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An Investigation of the Effects of Free Writing on the Scope and Control of Attention

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AN INVESTIGATION OF THE EFFECTS OF FREE-WRITING ON THE SCOPE AND CONTROL OF ATTENTION

by

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ABSTRACT

The possibility that writing can provide relief from endogenous sources of distraction and improve attention performance was examined. Participants completed attention scope and control tasks prior to and after completing a five-minute writing exercise. The writing exercise instructed participants to either copy text or write down tasks they intended to complete in the near future. Writing did not elicit effects in attention performance, but methodological limitations make it difficult to interpret this outcome. Individual differences in stress, cognitive control and flexibility under stress, and ruminative tendencies did not relate to attention performance. Stress was associated with poorer cognitive control and flexibility as well as a tendency to ruminate. Future research should verify writing-related performance improvements in other cognitive tasks before administering scope and control tasks to determine whether writing benefits attention and to disambiguate benefits related to liberated capacity from those related to renewed attention control.

INDEX WORDS: Attention control, Attention capacity, Journaling, Mental workload, Rumination, Stress, Cognitive control, Cognitive flexibility, Offloading

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1 INTRODUCTION

Much is known about inter-individual differences in attention and its control, but intra-individual differences are also important considerations of attention research. In other words, measures within an individual may differ from one instance to another, such as when an individual performs worse on a given task because they are fatigued or less motivated. These differences may be systematic and driven by a variety of factors. Broadly, the aim of the proposed study is to explore why an individual's performance on attention tasks might be relatively better or worse across occasions. Specifically, I propose to study the effects of a free-writing activity on the scope and control of attention. In order to discuss the potential implications of free-writing for attention performance, it is necessary to summarize briefly the history of attention research in psychology. I will review what researchers have learned about attention, how attention has been discussed and how it has been measured. I will discuss how attention is determined and how various constraints on attention have been classified. I will then suggest that these same constraints, although studied exclusively with exogenous stimuli, might also apply to attention to mental content (i.e., thoughts, memories). Moreover, an individual's susceptibility to distraction by such mental content might be influenced by the experience of stress, which likely increases the frequency of salient and distracting content while also fostering a profile of attention that makes these thoughts more difficult to ignore. I will proceed to discuss experimental manipulations that have been associated with improvements to dimensions of attention, including some preliminary data from participants who showed attention-related benefits after completing a free-writing exercise. I hypothesize that writing will improve attention performance, and that these improvements will be a consequence of reductions in task-irrelevant but resource-intensive rumination or stress about real-life problems. Thus, the present study falls within growing contemporary interest in complementary, alternative, and integrative approaches to psychological wellbeing, but the proposed study is also firmly rooted in a research tradition dating back to the founding of psychology as a science.

1.1 The History of Psychological Research on Attention

"Everyone knows what attention is." So begins the definition from William James' chapter, Attention, of his famed *Principles of Psychology* (1890/1952, 261), routinely referenced in the opening paragraphs of countless theses, articles, and book chapters written by scholars of attention. Although the quote frequently appears in literature on the topic, not everyone appreciates this particular assertion; moreover, the fact that James did not conclude his chapter after those five words suggests that it was his own position that attention is a universally experienced rather than a universally understood phenomenon. In fact, some scholars have arrived at a conclusion more closely aligned with that of Pashler (1998): "No one knows what attention is, and […] there may even not be an 'it' there to be known about (although of course there might be)" (p.1). Discussions of the phenomenology of attention, at least as we would recognize it today, can be traced as far back as the time of Augustine of Hippo (354-430 BC), but it was not until the 19th century that the topic became a focus for the burgeoning field of psychology (Pashler, 1998). According to Pashler, the works of early psychologists such as Titchener and James were clearly rooted in a folk psychology that conceived of attention as a limited commodity, the dispensation of which occurred simply by volitional control.

James (1890/1952) can be forgiven for finding inspiration in folk psychology, if only because his definition of attention is not too far afield from the manner in which some researchers might define it today: "Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others" (p. 261). This definition has endured over a century of academic scrutiny because it reduces attention to two fundamental aspects: focalization and concentration. Focalization represents the binary quality of attention, a stimulus is either attended to or it is not. Concentration captures the mental effort needed to protect against otherwise inevitable information loss. Variations of these two aspects are still found in the modern literature, perhaps rendered most recognizably in the distinction between attention scope and control (e.g., Shipstead, Harrison, & Engle, 2015), but certainly also evident in discussions of capture and disengagement (e.g., Koster, Crombez, Verschuere & Houwer, 2004), attentional selection (e.g., Failing & Theeuwes, 2018), and attention network theory (e.g., Posner, 2016). Though many researchers have defined attention differently (or not at all, e.g., Pashler & Johnston, 1998), there is a clear thread tying the perspective of James (1890/1953) to 21st century research, a thread that unites the overwhelmingly diverse set of phenomena that fall under the umbrella of attention research, and a thread that some might regard as the core of the attention construct: selection.

Use of the term "selection" in attention research and theory is pervasive. A passable account of the history of attention research could be constructed by considering solely the dominant hypotheses (expressed in metaphorical terms, where attention is considered to be filter-like, resource-like, gate-like, glue-like, spotlight-like, and so forth; Fernandez-Duque & Johnson, 1999, 2002; Johnson & Dark; 1986) about selection at each time point, and this is possibly the approach Pashler (1998) took when drafting his introduction to the edited book, "Attention." He wrote that after a quiet period during the era of Behaviorism, attention research blossomed again at the onset of the cognitive revolution when it became acceptable to discuss mental representations and when new technologies promoted novel explorations.

For instance, the emergence of the dichotic listening task (Cherry, 1953) provoked a great deal of debate surrounding chronology of selection and whether it occurred early in perception (e.g., Broadbent, 1958) or later, after semantic processing (e.g., Norman, 1968). Visual search tasks stimulated debates about the sequential versus holistic nature of selection in visual attention (e.g., Treisman & Gelade, 1980), while dual-task paradigms perpetuated the question of selection in post-perception processes such as decision making and planning (e.g., Pashler & Johnston, 1998). The debate has persisted in the decades since the publication of William James' *Principles*, with generations of researchers striving to illuminate the consequences and determinants of selection. The result of a century's worth of work is that there are two well-established types of determinants, top-down processing and bottom-up stimulus characteristics. A third determinant, selection history, has been discussed since the era of behaviorism (e.g., blocking effects, Kamin, 1969), but researchers have only recently realized its importance as a factor that governs selection.

1.1.1 Top-Down and Bottom-Up Attention Control

There is evidence that selection can occur on the basis of volitional, top-down processes that guide attention toward goal-relevant stimuli or on the basis of bottom-up stimulus characteristics that capture attention, such as salience, luminance, or abrupt onset (Carrasco, 2011; Corbetta & Shulman, 2002; Schreji, Owens, & Theeuwes, 2008; Theeuwes, 1991). Top-down and bottom-up effects have been well-documented using measures such as the Stroop task (Stroop, 1935) and Attention Network Task (ANT; Fan, McCandliss, Sommer, Raz & Posner, 2002). Though there are many variations on the Stroop task, the archetypal procedure involves instructing participants to report the ink or pixel color of a color word (e.g., 'blue'). Individuals are slower and commit more errors during trials in which the color word is printed in an incongruent color (e.g., the word 'blue' printed in green; Macleod, 1991) than if the word is printed in the congruent color (e.g., 'blue' printed in blue) or than if a baseline (noncolor) word is used (e.g., 'brew' printed in green). The typical interpretation of this robust finding is that interference in incongruent trials reflects the conflict experienced due to the bottom-up influence of the irrelevant stimulus feature (i.e., the meaning of the word) and the top-down processing of the relevant stimulus feature (i.e., the color; Washburn, 2016).

Similarly, in the ANT task, participants respond to the orientation of a central stimulus embedded in a display of congruent, incongruent, or neutral flankers. Strategic application of the subtractive technique has allowed researchers to quantify interference from different cue-target configurations, leading to the theoretical position that there are three networks that serve distinguishing functions of attention, namely, alerting, orienting, and executive control (Posner, 2016). The alerting network, responsible for information detection (i.e., a bottom-up determinant), is tested by measuring the influence of a warning signal on response times. The orienting network deals in the shifting of attention and is assessed by RT changes that stem from predictive cues that reliably indicate the location of an incoming target. The flanker task is considered an index of efficiency for the final network, executive control, the top-down function of which is to resolve competition from incongruent cues. The independence of top-down and bottom-up constraints on attention is evidenced in these behavioral tasks, both in task-specific metrics (e.g., Fan et al., 2009; Notebaert, Gevers, Verbruggen & Liefooghe, 2006; Pinto et al., 2013; Theeuwes, 1991) and in patterns of performance related to other measures or manipulations of cognitive control (e.g., Kane & Engle, 2003; Rauch & Schmitt, 2009). Further support for the idea that these determinants of attention are independent comes from the apparent segregation of brain networks active during bottom-up capture and top-down control in both the ANT (e.g., Callejas, Lupianez & Tudela, 2004; Corbetta & Shulman, 2002; Fan et al., 2009) and the Stroop task (e.g., Van Veen & Carter, 2005; West & Alain, 2000).

1.1.2 History-Based Attention Control

Recently, researchers have asserted that a third source of competition, selection history, should break up this long-standing theoretical dichotomy (e.g., Awh, Belopolsky & Theeuwes, 2012; Washburn & Taglielatela, 2006, 2012). Broadly, selection history is a class of attention biases that stem from past experiences. These biases include, but may not be limited to, reward history, priming, statistical learning (Failing & Theeuwes, 2018) and conditioned stimuli (Washburn & Taglielatela, 2006). For instance, recent history with interference trials has been shown to influence Stroop performance in subsequent trials (Botvinick, Braver, Barch, Carter & Cohen, 2001; Lorist & Joli, 2012; Salamanca & Washburn, 2016), and statistical regularity in the context or location of distracting stimuli can bias visual attention even when individuals lack awareness of the association (Chun & Jiang, 1998; Wang & Theeuwes, 2018). As it relates specifically to reward, stimuli previously associated with reward receive higher rates of detection in cueing tasks (e.g., Englemann & Pessoa, 2007), decreased Stroop magnitudes (Padmala & Pessoa, 2010) and resistance to attentional blink (Raymond & O'Brien, 2009) when those stimuli were situated compatibly with task demands. When reward-associated stimuli were positioned orthogonally to task-relevant stimuli in a spatial cueing experiment, Failing and Theeuwes (2015) observed performance costs, the magnitude of which corresponded to the degree of reward, such that stimuli formerly associated with higher rewards disrupted performance to a larger degree than those associated with smaller rewards. In an extensive theoretical review of reward-based selection history bias, Failing and Theeuwes (2018) argued that history-based biases are integrated with top-down and bottom-up demands for attention, a process that results in a continuously-shifting spatial priority map with the strongest attention selection bias corresponding to the location of highest activation. That is, attention will be routed to locations for which the strongest top-down, bottom-up, and history-based signals tend to coalesce.

1.2 Internal Sources of Distraction

Researchers have consistently focused on selection of exogenous stimuli to measure attention, but it is important to acknowledge that endogenously produced stimuli-- those many possible "trains of thought" James referenced over 120 years ago—might be equally influential on a person's ability to attend selectively to an object or a task. It is reasonable to suggest that distraction can be endogenously derived; however, isolating and quantifying internal distractions is intrinsically challenging. Until very recently, the idea that mental content could be a source of competition for attention was largely untouched in the literature on selective attention. Fortunately, the rising popularity of research on mind-wandering and its related constructs provides some justification for thinking about internally-sourced distraction. Although the study proposed here is not about mind-wandering, a brief foray into this literature will help to illustrate the kind of competition for resources that will be examined in the present research.

1.2.1 Mind-Wandering

Mind-wandering, or the drifting of attention away from an ongoing task and toward task-unrelated thoughts, is inherently difficult to measure, but researchers have developed several fruitful techniques including intermittent thought-probing, self-report questionnaires, and mind-wandering logs (Forster, 2013; Smallwood & Schooler, 2006, 2015). When combined with behavioral, physiological, and neuroimaging data, these measurements have led to some interesting developments in cognitive neuroscience. For instance, activation of the Default Mode Network, a set of brain regions that are active when individuals are preoccupied with off-task thoughts, such as thinking about themselves, others, or the future (Andrews-Hanna et al. 2014; Smallwood & Schooler, 2015) has been linked to mind-wandering behaviors (Mason et al. 2007; McKiernan et al., 2006).

The component process account of mind-wandering, summarized by Smallwood and Schooler (2015), contends that a limited number of constituent processes form the basis of mind-wandering, despite the potentially extreme variability in and complexity of mind-wandering experiences. Evidence of perceptual decoupling, a reorientation of attention involving de-prioritization of or desensitization to information from external inputs, during mind-wandering suggests that disengagement from the external environment occurs at both levels of perception and complex cognition (e.g., Barron, Riby, Greer & Smallwood, 2011; Kam & Handy, 2013) and may be one such component process. Another component process potentially implicated in mind-wandering involves the episodic memory system: The self-generation of mental content is thought to stem from a tendency to mentally time travel during mind-wandering (Tulving, 2002), a process that relies on episodic memory retrieval of past events and one that is also associated with the Default Mode Network (e.g., Addis, Knapp, Roberts & Schacter, 2012; Christoff, Gordon, Smallwood, Smith & Schooler, 2009; Mason et al. 2007).

Lastly, the regulation of mind-wandering likely involves executive control. Individuals who score highly on measures of cognitive control show evidence of increased mind-wandering when processing demands are minimal (Levinson, Smallwood & Davison, 2012; Kane et al., 2007), whereas individuals with low levels of cognitive control exhibit more task-unrelated thoughts in sustained attention and complex span tasks (McVay & Kane 2009; Mrazek et al.

2012; Unsworth & McMillan 2013). The inverse correlation between working memory capacity and mind-wandering suggests that the ability to limit mind-wandering in high-demand contexts rests on executive control (Kane et al., 2007; McVay & Kane, 2009, 2010). Mind-wandering can harm performance in some naturalistic contexts, especially those involved in academics, such as reading (e.g., Jackson & Balota, 2012), listening to a lecture (e.g., Farley, Risko & Kingstone, 2013), or taking the SAT (Mrazek et al., 2012).

To summarize, this growing body of literature has corroborated the suspicion that internally sourced distractions such as task-unrelated thoughts can interfere with performance of demanding tasks in ways similar to external stimuli. Moreover, failures to suppress task-unrelated thoughts (i.e., mind-wandering) might be propelled by some of the same constraints that govern selection of external stimuli, namely, bottom-up, top-down, and history-based influences on selection.

Individual Differences in Vulnerability to Distraction from Internal Stimuli

Some individuals may be more or less prone to experiencing distraction from task-unrelated mental content. This is likely correlated with the ability to resist distraction generally, an individual difference that is well-documented in measures of working memory capacity (e.g., Unsworth & Engle, 2007) and executive functioning (e.g., Friedman et al., 2008). There can be differences in the salience or significance of distracting mental content such that, controlling for differences in top-down control, some individuals might have a higher probability of experiencing thoughts that are simply more difficult to ignore. Another possibility is that history-based selection biases contribute to increased vulnerability to distraction from specific mental content. Each of these possibilities will be considered briefly.

1.2.2 Endogenous Distraction and Top-Down Attention Control

The effects of endogenous distraction on attention performance could be framed using resource or limited-capacity theories. Broadly, resource theorists assert that individuals possess a finite pool (or perhaps multiple finite pools; e.g., Wickens, 2008) of cognitive resources that can be divided and dispensed as needed in the execution of mental tasks (Kahneman, 1973). Performance will suffer when task demands exceed the available resource supply, such as when two or more concurrent tasks are competing for insufficient resources, as demonstrated in experiments using dual-task paradigms. The simultaneous performance of two tasks often results in some degree of disruption to both tasks (Pashler, 1994), even when both tasks are overlearned or automatic, such as driving and talking on the phone (Strayer & Johnston, 2001). Explanations for dual-task interference include bottlenecking, thought to occur when the production of a response in both tasks relies on the same processing mechanism, and crosstalk, the idea that conflict arises when multiple inputs load onto the same sensory modality (Pashler & Johnston, 1998).

However, the notion of capacity sharing is the most relevant explanation for endogenously-derived distraction because of its emphasis on so-called “central” cognitive limitations rather than limitations of perception or modality. Some capacity-sharing accounts have held that resources are completely allocated to the primary task until the secondary task target appears, at which point capacity is shared between the tasks up until the first response has been deployed (e.g., McLeod, 1977), but other interpretations suggest that resources are allocated according to primary task demands such that the bulk of capacity is used to maintain primary task performance, with any spare capacity routed to the secondary task (e.g., Kahneman, 1973). By this account, resource capacity can be measured by first manipulating characteristics in the primary task and then observing resultant changes in secondary-task performance. If there is a complementary decline in secondary-task performance as the primary task demands additional resources, this is taken as evidence of resource limitations. If secondary task performance improves when primary task demands are held constant, this is taken to be an indication that the amount of available capacity has increased. From this perspective, the additional resource demand required to resolve competition from task-unrelated thoughts could contribute to performance impairments in working memory and attention control tasks. In other words, distracting thoughts are analogous to a secondary task and thus introduce competition for valuable mental resources. Conversely, when resource competition ends, the capacity previously allocated to the secondary task is once again available for investment elsewhere.

1.2.3 Endogenous Distraction and "Bottom-Up" Attention Control

There also may be certain characteristics of task-unrelated thoughts that function analogously to stimulus features that provoke bottom-up attention capture. For instance, stimuli related to threat or fear are thought to receive privileged status such that processing is automatic or obligatory (e.g., Mulckhuyse & Dalmaijer, 2016; Olatunji, Armstrong, McHugo & Zald, 2013; Pessoa, McKenna, Guitierrez & Ungerleider, 2002). Though each of these studies involved the physical (i.e., external) presentation of fear-conditioned stimuli, mental (i.e., internal) representations of threat- or fear-related stimuli might also receive this type of prioritization. If that is indeed the case, then there may be individual differences in the frequency with which these types of thoughts come to mind.

1.2.4 Endogenous Distraction and History-Based Attention Control

Selection might also be driven by an individual's history with specific stimuli (Failing & Theeuwes, 2018). The idiosyncrasies inherent in experiential histories makes it difficult to predict how the constraints of priming, statistical learning, or conditioning would contribute to an individual's vulnerability to specific types of internally-generated distractions, but experiments that employ affective- and fear-conditioning procedures suggests that some common patterns of bias could be anticipated. For instance, fear-conditioned stimuli have been shown to produce more interference than physically salient stimuli (Schmidt, Belopolsky & Theeuwes, 2015a,b), and fear-conditioned stimuli elicited faster shifting in a spatial attention task (Armony & Dolan, 2002). There is evidence that attention is biased toward information that is congruent with current affective states (e.g., Blanchette & Richards, 2003; Nabi, 2003; Niedenthal & Setterlund, 1994; Okon-Singer, Hendler, Pessoa & Shackman, 2015), a bias also evident in emotional variations of the Stroop task (Algom, Chajut & Lev, 2004) and the ANT task (Pollak & Tolley-Schell, 2003; Pollak, Klorman, Thatcher, & Cicchetti, 2001). In a sense, the bias toward emotional and conditioned stimuli might reflect an acquired salience that makes capture by related mental content difficult to resist.

Of course, the acquisition of affective attentional bias is not limited stimulus associations that evoke fear, threat, or other forms of negative affect. Reward might also elicit biases toward internal stimuli over time, a mechanism that might work similarly to the theory of incentive salience, a theory of addiction acquisition cited by Failing and Theeuwes (2018) as further evidence of reward-based selection history. Specifically, incentive salience is the idea that repetitive association with reward changes the representation of a stimulus, so the reward transforms a neutral stimulus into one that captures attention or initiates a behavioral orienting response reminiscent of Pavlovian principles (Berridge, 2007). Though incentive salience was linked specifically with addiction, there might be similar history-based attention biases that underlie patterns of intrusive and unwanted thoughts in other forms of mental illness (Gabrys, Tabri, Anisman & Matheson, 2018), a hypothesis further encouraged by the fact that dopaminergic mechanisms have been implicated both in reward-based and in the incidence of certain psychopathologies, such as addiction (e.g., Taber, Black, Porrino & Hurley, 2012), schizophrenia (e.g., Howes & Kapur, 2009), and depression (e.g., Belujon & Grace, 2017). Though further discussion of the links between psychopathology and experiential constraints on attention toward mental content falls beyond the scope of the proposed study, it underscores the idea that the idiosyncrasies of mental content and selection-based history biases could conceivably contribute to individual differences in the susceptibility to distraction from endogenous sources.

1.2.5 Stress and Attention Control

Individual differences in levels of life stress could contribute to the incidence of distracting thoughts, and the patterns of attention performance associated with stress could make those thoughts particularly difficult to ignore. The influence of stressful experiences on attention performance has been discussed at least since Easterbrook (1959) posited that emotional arousal reduced the range of cue utilization: As physiological arousal increased, individuals used less information to guide their responses. Experiments that involve experiences of threat or stress have shown support for the link between stress and narrowed attention (e.g., Chajut & Algom, 2003; Gable & Harmon-Jones, 2010), but the role of arousal in this process has been less clear (Van Steenbergen, Band, & Hommel, 2011).

Evidence from Van Steenbergen and collaborator's (2011) study challenged this account. These experimenters used a pro- and anti-saccade task in which the fixation cross on each trial was preceded by a 500 millisecond display of an emotionally positive, negative, or neutral image. Because a narrowed attention focus would result in less effective detection of stimuli in the periphery (Harvey, 2016) and because the pro- and anti-saccade tasks involve peripheral stimulus presentation, the finding that negative pictures slowed down RTs in pro-saccade trials but did not speed up RTs in anti-saccades was taken as evidence of narrowed attention. Neither neutral nor positive images were associated with this pattern of narrowed attention, despite the fact that increased pupil dilation (a measure of arousal) was also observed in trials with positive images. Thus, attentional narrowing did occur after negatively-toned affective experiences, but this was not attributable to an arousal-based mechanism. If stress or negative affect does narrow the focus of attention, then narrowed focus combined with a bias toward stimuli that are fear- or threat-associated could be problematic, particularly in light of the increased costs associated with re-orienting attention once it has already been engaged (e.g., Posner, 2016).

There is additional evidence detailing stress-related effects on attention. Shields, Sazma, and Yonelinas (2016) published a meta-analysis in which they concluded that acute stress engendered a mental state characterized by deficiencies in cognitive inhibition, cognitive flexibility, and working memory (WM), but improvements in response inhibition. It is important that these effects were most influential at high WM loads, suggesting that the increased demand compounded stress effects. Shields and colleagues suggested that resources once allocated to WM and flexibility are rerouted to inhibitory control in an effort to enhance detection of threat-related information and to rapidly mobilize motor responses—a cognitive profile that is advantageous if a genuine threat is immediately extant. It would be ill-suited, however, to performing tasks that tap attention control such as Stroop or ANT, as poor cognitive flexibility and reduced availability of WM resources, combined with the diminished ability to inhibit irrelevant stimuli, would very likely result in performance decrements.

Plessow, Fischer, Kirschbaum and Goschke (2011) induced stress in half of their participants prior to measuring selective attention via a Simon task with spatial response-mapping conflicts. Stress-induced and comparison participants did not differ in accuracy regarding response conflicts, meaning that stress did not impair overall task performance. Group differences in cognitive flexibility emerged over the course of trials, however. Specifically, participants who were not subjected to the stress-induction procedure adjusted attention control from one trial to the next in accordance with the recency of response conflicts: If a response conflict was experienced in a previous trial, participants were less vulnerable to interference effects in the current trial (i.e., they engaged in attention control), but they quickly relaxed that control in subsequent non-conflict trials. In other words, these participants showed consistent levels of interference from response-mapping conflicts across the duration of the task. On the other hand, stressed participants showed a gradual and consistent increase in attention control regardless of conflict history in preceding trials (i.e., the level of interference from response-mapping conflicts declined over the course of the task). It is important to note that the adoption of a compensatory strategy involving rigid attention control has little overall cost in the context of a Simon task; however, adoption of this strategy could be inefficient for attention control measures involving higher demands or tasks that require flexibility, such as dual-task paradigms or problem-solving tasks, respectively.

The use of strategy to circumvent stress-related impairments was also examined by Plessow and colleagues (2017). They reported that stress-induced participants were capable of reliable shifting between a resource conservative strategy and a more effortful strategy when instructed to do so, an indication that they could voluntarily execute cognitive control despite a tendency to be resource-conservative when uninstructed. That individuals were able to recruit resources deliberately, though they were potentially less inclined to do so, suggests that the adoption of compensatory strategies can ameliorate acute stress-related impairments. In other words, it remains unclear whether individuals *cannot* or *do not* engage resources when stressed, a finding that underscores the argument that stress-related impairments are not uniformly unavoidable.

There are a number of limitations to consider when evaluating research on the association between stress and attention. First, there is the issue of directionality: it is possible that stress impairs aspects of attention and cognition more broadly, but it is also possible that individuals with cognitive limitations (e.g., lower WM capacity) experience more life stress because they have consistently fewer resources available to cope effectively. Alternatively, individuals who have sufficient cognitive resources (e.g., higher WM capacity) might be more sensitive to stress effects, given they may utilize that capacity to detect and monitor stressor-related information. The third-variable problem is also a concern as it is not clear whether effects arise due to stress per se or whether related variables (e.g., fatigue, arousal, distracting thoughts) are responsible.

To summarize briefly, the evidence reviewed in this section suggests that stress may be associated with a pattern of attention optimized for efficiency in threat responses, a pattern that is advantageous in many contexts (Lupien, McEwen, Gunnar, & Heim, 2009), although the advantage might come at the cost of performance deficits in other circumstances, such as those requiring a broader focus of attention (e.g., attending to global rather than local features of a stimulus) or those requiring cognitive control and flexibility (e.g., set-switching tasks). The consequences of stress for attention include an increased likelihood of experiencing endogenous distractions, an increased susceptibility to attention capture from those distractions, and a diminished ability to disengage from such distractions once initiated.

1.3 Reducing Interference from Endogenous Distractions

Several experimental manipulations such as meditation, prayer, exposure to nature, and possibly writing have been linked to improved performance in cognitive tasks, including those tasks thought to index attention control. Explanations for these effects can be broadly classified into two categories, liberated resources and a renewed ability to avoid being lured into distraction, both of which could involve the resolution of competition from endogenous distractors.

1.3.1 Meditation-Related Attention Improvements

Some types of state training, such as mindfulness meditation and yoga, have been linked to attention improvements. Tang, Posner, and Rothbart (2014) reported more efficient performance in the ANT after one month of integrated mind-body training, a form of mindfulness meditation. This meditation training involved maintaining the focus of attention on the present moment, often by bringing attention to the act of breathing (Posner & Rothbart, 2018). Posner and colleagues credit these effects to changes in brain states that facilitate attention control and that routinely engaging in this type of practice leads to structural changes in the white matter of areas associated with the executive attention network (Tang, Lu, Fan, Yang & Posner, 2012; Tang, Lu, Geng, Stein, Yang & Posner, 2010; Tang & Posner, 2009). The fact that these improvements were not present in a comparison relaxation group is good evidence that the effects associated with meditation were due to the brain changes produced by the practice of controlling attention and not attributable to a general relaxation effect. Diminished competition from internally-sourced distraction might be a natural consequence of the structural changes related to state training, although in this case it seems that the improvement would stem from top-down mechanisms rather than those that could be described as bottom-up. In other words, the quantity or salience of endogenous distractors might remain constant, but the meditation-related structural changes make it easier to control interference from task-irrelevant thoughts.

1.3.2 Exercise-Related Attention Improvements

Behavioral effects similar to those observed in the above meditation experiments have also been associated with different types of exercise or physical activity. Aerobic exercise has been linked to improved performance on measures of perceptual skill, verbal proficiency, and mathematics and academic readiness among school-aged children and physical activity has been associated with improvements to older adults' dual task performance (Hillman, Erickson & Kramer, 2008). The practice of yoga, a physical activity which may or may not include meditative practice, might also be beneficial for attention. Among children diagnosed with attention disorders, yoga interventions have been linked with improvements to sustained attention and improved discrimination (Chou & Huang, 2017) and self- and caregiver-reported decreases in attention-related symptoms (Harrison, Manocha, & Rubia, 2004). Yoga has also been shown to relate to improvements in cognitive control more broadly. For instance, participants exposed to six sessions of yoga showed improved performance on manipulation and maintenance measures of working memory (Brunner, Abramovitch, & Etherton, 2017). Gallant (2016) authored a comprehensive literature review to evaluate potential effects of mindfulness meditation on Friedman and Miyake's (2017) components of executive functioning. Benefits for inhibitory function were reported with a fair degree of consistency, whereas the effects on working memory and cognitive flexibility were less reliable. Participation in a mindfulness-based intervention was associated with improved inhibition, memory, and task switching in one study (Heeren, Van Broeck, & Philippot, 2009) and superior object detection in another (Anderson, Lau, Segal, & Bishop, 2007). Though many of these tasks are not designed to be measures of attention per se, a reduction in interference from internal distraction would conceivably translate into global benefits for attention-related constructs, such as cognitive flexibility, inhibition, or working memory.

1.3.3 Nature-Related Attention Improvements

Researchers seeking to test predictions of Attention Restoration Theory have reported improvements in both affective and cognitive measures after exposure to natural stimuli. These researchers have argued that natural features (i.e., stimuli in nature) capture attention and thereby institute opportunities to recover from the exertion of cognitive control (Kaplan, 1993). As it relates specifically to attention, exposure to natural environmental features has been linked to superior performance in a directed attention task (Tennessen & Cimprich, 1995), backwards digit span tasks (Abbott, Taff, Newman, Benfield, & Mowen, 2016; Van der Jagt, Craig, Brewer, & Pearson, 2017), and measures of sustained attention (Berto, 2005; Lee, Williams, Sargent, Williams, & Johnson, 2015). Participants in an office with natural plants were more likely to recover attention capacity after a fatiguing task than participants in the same office sans plants (Raanaas, Evensen, Rich, Sjøstrøm, & Patil, 2011), and individuals who had recently returned from a wilderness backpacking vacation detected significantly more errors in a proofreading task (i.e., showed stronger sustained attention) after fatigue induction than individuals who had vacationed in urban settings (Hartig, Mang, & Evans, 1991).

In the case of attention restoration theory, there is evidence to suggest that these effects are engendered by a general relaxation effect, as measured by reductions in physiological arousal. A group exposed to a video of natural scenery showed lower heart rates than a group who viewed a video of urban scenery, and these participants also evidenced less interference for invalidly-cued trials in an attention orienting task (Laumann, Gärling, & Stormark, 2003). At least when compared to the effects of anthropogenic scenes and sounds, features typically associated with natural environments might benefit performance in some attention tasks, and it is possible that this occurs by way of changes in physiological arousal. However, these results should be interpreted cautiously. Another group of researchers reported in a meta-analysis that there was limited support for Attention Restoration Theory, especially as it relates to measures of cognitive control (Ohly et al., 2016). Though the evidence is slight at best, it is possible that natural environments provide some reprieve from internal distractions and thereby improve aspects of attention performance.

1.3.4 Prayer-Related Attention Improvements

Prayer has been shown to elicit improvements to performance of attention tasks. For instance, a brief period of personal prayer helped to preserve Stroop performance after a resource-depleting thought suppression task whereas a quiet free-thought period did not ameliorate depletion effects (Friese, Schweizer, Arnoux, Sutter, & Wänke, 2014a, 2014b). Similarly, Adams, Kleider-Offutt, Bell, and Washburn (2017) detected pre- to post-prayer increases in attention resources among subjects who scored highly on a measure of religiosity, and there were also notable group differences: Participants who prayed about self-identified concerns boasted superior Stroop accuracy and faster response times in a continuous performance task relative to non-praying groups, and attention was biased toward problem-related stimuli in subsequent word-search tasks for the prayer condition. Freise and colleagues (2014a,b) attributed the effects to restored or recuperated capacity, but Adams and collaborators reasoned that prayer helped reduce demands, perhaps by shifting concerns temporarily to a deity. In other words, prayer appears to have helped participants resolve competition from task-irrelevant endogenous stimuli lobbying for attention.

1.3.5 Writing-Related Attention Improvements

Washburn (2003) reported on four experiments conducted as part of an in-class project series for introductory cognitive psychology courses. The experiments were intended to explore the possibility that a writing task would reduce mental workload and thus improve cognitive performance. Volunteers randomly assigned to a free-writing group were to write continuously for 5 minutes about whatever they wanted, though they were encouraged to write about life concerns; the remaining participants copied text for the duration of the five-minute period. In Experiment 1, participants completed a series of pre- and post-writing arithmetic problems (e.g., 713 * 17* 7). Between-groups accuracy, statistically indistinguishable before the writing task, was significantly different post-writing: The free-writing participants were significantly faster at solving arithmetic problems than the copying group, even though both groups were equivalent in the number of problems correctly solved both pre- and post-test. The same procedure was used in a subsequent experiment with the addition of a dual-task component: Participants completed the post-writing arithmetic task with the instructions that they should press the spacebar as quickly as possible upon presentation of an auditory tone stimulus. In a between-groups comparison, the diary-writing participants maintained equivalent arithmetic accuracy but had significantly faster solving times; further, they were faster than control counterparts at responding to the concurrent tone stimulus. Given that the task demands remained constant, detectable performance improvements in both the primary and secondary tasks indicate that the writing group had more attention resources available than participants who simply copied text. In another study in the series, 5 minutes of diary writing was associated with superior cued-recall accuracy in a 30-item paired-associates task when compared with the accuracy of the control group (copying accuracy = 40%, writing accuracy = 47%). In the final experiment, participants completed the Dundee

Stress-State Questionnaire (DSSQ) both before and after the assigned writing intervention (diary, copying). For diary-writing subjects, scores on the mood subscale of the DSSQ remained stable from pre- to post-task, but the copying group showed a significant drop in mood without changes in the other stress-state measures. The fact that slight but reliable writing-related improvements were present in a task requiring novel learning (i.e., paired-associates), a task requiring the mental manipulation of information (i.e., arithmetic calculations), and a dual-task procedure suggests an increased availability of attention resources or perhaps renewed motivation.

Washburn's (2003) pilot findings alone merit further investigation, but additional justification for studying writing-related improvements to attention can be found in the extensive body of literature on expressive writing. This research has documented a broader class of psychological effects related to writing that further illustrates the potential influence of endogenously-derived distraction. This work stems from Pennebaker and Beal's (1986) seminal study of experimental disclosure in which undergraduates were randomly assigned to write about either a traumatic, emotionally upsetting experience or an emotionally neutral topic for 15 minutes on four consecutive evenings. Among participants who provided both factual and emotional information about their traumas, there was an initial spike in negative mood and blood pressure readings, but a significant decrease in doctor's visits in the 6 months following the procedure. That such a brief and inexpensive intervention yielded observable and lasting benefits excited researchers and clinicians alike, so it is not surprising that hundreds of studies using the expressive writing task have since been published, often with similar results. More informative reviews of the associated effects of experimental disclosure and expressive writing exist elsewhere (e.g., Frattaroli, 2006; Sloan & Marx, 2004), but in general researchers have observed reductions in distress (e.g., Marlo & Wagner, 1999), enriched interpersonal interactions (e.g., Yang, Ziaoqing, Duan, & Zhang, 2016), and improved productivity in the workplace (e.g., Francis &Pennebaker, 1992; Spera, Burfeind & Pennebaker, 1994) and in academic study (e.g., Hines, Brown & Myran, 2016; Pennebaker & Francis, 1996). In the expressive writing literature, there is no evidence concerning immediate writing-related changes in measurements of attention specifically, but at least one theoretical explanation of these effects implicated relief from salient internal distractions in the genesis of psychological and health improvements. According to the Psychosomatic Inhibition Theory, inhibiting thoughts or emotions related to traumatic experiences can be stressful and thus increase the likelihood of health problems, and when these traumatic experiences are disclosed in writing, the need to inhibit trauma-related stimuli is reduced, as is stress and the incidence of stress-related health problems (Bootzin, 1997; Pennebaker, 1989). Together with Washburn's (2003) series of experiments, the well-documented psychological benefits of experimental disclosure suggest the possibility that individuals offload distracting mental content during writing and that this results in either liberated attention capacity due to load reduction (e.g., Adams et al., 2017), renewed top-down control due to state-based changes (e.g., Hillman et al., 2008; Posner & Rothbart, 2018) or both.

The performance benefits linked to writing could be due to immediate increases in capacity. Capacity, or the total amount of resources available at any given moment, is thought to be dictated by levels of physiological arousal (Kahneman, 1973), so one might predict that the generation of additional capacity could be limited to experiences that bring about marked shifts in arousal patterns (e.g., sleep, exercise). However, arousal-based increases in capacity would not explain improvements related to activities such as prayer, for which there is little reason to suspect significant changes in arousal levels.

Alternatively, attention performance could be improved utilizing available capacity more efficiently (thereby increasing effective capacity), perhaps by shifting strategy, by taking advantage of external cues, or by producing automatization of the primary task through practice. Human factors research has demonstrated that it is possible to circumvent the capacity limitations of operators under pressure. For instance, including a continuous display of task-related cues can reduce the amount of information a pilot must maintain or manipulate while attempting to diagnose a problem mid-flight (Wickens, 1996).

It is also possible that individuals can liberate capacity through writing by reducing demands through offloading of information or tasks, as in load shedding. Load shedding, a form of task simplification often studied in aeronautics, can help individuals maintain performance by decreasing resource demands (Staal, 2004). As traffic increases, Air Traffic Controllers will stop assessing nonessential data and limit monitoring to information that is central to maintaining safe distances between aircraft (Sperandio, 1971), and stressed or fatigued pilots will constrict their visual scans to instruments that are most critical to flying (Davis, 1948) and strategically discard low-priority tasks in favor of those that are indispensable (Raby & Wickens, 1990). This might also explain, in part, some of the expressive writing effects discussed earlier. Bootzin's (1997) explanation was that written disclosure of upsetting experiences reduced the need to inhibit thoughts or emotions related to those experiences and that this reduced stress. The same logic can be applied without invoking a stress-specific mechanism: If participants are routinely performing resource-demanding operations such as inhibiting information, maintaining intentions unrelated to task performance, or ruminating on personal concerns, then the opportunity to express these thoughts in writing might reduce the need for resource-taxing inhibition. After offloading nonessential tasks or extraneous information, previously-burdened resources are available for investment in other functions, much like the execution of an unfulfilled goal has been shown to reduce interference in tasks measuring executive functions (Masicampo & Baumeister, 2011). It may be sufficient to write down an intention or a concern temporarily to relieve the executive system of the need to rehearse intentions or monitor environments for problem- or solution-related information.

Writing may also benefit attention in that it may improve attention control. The ability to switch flexibly between laboratory tasks has been shown to be affected by concurrent loads (Liefooghe, Barrouillet, Vandierendonck, & Camos, 2008), so if an individual cannot effectively prevent task-irrelevant material from entering focal attention, then the ability to legislate between multiple ongoing tasks will likely diminish. Writing may calibrate processes related to self-reflection or goal-directed behaviors (e.g., Friese, Schweizer, Arnoux, Sutter, & Wanker, 2014a; 2014b) perhaps resulting in a more appropriate resource allocation policy or in the adoption of more effective control strategies, thereby strengthening attention control and improving the ability to manage multiple tasks.

The question then becomes how to distinguish performance improvements stemming from liberated capacity and those elicited by enhanced control. Fortunately, researchers have dissociated these two dimensions of attention through the distinction between scope and control tasks (Shipstead, Harrison, & Engle, 2015). According to Cowan et al. (2005), focal attention, or the preservation of information in the absence of interference, is crucial to working memory (i.e., mental manipulation of information not perceptually present). Scope, or the amount of information an individual can steadily maintain in focal attention, can be thought of as the capacity of the focus of attention. This is perhaps best illustrated in terms of the spotlight metaphor (e.g., Posner, Snyder & Davidson, 1980), in which the focus of attention is described as a spotlight that can be directed at a particular region of space. Scope, in this metaphor, would be characterized as the width of the spotlight, with a broader beam (i.e., greater scope) resulting in more spatial coverage but a diluted intensity of light, and a narrower beam (i.e., reduced scope) resulting in more intense beam focused on a smaller region of space. The control of attention is the management of information that occupies focal attention (i.e., the spotlight) and can itself be partitioned into two processes: resisting distraction (i.e., cognitive inhibition) and refocusing on information relevant to the interrupted task (i.e., shifting). In short, this framework suggests that there are two (not necessarily independent) pathways to attention recovery: a larger maintenance capacity (i.e., a wider spotlight) such that more information can be held in the focus of attention and some renewed ability to control information in the focus of attention (i.e., direct the spotlight).

Measurements of scope and control have centered on the visual array (VA) task and the complex span (CS) task respectively. The typical VA task involves the rapid display of object arrays that vary along some dimension; at test, participants indicate whether a probe was present or absent in the array. As set size increases, accuracy declines. The outcome measure, K, has been described as the number of items an individual can hold in focal attention; thus, one would predict that as load increases, such as when resources are allocated to other activities, scope would decline. In complex span tasks, a to-be-remembered item (e.g., a letter) follows each trial of a processing task (e.g., a simple math problem). Series of trials are presented as sets that vary in length, and at the end of a given set, a participant is instructed to recall the to-be-remembered items in the presented order. The outcome measure, the number of items recalled in the correct location, is considered an index of how well individuals can maintain information amidst distracting processing demands.

Using the VA and CS tasks to measure the effects of free writing on attention should thus serve to elucidate whether such interventions work by eliminating the distraction that competes for selection or by improving the individual's resistance to such distraction. If writing improves attention performance by purging distracting information from the focus of attention, then improvements in VA performance would be expected. If the ability to control attention is strengthened by a free-writing task, then this should be detected in CS performances. The proposed study was designed to explore the idea that writing improves attention performance by way of resolution of competition from endogenous sources of distraction.

2 METHOD

2.1 Sample

During the fall semester of 2019, Georgia State University students used the SONA Systems website to sign up as research participants in this study. The study description informed participants that normal or corrected to normal vision, including color vision, was necessary for eligibility in the study. Participation resulted in a one-hour research credit for use in a psychology course. In total, 263 students participated. Unfortunately, data from over half these individuals were not usable due to computer or program-related errors ($n = 123$), missing data and duplicated identification numbers ($n=14$), and behavioral observations (i.e., cheating on tasks or not writing during the experiment; $n = 4$). Univariate outliers on the dependent measures (i.e., scope or control scores +-3.29 standard deviations from the condition mean) were also excluded from analyses ($n=2$). Thus, the final sample included 120 participants, evenly split between the copying condition ($n=60$) and writing condition ($n=60$).

This sample size meets criteria established by the Central Limit Theorem, which holds that a minimum of 30 participants per group is necessary to obtain sampling distributions that approximate normality (DasGupta, 2010). Further justification for this sample size comes from the second experiment reported in Adams et al. (2017), which shared several relevant design elements (e.g., mixed design with pre-post observations using a battery of attention tasks) with the current study. Adams and colleagues demonstrated that a similar sample size showed adequate statistical power. The sample size is also greater than the samples from the Washburn (2003) demonstration studies, which shared essential design elements.

2.2 Design

The current study was of mixed design. The between-subjects variable was writing condition (Copying, Free Writing). The within-subjects variables were the pre- and post-manipulation scores obtained using the scope and control attention tasks.

2.3 Apparatus and Assessments

2.3.1 Writing Conditions

The instructions provided to participants in the free-writing condition were intended to maximize the likelihood of offloading. The instructions encouraged participants to write about pending tasks or short-term goals they hoped to achieve soon. Participants could write in a list or paragraph form, and the only additional constraint was that the participant should write by hand and without stopping for the entire 5-minute interval, even if they could think of nothing meaningful to write. Instructions for the writing condition were a modified version of those used by Scullin, Krueger, Ballard, Pruett and Bilwise (2018), who conducted a study in which participants wrote a to-do list before falling asleep. This form is available in Appendix C. The instructions for the control condition indicated that participants should copy sentences from a Wikipedia entry on bird migration (see Appendix D) by hand for 5 minutes. Again, instructions emphasized the need to write continuously for the entire 5-minute period. Research assistants made photocopies of writing samples and returned the originals to participants. Writing samples were kept anonymous.

2.4 Scope and Control

The administration of a full scope and control task series required an unrealistic amount of time for a one-hour pre-post study. Moreover, the full series was not appropriate for examining writing-related effects in the current study because researchers have typically used this approach to predict stable traits of cognition, such as fluid intelligence (e.g., Shipstead, Harrison, & Engle, 2015). To that end, researchers typically collect multiple measurements for the express purpose of reducing task- or context-specific sources of variance. Thus, a single scope task and a single control task were better suited to measuring transitory changes in scope and control related to the experience of writing.

The Color Visual Array (Color VA) task was used to measure attention scope. Color VA trials began with a neutral fixation point. A set of 4, 6, or 8 colored boxes (red, black, white, green, yellow, purple, blue) appeared on the screen for 250ms, followed by a blank screen. After a 900ms interval, participants indicated whether a circled box changed in color from its original presentation. Participants pressed 'S' if items remain unchanged and 'D' if a change occurred. This task lasted approximately 5 minutes and consisted of 84 total trials: There were 28 trials for each set size, and a change occurred during half of these trials. K was calculated for each set size using Cowan's (2005) single probe correction [K = N (hit rate + correction rejection rate – 1)] where N represents the number of valid target items in a given set. Set sizes within each task will be presented at random.

The Running Letter Span (RunLet) was used to measure attention control. There were five blocks of three RunLet trials. At the start of a trial, instructions informed participants to remember the last three to seven letters presented in a list. List length, of which the participants were unaware, ranged from five to nine items that remained on screen for 300 ms with 200 ms pauses between letters. The total number of letters recalled in the correct serial location constituted the primary outcome measurement.

The RunLet task is considered a running span task (Shipstead, Redick, Hicks & Engle, 2012), which are strongly correlated to other complex span tasks (e.g., operation span) and predict similar variations in fluid intelligence (Broadway & Engle, 2010). Moreover, complex span tasks have predicted performance in controlled attention tasks such as Stroop (e.g., Hutchison, 2007) and anti-saccade (Unsworth, Schrock, & Engle, 2004). Taken together, these findings suggest that RunLet is an acceptable proxy for assessing individual differences in the controlled-attention component of working memory capacity.

2.5 Individual Difference Measures

The inclusion of three additional questionnaires was intended to aid in disentangling the possible influences of stress and ruminative tendencies on attention performance in scope and control tasks.

2.5.1 Perceived Stress Scale (PSS)

The PSS is a self-report scale designed to capture the degree to which an individual is experiencing stress (see Appendix A). Participants endorsed the recent frequency of stress-related thoughts and feelings (e.g., “How often have you felt that you were unable to control the important things in your life?”) using a 5-point Likert scale (0 = never, 4 = very often). The 10-item versions of the PSS have shown satisfactory validity and reliability among samples of college students (Cohen, Kamark & Mermelstein, 1983; Lee, 2012). Higher scores on the PSS are indicative of higher levels of perceived life stress.

2.5.2 Cognitive Control and Flexibility Questionnaire (CCFQ)

The CCFQ is an 18-item self-report measure that includes two subscales. The first subscale assesses the degree to which an individual believes they can cope flexibly in stressful situations, and the second subscale measures the degree to which they believe they can assert control over negative thoughts and emotions (e.g., Gabrys et al., 2018; see Appendix B). Gabrys and collaborators reported adequate internal reliability and construct validity for the CCFQ. Specifically, participants who reported lower levels of cognitive control over emotions had more symptoms of depression and were more likely to experience repetitive thoughts and rumination. Similarly, participants with lower scores on the appraisal and coping flexibility CCFQ dimension showed a higher incidence of depression symptoms and were less likely to endorse flexible and effective coping strategies.

2.5.3 Rumination-Reflection Questionairre-Rumination Subscale (RRQ-Rum)

If the writing exercise inspired ruminative thinking in some participants, it might have lessened or even eliminated the potential attention benefits related to free-writing. The rumination portion of the RRQ (Trapnell & Campbell, 1999; see Appendix E) provided a way to account for individual differences in proneness to rumination. Participants used a rating scale of 1 (strongly disagree) to 5 (strongly agree) to indicate agreement with 12 statements concerning ruminative thinking (e.g., “My attention is often focused on aspects of myself I wish I’d stop thinking about”).

2.6 Procedure

A trained research assistant explained the overall procedure of the study and assigned each participant an identification number. Based on their identification number, participants were pseudo-randomly assigned to the control condition or the experimental condition. Research assistants then walked each participant to a computer testing station where informed consent was obtained electronically. Participants first completed the baseline scope and control tasks. Upon completion of the baseline block, participants wrote or copied sentences by hand for 5 minutes. Participants then completed the post-task scope and control measures, followed finally by the PSS, CCFQ, and RRQ-Rum. Once a participant finished, a research assistant debriefed the student and thanked them for their time.

3 RESULTS

The pre-manipulation scores from the VA Color and RunLet tasks were first compared to scores from the same tasks reported in Shipstead et al. (2012; Data Set B). The means at each set size of the VA Color task were comparable to those reported by Shipstead et al., as were the scores for RunLet. The Shipstead et al. data shows slightly more variability than the current study, likely due to differences in sampling procedures. All participants in the current study were Georgia State University undergraduate students, arguably more homogenous than the sample of community members and students from multiple colleges used by Shipstead and collaborators. Descriptives for the current study as well as the Shipstead et al. Data Set B are displayed in Table 1. T-tests confirmed that pre-manipulation scope and control scores were equivalent across conditions ($p > 0.05$) and typical of performance reported in the literature.

Table 1 Descriptives for VA Color and RunLet Tasks

TASK	CONDITION	MEAN (SD)	RANGE	SKEWNESS	KURTOSIS
VA -4 (PRE)	Copy	3.37 (0.87)	-0.29 to 4	-2.03	4.80
	Write	3.21 (0.74)	0.57 to 4	-1.56	3.09
	Shipstead et al. Data Set B	3.26 (0.87)	-2 to 4	-2.01	5.12
VA-6 (PRE)	Copy	4.67 (1.37)	0.43 to 6	-1.41	1.61
	Write	4.19 (1.25)	0.43 to 6	-0.70	0.56
	Shipstead et al. Data Set B	3.80 (1.60)	-3 to 6	-1.22	2.00
VA-8 (PRE)	Copy	5.09 (1.98)	0 to 8	-0.67	-0.35
	Write	4.87 (2.09)	-1.71 to 8	-0.94	0.96
	Shipstead et al. Data Set B	3.95 (2.10)	-2.4 to 8	-0.63	0.23
RUNLET (PRE)	Copy	39.78 (10.26)	11 to 71	-0.15	1.19
	Write	38.53 (10.10)	12 to 57	-0.18	-0.43
	Shipstead et al. Data Set B	39.89 (13.47)	6 to 71	-0.15	-0.58

3.1 Effects of Writing Condition on VA Color Performance

3.1.1 Accuracy

The influence of writing condition on the scope of attention (k) was assessed using a two-way 2 (condition: free-writing or copying) x 2 (pre-task Color VA score, post-task Color VA score) mixed ANOVA with repeated measures. There was no main effect of time, $F(1,118) = 0.93$, $p > 0.05$, nor was there a main effect of condition, $F(1,118) = 1.18$, $p = .279$. There was no evidence of an interaction, $F(1,118) = 0.01$, $p > 0.05$. Figure 1 displays pre and post VA Color performance for each condition.

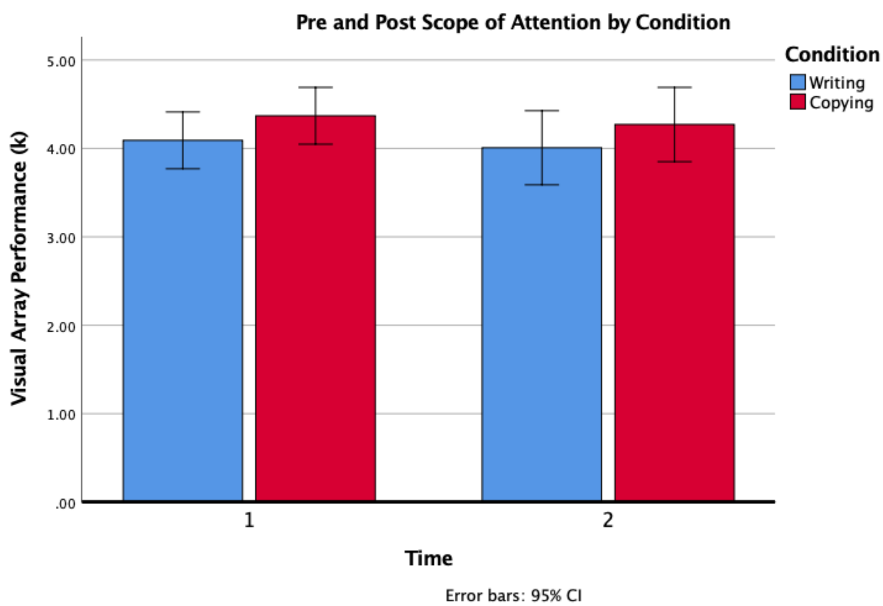


Figure 1 Pre and Post VA Color Performance by Condition

3.1.2 Response Times

Though response times (RTs) for visual array tasks are not typically reported, it was appropriate to examine them as a dimension of performance that might have changed after writing. Response times were measured as the time between the onset of the probe array and a valid keypress ('s' or 'd'). RTs were cleaned according to the procedures outlined by Whelan (2008) and entered into a 2 (condition: free-writing or copying) x 2 (pre-task RT, post task RT) mixed ANOVA with repeated measures. There was a main effect of time, indicating that RTs changed from pre- to post-manipulation, $F(1,118) = 55.41$, $p < 0.001$. Pre and post mean RTs revealed a tendency for participants to speed up (i.e., lower RTs) in the second block of VA Color task. There was no main effect of condition, $F(1,118) = 0.627$, $p = 0.430$, and a time by condition interaction was also absent, $F(1,118) = 0.26$, $p = 0.612$. Thus, the writing manipulation did not produce observable effects on either attention or speed performance in a VA Color task. Response times for each condition are displayed in Figure 2.

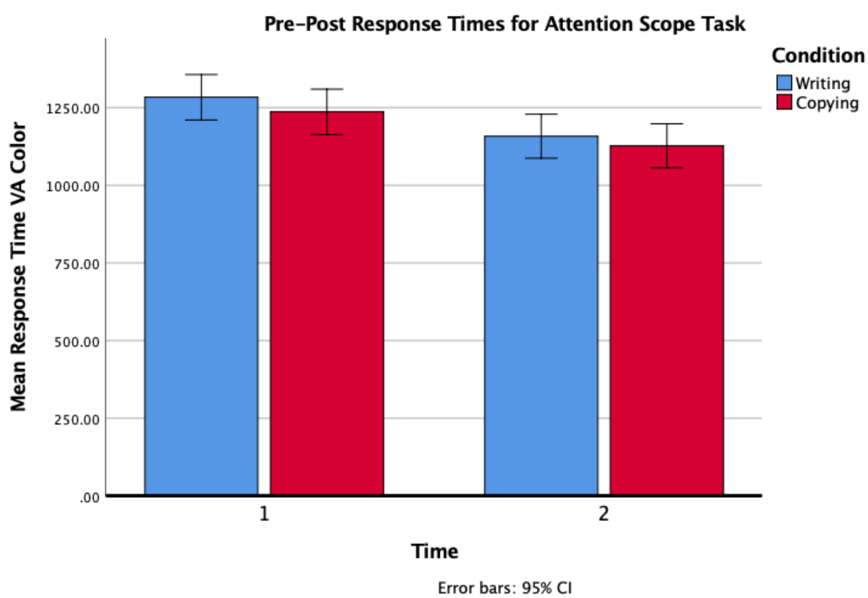


Figure 2 Pre and Post Response Times for VA Color Task

3.2 Effects of Writing Condition on RunLet Performance

The influence of writing condition on the control of attention was assessed using a two-way 2 (condition: free-writing or copying) x 2 (pre-task RunLet span, post-task RunLet span) mixed ANOVA with repeated measures. Writing condition had no effect on RunLet performance, $F(1,118) = 1.34$, $p = 0.249$. There was no main effect of time, $F(1, 118) = 1.45$, $p = 0.231$, and no interaction was present $F(1, 118) = 0.802$, $p = .372$. Thus, there was no evidence to suggest that the writing manipulation affected performance in the RunLet task.

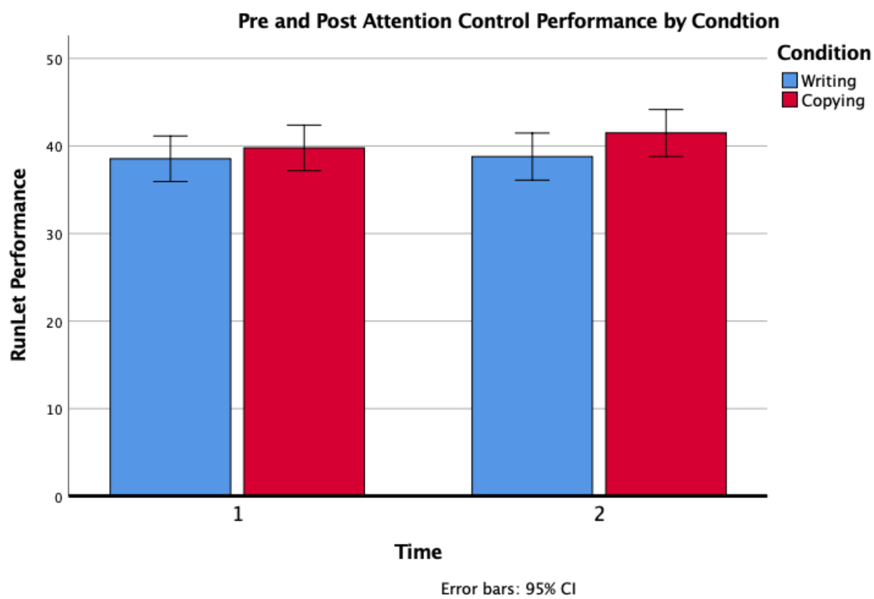


Figure 3 Pre and Post Attention Control Performance by Condition

3.3 Analysis of Writing Content

Using the writing samples, the amount of content offloaded can be approximated by dimensions such as word count. Both writing and copying conditions were coded for word count. The copying condition wrote a greater number of words (M =103.27, SD=26.48) than the writing condition (M =78.50, SD=30.82), likely reflective of the additional time and effort participants in the writing condition used to generate content. Within the writing condition, tertiles were created on the basis of word counts. Mean word counts for the upper (M = 121.71, SD=17.60) and lower (M =54.37, SD=15.42) tertiles within the writing condition were significantly different, $t(42) = -12.902$, $p< 0.001$, confirming that these could be classified as extreme groups. Next, a repeated measures ANOVA was conducted with word-count tertile as the between-groups variable. High and low word-count groups in the writing condition did not differ in either VA color performance, $F(1,42) = .414$, $p = .523$, or RunLet performance, $F(1,42) = .1 48$, $p = .703$.

Further examination of the actual writing content revealed different styles of writing. Some participants wrote every detail of their schedule for the next 24 hours, including routine tasks like eating meals and bathing. Other participants provided a lot of detail about a few specific tasks that needed to be completed. The implication is that word count might not be the optimal proxy for the amount of content offloaded because some individuals have high word counts but they are offloading habitual tasks that arguably require less mental effort to plan or execute than more complex tasks, like writing a final paper for a course or planning to return home for the holiday break. To account for this, the writing samples were coded for number of unique items listed. Each item in a bulleted list was counted as a unique item. For samples written in sentence format, each mention of a new task or event was counted as a unique item regardless of the amount of detail provided or the number of sentences written about that item. Next, a new variable, Words per Item (WPI), was computed as the word count divided by the number of items in each participant's sample. This roughly captures the level of detail or "depth" of the writing content. Tertiles were created for WPI. The WPI of the upper tertile (M=4.38, SD=3.281) were significantly different from the WPI of the lowest tertile (M=2.74, SD=0.933), $t(41)$= -2.105 , p = 0.41. However, there were still no group differences in attention scope, $F(1, 41) = 0.037$, $p = 0.848$, or attention control performance, $F(1, 41) = 1.089$, $p = 0.303$, even when accounting for this aspect of writing.

3.4 Attention and Individual Differences in Stress, Cognitive Control, and Rumination

The PSS, CCFQ, and RRQ-Rum measures were included so that the effects of life stress, cognitive control over thoughts during stress, and rumination could be examined as potential moderators in the relation between free-writing and attention performance. Because there were no writing effects on attention, these data were instead used to explore how these individual differences might affect the scope and control of attention. An extreme group approach (EGA) was proposed to explore this possibility as it would increase statistical power to detect small effects. Table 2 displays the descriptives for each measure by condition.

Table 2 Descriptives for Individual Difference Measures

QUESTIONAIRRE	CONDITION	MEAN (SD)	RANGE	SKEWNESS	KURTOSIS
PSS	Copy	24.18 (6.70)	8 to 41	-0.35	0.08
	Write	25.03 (5.74)	15 to 38	0.47	-0.31
CCFQ-A	Copy	45.30 (9.76)	12 to 63	-0.66	1.35
	Write	44.15 (8.08)	27 to 62	0.15	-0.55
CCFQ-C	Copy	36.95 (9.95)	17 to 63	0.47	-0.12
	Write	36.03 (9.81)	15 to 55	-0.18	-0.43
RRQ-RUM	Copy	40.85 (9.05)	17 to 59	-0.50	0.31
	Write	42.27 (8.80)	16 to 60	-0.34	0.59

3.4.1 Perceived Stress and Attention Performance

First, the entire sample was split into tertiles on the basis of PSS scores. A t-test confirmed that the groups were indeed extreme, $t(79) = -17.667$, $p<0.001$. The mean PSS score of the upper tertile (M=31.51, SD=3.15) was significantly higher than the mean PSS score of the lowest tertile (M=18.14, SD=3.62). The pre-test VA and RunLet performance of these extreme groups were then assessed by t-test. However, participants with high and low PSS scores did not differ according to VA Color performance, $t(79) = -0.66$, $p = .525$. PSS scores were also unrelated to control of attention in the RunLet task, $t(79) = -0.74$, $p = .218$. Thus, it was concluded that the experience of life stress is not a significant contributor to attention performance in either VA Color or RunLet tasks.

3.4.2 Cognitive Control, Cognitive Flexibility, and Attention Performance

Next, the sample was split into tertiles based on each CCFQ subscale. A t-test confirmed that the mean CCFQ Control score of those reporting the strongest cognitive control of the sample (*M*=47.39, *SD*=6.42). was significantly different ($p < 0.001$) from the mean CCFQ control score of those with the weakest cognitive control of the sample (*M*=25.39, *SD*=5.01). Again, these tertiles were used as the grouping variable in an independent samples t-test. VA Color performance did not vary between high and low cognitive control groups, $t(88) = 1.34$, $p = .109$, and neither did RunLet performance, $t(88) = -0.21$, $p = .742$. Scores on the appraisal subscale of the CCFQ were split into tertiles and groups were confirmed to be extreme. Scope performance did not differ between high- and low-flexibility participants, $t(77) = -0.29$, $p = .177$. There were also no difference in RunLet performance between these groups, $t(77) = -0.07$, $p = .439$.

3.4.3 Rumination and Attention Performance

Finally, the same technique was repeated for RRQ-Rum scores. The upper tertile (*M*=50.68, *SD*=4.33) of the rumination scores were significantly greater ($p<0.001$) than rumination scores of the lowest tertile (*M*=32.07, *SD*=5.93). Groups with high and low RRQ-Rum scores did not differ in attention performance in either VA Color ($t(80) = -1.33$, $p = .186$) or RunLet ($t(80) = -0.09$, $p = .931$) tasks.

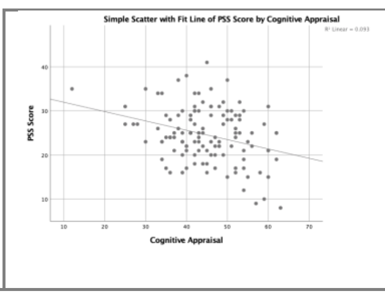
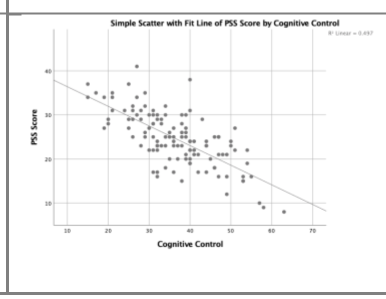
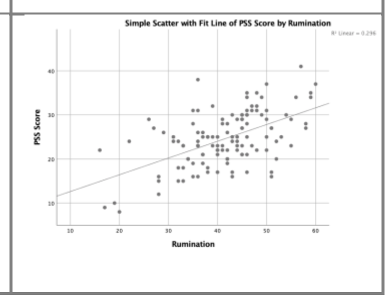
Table 3 Descriptives for Extreme Groups Analysis

QUESTIONAIRRE	GROUP	N	MEAN (SD)	VA COLOR-PRE	RUNLET-PRE
PSS	Low Stress	42	18.14 (3.62)	4.23 (1.19)	40.79 (8.82)

	High Stress	39	31.51 (3.15)	4.39 (0.97)	39.15 (10.89)
CCFQ-A	Low Flexibility	38	34.89 (5.67)	4.26 (1.53)	38.39 (11.58)
	High Flexibility	41	54.32 (4.13)	4.35 (1.09)	38.56 (9.35)
CCFQ-C	Low Control	46	25.39 (5.01)	4.36 (0.99)	39.13 (10.09)
	High Control	44	47.39 (6.42)	4.03 (1.35)	39.57 (9.80)
RRQ-RUM	Low Rumination	42	32.07 (5.93)	4.08 (1.48)	38.60 (11.25)
	High Rumination	40	50.68 (4.33)	4.45 (0.97)	38.80 (10.10)

3.5 Correlations Among Individual Difference Measures

The current study presented an opportunity to evaluate the relations between three survey instruments: a measure of perceived life stress, self-reported cognitive control and flexibility under stress, and self-reported rumination proneness. There were significant correlations between each of these instruments. PSS scores were negatively correlated with both subscales of the CCFQ. Higher levels of reported life stress were weakly but significantly associated with lower levels of cognitive flexibility under stress, $r(120)=-.305$, $p=0.001$. Higher life stress was associated with weaker cognitive control, $r(120)=-.705$, $p<0.001$. There was a moderate positive correlation between PSS scores and RRQ-Rum scores, $r(120) = .544$, $p < 0.001$, suggesting that a tendency to ruminate was associated with reporting higher levels of life stress. RRQ-Rum scores were also related to the CCFQ subscales. Higher RRQ-Rum scores were correlated with lower CCFQ-Appraisal scores, indicating that stronger ability to cope flexibly under stress is weakly associated with lower reported rumination, $r(120)=-.248$, $p=0.006$. Rumination was most strongly correlated with cognitive control, $r(120)=-.705$, $p<0.001$. Those with higher rumination scores reported lower scores on a questionnaire concerning cognitive control. The two CCFQ subscales were weakly correlated with one another, $r(120)=.340$, $p<0.001$. Higher scores on cognitive control were slightly associated with an increased likelihood to report stronger ability to cope flexibly. A scatterplot matrix depicting these correlations can be found in Figure 3.

	CCFQ-A	CCFQ-C	RRQ-Rum
PSS			

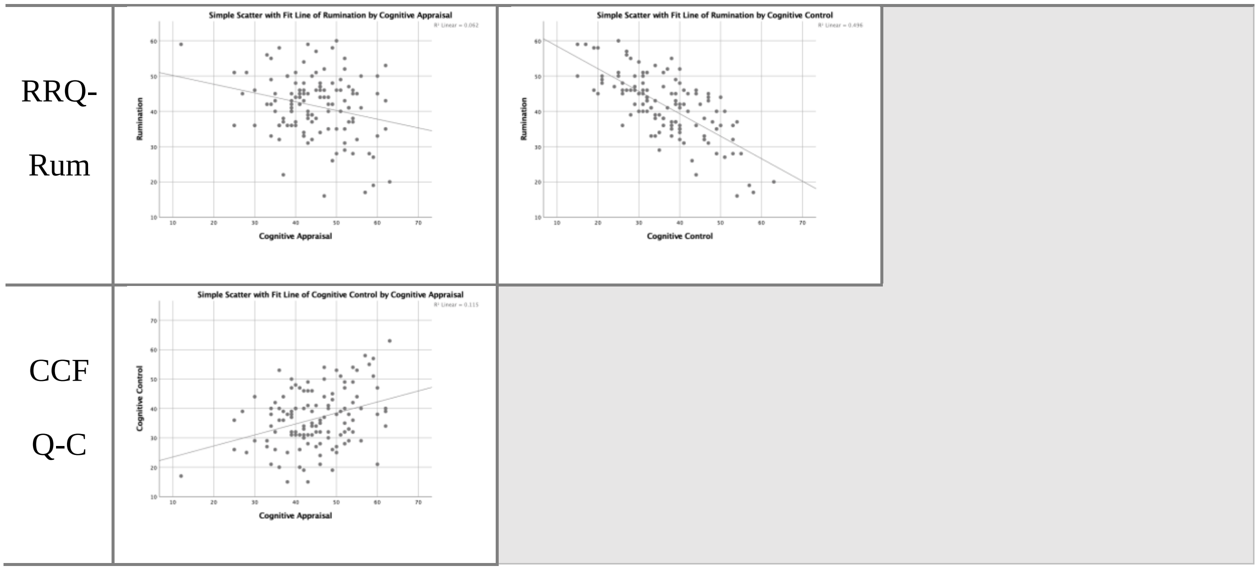


Figure 4 Scatterplot Matrix of Individual Difference Measures

4 DISCUSSION

This experiment was an investigation of the effects of a free-writing manipulation on attention scope and attention control performance. This experiment was, in part, an attempt to reproduce and explain the effects observed in a class-demonstration study by Washburn (2003). Washburn observed that participants who completed a brief writing exercise exhibited reliable performance improvements across a broad range of tasks, including paired-associates, arithmetic, and a dual-task measure. It was important to determine whether these performance changes arose from changes in general resource availability or from a renewal of top-down attention control, and correspondingly whether writing-related performance changes could also be detected in tasks that measure these aspects more directly. There were no observable effects of a free-writing exercise on either attention scope or attention control. There are two possibilities that warrant additional investigation. First, it is possible that the writing manipulation did not engender the effects that Washburn observed. Second, it is possible that any writing-related performance changes would not manifest on the dependent measures used in the current study, namely scope and control attention tasks.

4.1 Writing Manipulation

It may be that there is an effect of writing on the scope and control of attention, but this effect was not elicited by the writing procedure administered in the current study. A manipulation check would have been prudent, but administration of the tasks used in the Washburn (2003) study was too time-intensive for the constraints of the current study. The duration of the writing procedure, the frequency of the writing manipulation, and the nature of the instructions are three elements that could be modified in future studies. Regarding duration, it is possible that such a 5-minute writing procedure may not be long enough for individuals to write down an amount of content that would produce observable benefits for attention performance. It seems unlikely that insufficient duration fully explains the absence of writing-related attention effects as the writing procedures in each of the Washburn (2003) experiments also lasted 5 minutes, and he observed improvements in several tasks, including dual-task performance. Evidence of performance differences between participants with the highest and lowest wordcounts would support the interpretation that the writing manipulation in the current study was not long enough, but such a trend was also absent. It is worth noting that longer writing periods are typical in the expressive writing paradigm, and the writing procedure is repeated on multiple occasions. For instance, Pennebaker and Beal (1986) instructed participants to write for 15 minutes on four consecutive evenings. Therefore, it is possible that writing effects would arise in an experiment with a longer writing session or perhaps even multiple writing sessions.

In the current study, the instructions for the writing task were designed to maximize offloading of endogenous distractors that might compete for access to the focus of attention, so participants were instructed to write down all of the tasks they needed to complete in the coming days. These instructions differed slightly from those of Washburn (2003) in which participants could write about whatever they wanted. A more open-ended prompt (e.g., write about a topic that has been occupying your thoughts recently) might result in offloading of content that is—by each individual's evaluation—something that has been consuming attention. Additionally, the instructions in the current study were entirely focused on tasks and goals. Though Washburn (2003) permitted participants to write about anything, they were encouraged to write about "life concerns." Similarly, Adams and collaborators (2017) instructed participants to pray about something that was worrying them, and instructions for the expressive writing paradigm specify that individuals write about traumatic or emotionally upsetting experiences. It is possible that cueing participants to engage in a more personal or emotional form of reflection would elicit benefits similar to those observed in Washburn's experiments.

A strength of the present study is that the writing samples were retained and analyzed in several ways for patterns that might relate to task performance. No meaningful differences were observed in these analyses; however, a more intensive qualitative analysis of the writing samples in the current study could prove fruitful for prioritizing changes to the writing manipulation and planning subsequent efforts to explore the connection between writing and cognitive performance. Word count and words-per-item did not uncover any identifiable patterns, but there are other characteristics of writing that could be examined. For instance, the use of personal pronouns or certain emotion-related keywords could provide a basis for examining the idea that a more personal or emotional style of writing contributes to changes in attention. Beyond these properties, it would be very difficult to code these samples for other variables, such as the importance of tasks listed or the amount of load each item creates for an individual. Using a more structured writing task (e.g., an Eisenhower matrix) would allow for that type of analysis and potentially identify the aspects of writing that matter most.

4.2 Dependent Measures

It was hypothesized that writing would either reduce competition from endogenously-sourced distractions through offloading or improve individuals' resistance to these distractions. The dependent measures used in the current study, VA Color and RunLet of the scope and control framework, were intended to help distinguish between these two possible pathways to performance improvements. As there were no changes to attention performance, the current evidence cannot be used to support either account. Because no manipulation check was performed, however, it is not clear whether attention changes did not manifest because the writing manipulation was ineffective or because free writing had no effect on VA Color or RunLet performance. Future efforts should verify writing-related performance improvements in other cognitive tasks first, then evaluate scope and control. The advantage of using the scope and control framework in the current study was the opportunity to determine which of two possible pathways, liberated maintenance capacity or renewed attention control, contributed to any observed performance changes. However, it may be that transient changes in attention performance are simply not detectable in scope or control tasks which are often used to predict trait-like aspects of cognition (e.g., fluid intelligence; Shipstead et al., 2015). If that is the case, alternative attention tasks, such as the Attention Networks Task (Posner, 2016), could be used. Selection of dependent measures could also be informed by examination of tasks that are affected by relevant individual difference variables, such as those assessed in the current study.

4.3 Individual Differences & Attention Performance

Arguably, interference arising from endogenous distraction should be highest among stressed individuals, those who tend to ruminate, and those have poor cognitive control. If that is true, then weaker attention performance would be expected from individuals in these groups. Thus, self-report measures of stress, cognitive control, cognitive flexibility, and rumination were included in the current experiment. However, there were no differences in scope or control performance between high or low-scoring participants on PSS, CCFQ, or RRQ-Rum. Each of these measures are based on self-report, so it is critical to note that this evidence only suggests that individual differences in self-reports of stress, cognitive control, cognitive flexibility, and rumination did not relate to performance in a visual array task or a running span task. These factors could be measured differently, either through more direct measures or by using more extreme groups in order to obtain stronger evidence that these individual differences do not actually affect attention scope or attention control.

That these individual differences did not predict differences in scope or control performance provides some support for the idea that scope and control tasks might not be best suited to observing writing-induced changes in cognitive performance. The literature on stress and attention suggests a high frequency of distracting thoughts accompanied by a narrower, more rigid focus of attention such that individuals become experience an increased vulnerability to and a difficulty disengaging from stress-related distractions. Thus, these individual differences may show stronger influences in tasks with high working memory loads (e.g., complex span), tasks that benefit from a broader focus of attention (e.g., pro-saccades), and tasks that require a high degree of cognitive flexibility (e.g., set-switching). This finding does indicate that at least some scope and control tasks are impervious to individual differences in self-reported perceived stress, cognitive control and flexibility, and rumination. This bodes well for the continued use of these tasks as it is an important indicator of measurement validity.

4.4 Correlations Among Perceived Stress, Cognitive Control and Flexibility, and Rumination

The current experiment also allowed for an examination of the relations among measures of perceived life stress, self-reported cognitive control and flexibility under stress, and self-reported rumination proneness. Each of these measures were correlated to varying degrees, which has important implications for construct and measurement validity. Convergent validity, or the degree to which two measures of theoretically-related constructs are actually related, is one component of construct validity. In the current experiment, reports of higher perceived stress were weakly associated with lower levels of cognitive flexibility and strongly correlated with impaired cognitive control. This converges with reports that stressed individuals exhibit more rigid strategy use (Plessow et al., 2011), and provides additional evidence that increased stress is tied to patterns of cognitive inflexibility. Increased stress has also been linked to poorer cognitive control elsewhere (Shields et al., 2016), but an examination of items within each measure reveals some similarity (e.g., “In the last month, how often have you been angered because of things that happened that were outside of your control?” and “Generally, in stressful situations I feel like I lose control over my thoughts and emotions”). A sense that one is not in control of events is likely to be a central feature of the stress experience, so these measures might also overlap in measurement.

Stress was also higher among individuals who tend to ruminate. The relation of these variables could go in either direction. It might be that stress induces rumination for some, or it might be that people who are already prone to rumination tend to experience more stress either as a result of difficulty managing self-focused distraction. This correlation does support the assertion that stressed will be more likely to experience distraction from endogenous sources.

A reported tendency to ruminate was weakly tied to poorer cognitive flexibility. This also makes sense, as rumination or brooding is a pattern of thinking that is by its very nature inflexible. Higher levels of rumination were strongly linked to reports of lower cognitive control. Combined with the evidence that individuals who reported weak cognitive control over emotions were more likely to experience ruminative symptoms of depression (Gabrys et al., 2018), this suggests that low cognitive control and rumination are closely related. The strong correlation suggests the possibility that the RRQ-Rumination and CCFQ-Control subscales tap the same construct, and the items are quite similar. For instance, one item on the CCFQ-Control is "Generally, in stressful situations it is easy for me to ignore distracting thoughts." This is very similar to the RRQ-Rum item, "It is easy to put unwanted thoughts out of my mind." The correlation between CCFQ-Control and RRQ-Rum should be more closely examined to determine what dimensions of these measures overlap and what dimensions remain unique to each construct.

Lastly, the two subscales of the CCFQ, cognitive control and appraisal/flexibility were modestly associated: reports of higher cognitive control corresponded to reports of more flexible cognitive coping. Specifically, participants who reported lower levels of cognitive control over emotions had more symptoms of depression and were more likely to experience repetitive thoughts and rumination. That these were not more strongly correlated is good evidence that these subscales measure slightly different constructs.

4.5 Summary

The current experiment did not yield evidence that a five-minute free writing experience produced changes to attention scope or control performance, but additional experiments are required before it can be concluded that there are no benefits of writing for attention. Despite consistently null results for the comparison between writing and copying in the current study, the evidence is insufficient to conclude that free-writing activities do not produce changes to attention performance. A number of possibilities remain open to investigation, specifically surrounding the writing manipulation itself and the use of dependent measures. The Washburn (2003) pilot series should be reproduced by using the same dependent measures under more tightly controlled conditions. This approach would also help determine which aspects of the writing manipulation (duration, nature of the instructions) elicit performance benefits so that these benefits can be observed in other component cognitive tasks. A replication failure in that instance would be much stronger evidence that the effects observed by Washburn (2003) were indeed anomalous.

It is important to note that this study failed to provide evidence that attention scope or control performance is sensitive to self-reported life stress, ruminative tendencies, or the ability to control intrusive thoughts. The fact that responses to PSS, CCFQ, and RRQ-Rum items did not relate to pre-test VA Color or RunLet performance suggests these specific attention measures could be resilient to individual differences in these self-report instruments. Additionally, the correlations among stress, cognitive control, cognitive flexibility and rumination provide some support for the idea that stress is an important individual difference factor. If stressed individuals show poorer cognitive flexibility, impaired cognitive control, and an increased likelihood of having distracting self-focused thoughts, then this influence would likely manifest in some measures of cognitive performance. These correlations also provide good evidence of convergent validity of the measures, but additional research should be conducted to explore discriminant validity, the other aspect of construct validity.

It remains an open question as to whether writing benefits attention, and whether such benefits would stem from the liberation of resources or state-based renewal of top-down control. This experiment provided a novel approach for examining the role of endogenous sources of distraction on attention performance. Continued exploration of experiences that improve cognitive performance will likely contribute to our understanding of the role of endogenous distraction in cognitive performance more broadly, and it should open the door to discussions of important theoretical implications of endogenous distraction, especially as it relates to top-down, bottom-up, and history-based constraints on attention. In an applied sense, research efforts focused specifically on writing techniques are particularly important, as popular media has a tendency to tout writing and offloading-type activities as performance-enhancement strategies. The claim that writing or offloading information improves mental performance has yet to be formally addressed in the cognitive science literature. Future efforts to develop strategies and techniques for improving productivity and cognitive performance should be rooted in evidence and subjected to rigorous testing.

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APPENDICES

Appendix A: Items and Instructions for Perceived Stress Scale (10-item)

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

For each question, choose from the following alternatives:

0. Never
1. Almost never
2. Sometimes
3. Fairly often
4. Very often

1. In the last month, how often have you been upset because of something that happened unexpectedly?
2. In the last month, how often have you felt that you were unable to control the important things in your life?
3. In the last month, how often have you felt nervous and "stressed?"
4. In the last month, how often have you felt confident about your ability to handle your personal problems?
5. In the last month, how often have you felt that things were going your way?
6. In the last month, how often have you found that you could not cope with all the things that you had to do?
7. In the last month, how often have you been able to control irritations in your life?
8. In the last month, how often have you felt that you were on top of things?
9. In the last month, how often have you been angered because of things that happened that were outside of your control?
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Appendix B: Cognitive Control and Flexibility Questionnaire

The purpose of this questionnaire is to determine what you generally think/feel/do when stressful situations provoke negative thoughts and emotions. Of course, you may act differently depending on the situation, but try to think of what you usually think/feel/do when you are stressed or upset. Using the scale below, indicate the extent to which agree or disagree with the following statements.

For each question, choose from the following alternatives:

1. Strongly disagree
2. Disagree
3. Slightly disagree
4. Neither agree nor disagree
5. Slightly agree
6. Agree
7. Strongly agree

1. Generally, in stressful situations I take the time to think of more than one way to resolve the problem.
2. Generally, in stressful situations I approach the situation from multiple angles.
3. Generally, in stressful situations I consider the situation for multiple viewpoints before responding.
4. Generally, in stressful situations I take the time to think of several ways to best cope with the situation before acting.
5. Generally, in stressful situations I manage my thoughts or feelings by reframing the situation.
6. Generally, in stressful situations I weigh out my options before choosing how to take action.
7. Generally, in stressful situations I take the time to see things from different perspectives before reacting.
8. Generally, in stressful situations I can easily think of multiple coping options before deciding how to respond.
9. Generally, in stressful situations I control my thoughts and feelings by putting the situation into context.
10. Generally, in stressful situations I can remain in control of my thoughts and emotions.
11. Generally, in stressful situations I feel like I lose control over my thoughts and emotions.
12. Generally, in stressful situations I find it easy to set-aside unpleasant thought or emotions.
13. Generally, in stressful situations I have a hard time managing my emotions.
14. Generally, in stressful situations it is easy for me to ignore distracting thoughts.
15. Generally, in stressful situations it’s hard for me to shift my attention away from negative thoughts or feelings.
16. Generally, in stressful situations my thoughts and emotions interfere with my ability to concentrate.
17. Generally, in stressful situations I get easily distracted by upsetting thoughts or feelings.
18. Generally, in stressful situations it’s difficult let go of intrusive thoughts or emotions.

Appendix C: Writing Task Instructions for Free-Writing Condition

Using the pen and paper provided, please spend the next five minutes writing down everything you have to remember to do over the next few days. These tasks can be related to your classes, your job, your personal life, your goals for the near future, and so on. You can write these in paragraph form or in bullet points. Use all five minutes to write about tasks you have to complete tomorrow and in the near future, even if few are coming to you.

Appendix D: Writing Task Instructions for Control Condition

Using the pen and paper provided, please spend five minutes copying sentences from this encyclopedia entry. Please copy the text exactly as it is written, and try to copy as much text as you can in the time provided. An assistant will keep track of the time, and he/she will provide further instructions when five minutes has passed.

Bird Migration

Bird migration is the regular seasonal movement, often north and south along a flyway, between breeding and wintering grounds. Many species of bird migrate. Migration carries high costs in predation and mortality, including from hunting by humans, and is driven primarily by availability of food. It occurs mainly in the northern hemisphere, where birds are funneled on to specific routes by natural barriers such as the Mediterranean Sea or the Caribbean Sea.

Migration of species such as storks, turtle doves, and swallows was recorded as many as 3,000 years ago by Ancient Greek authors, including Homer and Aristotle, and in the Book of Job. More recently, Johannes Leche began recording dates of arrivals of spring migrants in Finland in 1749, and modern scientific studies have used techniques including bird ringing and satellite tracking to trace migrants. Threats to migratory birds have grown with habitat destruction especially of stopover and wintering sites, as well as structures such as power lines and wind farms.

The Arctic tern holds the long-distance migration record for birds, travelling between Arctic breeding grounds and the Antarctic each year. Some species of tubenoses (Procellariiformes) such as albatrosses circle the earth, flying over the southern oceans, while others such as Manx shearwaters migrate 14,000 km (8,700 mi) between their northern breeding grounds and the southern ocean. Shorter migrations are common, including altitudinal migrations on mountains such as the Andes and Himalayas.

The timing of migration seems to be controlled primarily by changes in day length. Migrating birds navigate using celestial cues from the sun and stars, the earth's magnetic field, and mental maps.

Historical views

Records of bird migration were made as much as 3,000 years ago by the Ancient Greek writers Hesiod, Homer, Herodotus and Aristotle.The Bible also notes migrations, as in the Book of Job (39:26), where the inquiry is made: "Is it by your insight that the hawk hovers, spreads its wings southward?" The author of Jeremiah (8:7) wrote: "Even the stork in the heavens knows its seasons, and the turtle dove, the swift and the crane keep the time of their arrival." Aristotle noted that cranes traveled from the steppes of Scythia to marshes at the headwaters of the Nile. Pliny the Elder, in his Historia Naturalis, repeats Aristotle's observations.

Swallow migration versus hibernation

Aristotle, however, suggested that swallows and other birds hibernated. This belief persisted as late as 1878, when Elliott Coues listed the titles of no less than 182 papers dealing with the hibernation of swallows. Even the "highly observant" Gilbert White, in his posthumously published 1789 The Natural History of Selborne, quoted a man's story about swallows being found in a chalk cliff collapse "while he was a schoolboy at Brighthelmstone", though the man denied being an eyewitness. However, he also writes that "as to swallows being found in a torpid state during the winter in the Isle of Wight or any part of this country, I never heard any such account worth attending to", and that if early swallows "happen to find frost and snow they immediately withdraw for a time—a circumstance this much more in favour of hiding than migration", since he doubts they would "return for a week or two to warmer latitudes.

Appendix E: Rumination Reflection Questionnaire-Rumination Subscale (RRQ-Rum)

For each of the statements located on the next two pages, please indicate your level of agreement or disagreement by circling one of the scale categories to the right of each statement. Use the scale as shown below:

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	**2**	**3**	**4**	**5**

1. My attention is often focused on aspects of myself I wish I'd stop thinking about.
2. I always seem to be "re-hashing" in my mind recent things I've said or done.
3. Sometimes it is hard for me to shut off thoughts about myself.
4. Long after an argument or disagreement is over with, my thoughts keep going back to what happened.
5. I tend to "ruminate" or dwell over things that happen to me for a really long time afterward.
6. I don't waste time re-thinking things that are over and done with.
7. Often I'm playing back over in my mind how I acted in a past situation.
8. I often find myself re-evaluating something I've done.
9. I never ruminate or dwell on myself for very long.
10. It is easy for me to put unwanted thoughts out of my mind.
11. I often reflect on episodes in my life that I should no longer concern myself with.
12. I spend a great deal of time thinking back over my embarrassing or disappointing moments.