	−.09	**−.17**	**.19**	.01	**−.24**	**−.52**	**.27**	**.35**	—		
12. Neuroticism	**−.14**	**−.20**	.13	**.17**	−.10	−.05	**.48**	**.42**	**−.21**	**−.20**	**−.40**	—	
13. Openness	**.17**	**.17**	−.05	**−.20**	**.16**	**.28**	−.04	−.01	**.28**	.02	.06	−.12	—

Note. Values in bold indicate statistical significance: *r*s > .134 are significant at $p < .05$; *r*s > .176 are significant at $p < .01$; *r*s > .215 are significant at $p < .001$; Recall accuracy = proportion of correctly recalled words; Proportion on task = proportion of on-task thought reported during study; Proportion TRI = proportion of task-related interference reported during study; Proportion TUT = proportion of task-unrelated thought (mind-wandering, external distraction, and mind-blanking) reported during study; Motivation = mean task-specific motivation (average of pre- and posttask ratings); Strategy use = proportion of effective strategies used (out of three total: sentence generation, mental imagery, and grouping); Negative affect = negative affect factor composite score (using scores from Spielberger State-Trait Anxiety Inventory and Positive and Negative Affectivity Scale); Attention-deficit hyperactivity disorder (ADHD) = mean rating across Adult ADHD Self-Report Scale-v1.1 screener.

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