THOUGHT CONSTRAINT AS AN INDIVIDUAL DIFFERENCES VARIABLE

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ABSTRACT

THOUGHT CONSTRAINT AS AN INDIVIDUAL DIFFERENCES VARIABLE

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This quasi-experimental study examined the dissociability of thought constraint from task relatedness (i.e., whether thoughts are related to the task at hand) and the rank-order stability of thought constraint. The study also tested predictions (Christoff et al., 2016) about the relationship between thought constraint and psychological symptoms and the influence of thought constraint on task performance. Like previous research, thought constraint was dissociable from task relatedness (Alperin et al., 2021; Kam et al., 2021; Mills et al., 2018; Mills et al., 2021; O'Neill et al., 2020; Smith et al., 2018). Thought constraint demonstrated rank-order stability across two measures of sustained attention. Higher reports of depressive symptoms, rumination, state anxiety, and trait anxiety were associated with less constrained thoughts, which is contrary to the predictions of Christoff et al. (2016) and Mills et al. (2021). Consistent with Christoff et al. (2016) and Alperin et al. (2021), higher reports of overall ADHD symptoms (inattention and hyperactivity combined) were associated with less constrained thought. As expected, symptoms of inattention and hyperactivity alone were positively associated with less constrained thought. Thought constraint also predicted unique variance in response accuracy via the Sustained Attention to Response Task (Robertson et al., 1997; as in Smith et al., 2022) and response time variability via the Metronome Response Task (Seli et al., 2013a). There was an interaction between thought constraint and task relatedness in the model predicting SART response time variability, indicating that response time was more variable when thoughts were off-task and less constrained than usual. The study suggests that thought constraint is a promising individual differences variable, but further research is needed to fully understand this phenomenon.

Keywords: freely-moving thought, mind wandering, individual differences, measurement

CHAPTER ONE: LITERATURE REVIEW

Mind wandering has become a popular research topic over the last decade and is a widely experienced phenomenon (Callard et al., 2013). Traditionally, mind wandering has been operationally defined as task-unrelated thought (i.e., thoughts irrelevant to the task at hand; Smallwood & Schooler, 2015). Examples of task-unrelated thoughts include musing about dinner plans while jogging, sitting in a college lecture reminiscing about your 2nd-grade teacher, and attempting to read a book in a coffee shop while also thinking about the music playing.

Conversely, Christoff et al. (2016) proposed the Dynamic Framework theory of mind wandering. The Dynamic Framework asserts that the predominant operationalization of mind wandering (i.e., task-unrelated thought, referred to as task relatedness hereafter) has neglected the movement of thought, which is an ordinary yet understudied component of consciousness. The Dynamic Framework suggests that thought content (i.e., how related thoughts are to the task at hand) is not the critical defining feature of mind wandering, but the movement (i.e., dynamics) between thoughts is. According to the Dynamic Framework, varying degrees of thought constraint, whether automatic (as in affective or sensory salience, like rumination or being automatically distracted by the sound of a jackhammer) or deliberate (as in purposeful cognitive control, like studying for a test), dictate how freely one's thoughts move.

According to the Dynamic Framework, the least constrained type of thought is dreaming, while rumination and goal-directed thinking are the most constrained. Mind wandering falls somewhere in the middle, with thoughts that are "more deliberately constrained than dreaming but less deliberately constrained than creative thinking and goal-directed thought" (Christoff et al., p. 2). For example, while riding the bus home, you might picture yourself having dinner that evening, then wonder if you have been overeating fast food, then notice the faint music playing from another passenger's headphones and remember a song you heard at a party the night before. In this framework, the movement between these thoughts, rather than the content of the thoughts, would qualify this as mind wandering. For this study, "task relatedness" refers to the extent to which thoughts are focused on or diverge from the current task, and "thought constraint" refers to the level of freedom with which thoughts move.

Besides suggesting a new framework for understanding mind wandering, Christoff et al. (2016) proposed that thought constraint is a stable individual difference (i.e., a trait-like construct) associated systematically with certain dysfunctional psychological characteristics. Here, rather than adjudicate amongst theories and definitions of mind wandering, I assessed if thought constraint measured with in-the-moment thought probes shows potential as an informative individual difference variable.

Dissociating Thought Constraint from Task Relatedness

Mills et al. (2018) conducted an experience-sampling study investigating if task-unrelated thought is dissociable from thought constraint. They used mobile devices to survey participants at random intervals throughout their daily lives, asking about how freely moving their thought were, the task relatedness of their thoughts, and their awareness of their surroundings. Mills et al. predicted that if thought constraint were redundant with task relatedness, all task-unrelated thoughts would also be endorsed as freely moving. By computing the correlation between thought constraint and task relatedness for each participant at the trial level (i.e., intraindividual correlation; Bakdash & Marusich, 2017), Mills et al. found the average correlation between thought types across all participants was positive, albeit weak (r_{rm} = .24; N = 165). The authors also computed an interindividual correlation and found a weak association between thought types

($r[165] = .16$, $p = .05$), suggesting that the two dimensions (or at least thought reports on these dimensions), although overlapping some, are distinct. A similar study by Mills et al. (2021) supported these findings, showing that task-unrelated and unconstrained thought are positively associated, though not wholly redundant (task relatedness accounted for less than 10% of the variance in unconstrained thought; Study 1).

O'Neill et al. (2020) used task-embedded thought probes to assess thought constraint in a sustained attention task. These probes, which are commonly used to study thoughts during tasks (Giambra, 1995; Schooler et al., 2005; Smallwood & Schooler, 2006; Weinstein, 2017; Wiemers & Redick, 2019), ask participants questions about their thoughts while they perform a task. In this case, the task was watching the revolution of clock hands and pressing a button each time the hand pointed at 12:00. Clock hands moved one tick per second, with 20 ticks equating to one full clock revolution; participants watched 60 revolutions. The thought probes assessed whether thoughts were related to the task, intentional, and constrained.

Consistent with Mills et al. (2018), O'Neill et al. found a statistically significant number of thoughts were both on-task *and* freely moving ($M = 0.40$, $t[110] = 2.89$, $p < .001$, $N = 111$) and off-task *and* constrained ($M = 0.06$, $p < .001$, $N = 111$), supporting the idea that task relatedness and thought constraint are distinct dimensions of thought. Additionally, O'Neill et al. found that thought constraint remained stable throughout the lab task while task-related thoughts strategically changed with the task's demands. That is, participants reported less task-unrelated thought when they were closer to responding during the clock task. Conversely, thought constraint did not fluctuate with task demand. In an experience-sampling study and a re-analysis of Mills et al. (2018), Smith et al. (2018) reported that thought constraint reports rose and fell from most constrained in the morning and late afternoon to less constrained in the early afternoon and night. In contrast, task-unrelated thoughts increased throughout the day.

As with Mills et al. (2018) and O’Neill et al. (2020), Kam et al. (2021) investigated the separation of thought constraint from task relatedness by examining responses to thought probes during a sustained attention task. Thought probes were presented at the end of each block of a task that required participants to indicate whether a left or right arrow was presented by pressing right or left arrow keys. The probes assessed task relatedness, if thoughts were freely moving (i.e., unconstrained), if thoughts were intentionally constrained, and if thoughts were automatically constrained (i.e., constrained due to reasons outside of participant control as with rumination or affective salience).

Kam et al. found results like Mills et al. (2018) and O’Neill et al. (2020) in that task-unrelated thought and unconstrained thoughts occurred at different rates (66% and 47%, respectively), suggesting that the thought probes indexed separable dimensions of thought. Kam et al. found a correlation between thought constraint and task relatedness (by testing the mean of intraindividual correlations against zero; $r_{\text{rm}} = 0.51$, $Z = 4.29$, $p < .001$), which was higher than that was reported by Mills et al. 2018 ($r_{\text{rm}} = .24$). In addition, Kam et al. collected concurrent electroencephalogram (EEG) measurements to investigate whether task-unrelated thought and freely-moving thought show different electrophysiological patterns. They found that parietal P3 activation was evident for on- and off-task thoughts, whereas frontal P3 activation was activated for constrained and unconstrained thoughts, suggesting that each respective thought type was indexed in different locations on the brain.

Alperin et al. (2021) investigated the relationship between thought constraint, off-task thought, and ADHD by administering thought probes during a sustained attention task while taking EEG measurements. For reference, more complex EEG measurements indicate increased brain activity in that particular area. As with the studies described above (Kam et al., 2021; Mills et al., 2018, 2021; O'Neill et al., 2020), off-task thought was described as either freely moving (roughly 70% of the time) or constrained (roughly 30% of the time). EEG complexity was positively associated with the percentage of time participants engaged in off-task thought (β = 0.28, $p = 0.02$) *and in* freely-moving thought (β = 0.29, $p = 0.01$). Alperin et al. noted that it was difficult to ascertain if EEG complexity captured pure measures of either task relatedness or thought constraint, given the relatively high degree of overlap.

Individual Differences Within Thought Constraint and Task Relatedness

Thought constraint has not yet been established as a stable individual difference; however, emerging evidence suggests it may be. For example, O'Neill et al. (2020) reported that freely-moving thoughts remain stable over time, whereas the incidence of task-unrelated thoughts rises and falls based on task demand. O'Neill et al. results suggest that thought constraint may be less contextually influenced than task relatedness and thus more trait-like. Via an experience sampling study, Smith et al. (2018) also reported that levels of thought constraint exhibited a predictable pattern throughout the course of the day, regardless of other potential contextual influences (e.g., where the participant was or what they were doing while responding to thought probes).

Task-unrelated thought has been established as a stable individual difference variable. People who report increased task-unrelated thought do so reliably and predictably across multiple contexts (e.g., Kane et al., 2007; Kane et al., 2016; McVay & Kane, 2009; McVay & Kane, 2012b; Mrazek et al., 2012; Randall et al., 2014; Robison et al., 2020). Moreover, task-unrelated thought has been shown to systematically covary with other individual difference variables. For example, task-unrelated thought is negatively associated with working memory capacity (Kane et al., 2007; McVay & Kane, 2009; McVay & Kane, 2012b; Randall et al., 2014). When people try to concentrate, those with lower working memory capacities tend to experience task-unrelated thought at greater rates than those with higher working memory capacities. Finally, there is some evidence that individuals who score higher on neuroticism measures exhibit more task-unrelated thought reports, though these results are not consistent between the laboratory and real-life settings (Kane et al., 2017; Robison et al., 2017).

Individual Differences in Thought Constraint and Task Relatedness Within Psychological Disorders

Depression

Christoff et al. (2016) characterized depressive disorders as having automatic, affective, and excessive constraints on thought (as opposed to being freely-moving). The hypothesis that depression is associated with excessive thought constraint may be best understood by examining the ruminative processes that often accompany depression. Rumination is the tendency for one to perseverate on negative thoughts and feelings (Fell, 2018). Since Christoff et al. (2016) initially hypothesized the association between thought constraint, depression, and rumination, only one study has explicitly examined thought constraint and its association with depressive symptoms (Smith et al., 2022). In Smith et al. (2022), participants responded to thought probes embedded within a sustained attention task (i.e., a 2-back task). Thought probes assessed task relatedness, intentionality, and thought constraint. Following the 2-back task, participants completed the Depression, Anxiety, and Stress Scale (DASS-21; Lovibond & Lovibond, 1995). Smith et al. (2022) failed to find a statistically significant association between depressive symptoms and freely-moving thought (r = .04, p = .57, N = 224); however, they did not assess the association between rumination and thought constraint, as the DASS-21 does not include items that assess rumination. Accordingly, Smith et al. suggested that future work should investigate the relationship between thought constraint and rumination, consistent with the original suggestion made by Christoff et al. (2016).

People experiencing depressive symptoms have increased task-unrelated thought rates relative to those not experiencing depressive symptoms (Deng et al., 2014; Hoffman et al., 2016; Marchetti et al., 2018; Smallwood et al., 2007; Smallwood et al., 2009). Moreover, individuals indicating low mood or depressive symptomatology report more self- and past-related thoughts and rate themselves as being more off-task than their non-depressed counterparts (Hoffman et al., 2016; Marcusson-Clavertz et al., 2020; Robison et al., 2020; Smallwood et al., 2009). Induction of negative mood can also negatively impact performance on measures of sustained attention and affect one's ability to re-engage with the task after experiencing off-task thoughts (Smallwood et al., 2009). It appears that negative mood significantly increases one's vulnerability to task-unrelated thought; however, there has not yet been any support for the claim that depressive symptomatology or ruminative tendencies associates with thought constraint.

Mills et al. (2021) conducted two separate experience sampling studies to examine whether off-task thought and freely-moving thought is distinct regarding their affective correlates (i.e., arousal and valence). In line with previous research and the Dynamic Framework, task-unrelated thought was negatively associated with affective valence (i.e., those with increased off-task thought indicated more negative affect; Christoff et al., 2016; Deng et al., 2014; Hoffman et al., 2018; Killingsworth & Gilbert, 2010; Marchetti et al., 2018; Smallwood et al., 2007; Smallwood et al., 2009). In contrast, unconstrained thought (i.e., freely moving thought) was positively associated with affective valence (i.e., those with higher reports of unconstrained thought indicated more positive affect). Regarding arousal, results were mixed in that unconstrained thought was positively associated with arousal, and task-unrelated thought was not associated with arousal in Study 1; however, in Study 2, the results were the opposite.

Anxiety

Christoff et al. (2016) predicted that people with anxiety have excessively constrained thoughts, such as excessive worry and repetitive negative thoughts. Smith et al. failed to find a statistically significant association (r = .10, p = .15, N = 224) between thought constraint and anxiety (measured by the DASS-21; Lovibond & Lovibond, 1995).

Task-unrelated thought reports are positively associated with increased anxiety levels (Figueiredo et al., 2020; Kane et al., 2007; Mowlem et al., 2019; Robison et al., 2017; Seli et al., 2019). This relationship between anxiety and task-unrelated thought has been demonstrated in an experimental setting where participants' worries were cued and led to an increased rate of task-unrelated thought, (McVay & Kane, 2013), in daily life studies (e.g., Kane et al., 2007; McVay et al., 2009), and in correlational designs within the laboratory (e.g., Figueiredo et al., 2020; McVay et al., 2009; Mowlem et al., 2019; Robison et al., 2017; Seli et al., 2019).

Attention-Deficit/Hyperactivity Disorder

Christoff et al. (2016) characterize attention-deficit/hyperactivity disorder (ADHD) as a disorder that has "excessive variability of thought" (i.e., thoughts are highly unconstrained; Christoff et al. did not make specific claims related to the inattentive or hyperactive subtype; p. 9). Namely, individuals with ADHD may have thoughts that bounce between different topics, goals, and states. When considering the diagnostic characteristics of ADHD (e.g., easily distracted, often forgetful, dislikes tasks that require sustained mental effort), the prediction of excessive thought variability is reasonable (American Psychiatric Association, 2022). However, Smith et al. (2022) did not find a statistically significant positive association between freely-moving thought and scores on the Short-Form of the Adult Self-Report ADHD Scale (Kessler et al. 2005; $r = .09$, $p = .19$, $N = 224$). Although the Short-Form of the Adult Self-Report ADHD Scale is a valid and sensitive measure to screen for ADHD symptoms (Adler et al., 2006; Kessler et al., 2005; Matza et al., 2011), the scale consists of only six items which yield an overall combined score of inattention and hyperactivity. Because the Short-Form of the Adult Self-Report ADHD Scale does not have separate inattention or hyperactivity measures, Smith et al. could not assess the association between thought constraint and inattention.

Alperin et al. (2021) examined off-task thought and thought constraint rates in individuals who met the criteria for ADHD and their non-clinical counterparts. Alperin et al. found that people with ADHD endorsed unconstrained thoughts more frequently than controls via thought reports during a sustained attention task ([$F1,38$] = 71.50, $p < 0.001$, $d = 5.86$] and [$F1,35$] = 8.67, $p = 0.006$, $d = 2.71$, respectively). As with Smith et al. (2022), results were not calculated separately for inattention or hyperactive symptoms. Alperin et al.'s results (2021) are consistent with Christoff et al. (2016)'s claim that ADHD symptomology is positively associated with freely-moving thoughts.

People who endorse more ADHD symptoms report task-unrelated thoughts more frequently than those who endorse less ADHD symptoms (e.g., Alperin et al., 2021; Franklin et al., 2017; Lanier et al., 2019; Meier, 2020; Seli et al., 2015c). Excessive off-task thought (as measured by the Mind Excessively Wandering Scale; Mowlem et al., 2019) also positively correlate with inattention ($r = 0.77$; $N = 108$) and hyperactivity ($r = 0.69$; $N = 108$), as well as the severity and overall impairment attributed to the ADHD symptoms ($r = 0.81$; $N = 108$; Mowlem et al., 2019).

Thought Constraint and Task Performance

The relationship between thought constraint and attention task performance has been examined by two studies (Kam et al., 2021; Smith et al., 2022). Smith et al. conducted a study in which they administered a 2-back task to participants, where participants were presented with a series of letters and instructed to press the spacebar whenever the letter on the screen matched the letter presented two trials ago. During this task, participants were presented with thought probes that assessed task relatedness, intentionality of task-unrelated thoughts (i.e., unintentional or deliberate), and thought constraint. Performance on the 2-back task, as measured by d' (discrimination between target and non-target stimuli), was significantly worse for participants who reported more unconstrained thoughts (r = -.26, p < .001). In other words, there was a negative relationship between thought constraint and performance on the 2-back task, such that participants who had more difficulty controlling their thoughts performed worse on the task.

Kam et al. (2021) investigated thought constraint and task performance by investigating mean response accuracy, mean response time, and mean response time variability during a simple sustained attention task (i.e., participants press either a right or left arrow on the keyboard when they saw a right or left arrow on the computer screen). After adjusting for multiple comparisons (i.e., Bonferroni correction), Kam et al. reported no statistically significant differences between thought type (i.e., thought constraint or task relatedness) and mean response accuracy or mean response time. They did, however, find increased reaction time variability during periods of task-unrelated thoughts (M = 161ms) when compared to task-related thoughts (M = 114ms). Additionally, there was more reaction time variability during periods of freely-moving thought (M = 162ms) than during constrained periods (M = 119ms).

Task Relatedness and Task Performance

The relationship between one's ability to stay on-task and task performance is evident in various contexts. People with more task-unrelated thoughts than others perform worse overall on tasks of sustained attention (e.g., Cheyne et al., 2009; Mooneyham & Schooler, 2013; Randall et al., 2014; Thomson et al., 2014; Unsworth & McMillan, 2013). The detrimental effects of task-unrelated thoughts on task performance are evident at the aggregate level (when considering all trials combined) and at the trial level (McVay & Kane, 2009; McVay & Kane, 2012a, McVay et al., 2013). Specifically, trial response times preceding task-unrelated thoughts are more variable than trials preceding on-task reports. People with a greater propensity for task-unrelated thought tend to commit more errors (Cheyne et al., 2009; Manly et al., 1999; McVay & Kane, 2009; Mooneyham & Schooler, 2013). Not only is evidence for the association between off-task thought and task performance found in laboratory settings, but in everyday life tasks. Higher rates of off-task thought associate with poorer reading comprehension, difficulty inhibiting distractions and persisting towards a goal, memory failures, and lower Scholastic Aptitude Test scores (Kane et al., 2007; Kane & McVay, 2012; McVay et al., 2009; Mrazek et al., 2012; Unsworth et al., 2012).

CHAPTER TWO: THE CURRENT STUDY

Thought constraint as a unique thought characteristic is in the early stages of investigation since its introduction by Christoff et al. (2016). So far, the evidence suggests that task relatedness and thought constraint are separable dimensions of thought (Alperin et al., 2021; Kam et al., 2021; Mills et al., 2018; Mills et al., 2021; O'Neill et al., 2020, Smith et al., 2018). There is some evidence suggesting that thought constraint is less influenced by task demands than task-unrelated thought (O'Neill et al., 2020), and the results regarding the associations between thought constraint and psychological disorders are mixed (Alperin et al., 2021; Mills et al., 2021; Smith et al., 2022).

Here, I explored the frequency and potential unique behavior patterns of task-unrelated thought and thought constraint (as in Mills et al., 2018 and O'Neill et al., 2020), the rank-order stability of thought constraint as an individual differences variable across two different tasks with embedded thought probes, the relations between thought constraint and various psychological disorders (as in Alperin et al., 2021, Mills et al., 2021, and Smith et al., 2022), and the relationship between thought constraint and task performance (as in Kam et al., 2021 and Smith et al., 2022). Overall, this study aimed to empirically assess thought constraint's potential as an illuminating individual difference construct.

Method

This study was preregistered on February 6th, 2020 (https://osf.io/74e92?view_only=f88092516b4d494d92ad5dfaf93226c9). Data collection began on February 6th, 2020 and concluded on November 24th, 2020. Data collection moved from in-person to online in April 2020 and stayed online through November 2020 due to the COVID-19 pandemic.

Transitioning from In-Person to Online Data Collection

Often studies of individual differences are conducted in the laboratory to minimize confounds such as distractions, cheating, sleeping, cell phone use, and other behaviors that may negatively impact data integrity. Although it was impossible to control for the context or behaviors of online subjects in the current study, exclusion criteria were used to ensure data integrity. As specified in the preregistration, I excluded participants' data from all analyses if they did not respond to at least 10% of the Metronome Response Task trials (MRT; Seli et al., 2013a), or if their Sustained Attention to Response Task (SART; Robertson et al., 1997) nontarget response time variability or d' was more than three times the interquartile range away from the upper or lower hinges of a boxplot. I used these exclusions for data collected in the lab and online (boxplots of SART data were done separately for online and in-the-lab participants).

To further reduce measurement error, I applied additional exclusions to the dataset, which were not included in the original preregistration as it was unknown that data collection would move online. Accordingly, I used the response times to probes to screen data from subjects who participated online. I dropped any subject from all analyses with a single probe response time of over five minutes. I scored any probe response that took over 15 seconds as missing data. I dropped from all analyses subjects who did not have at least 6 valid (less than 15 seconds) probe responses for either the MRT or SART task. As with the MRT, I dropped participants from all analyses if they did not respond to at least 10% of the trials during the SART.

My study is not the first to use an online platform to study individual differences in sustained attention. Seli et al. (2013b) investigated how MRT data collected online compared to

MRT laboratory data and found similar mind-wandering rates. Other experiments that measure response times and aspects of cognition have also found that data collected online is comparable to that from the laboratory (Chetverikov & Upravitelev, 2016; Finley & Penningroth, 2015; Germine et al., 2012).

Questionnaire data obtained online is generally consistent with data collected within a laboratory (Clifford & Jerit, 2014; Weigold et al., 2013). Of particular concern would be one's propensity to engage in socially desirable responding within the laboratory or lackadaisical responding outside the lab. Clifford and Jerit (2014) found no significant differences between groups who completed self-report questionnaires within the laboratory versus an online setting regarding social desirability and attention paid to items. Similarly, Weigold et al. (2013) found general equivalence between in-person and online data collection, even when controlling for experimenter contact, and no differences between completion time and comfort with completing the lab and online collection measures. Although certain variables are outside our control when using online data collection methods, the quality of data obtained online should be like that of data collected in-person.

Participants

From February 2020 to March 2020, I recruited participants from the Western Carolina University Department of Psychology subject pool to participate in the lab. Data collection moved entirely online from April to May 2020, with only Duke University students as participants. Participation resumed online for Western Carolina University and Duke University students from September 2020 through November 2020. At Western Carolina University, advertised eligibility criteria for participation were being within the age range of 18-30, being fluent English speakers, and having no serious visual or hearing impairments; Duke University did not advertise any eligibility criteria. All participants were undergraduate students enrolled in an introductory course for psychology and received partial credit toward a class requirement for their participation. I preregistered to stop collecting data at the end of a semester in which I collected data from at least 250 subjects (i.e., fall semester 2020). I chose a sample size of at least 250 participants based on previous research that demonstrated that correlations as weak as $\rho = .10$ stabilize within a narrow window when sample sizes approach that number (Schönbrodt & Perugini, 2013).

Prior to applying exclusion criteria (outlined below), 627 participants completed informed consent. After exclusions, 59 participants from Duke University and 386 from Western Carolina University were included in the final sample (N = 445). Ninety-five participated in the lab, and 350 participated online. Of these 445 participants, 178 were male, and 264 were female; two people did not disclose their gender, and one person provided an erroneous response. The mean age of the sample was 18 (*SD* = 1). Of those who provided information about their race (three participants declined, and one erroneously responded), 341 identified as white, 21 identified as Asian, 40 identified as Black, one identified as Native American, 19 identified as Hawaiian Native, eight identified as multiracial, and 11 identified as other.

General Procedure

In-Person Laboratory Sessions

Laboratory sessions had either one or two participants and lasted approximately 90 minutes. A research assistant was present for each session. The research assistant read instructions for each measure aloud as the participants read along and answered any questions participants had. After obtaining informed consent, all participants completed tasks in the following order: Operation Complex Span (Unsworth et al., 2005), the Sustained Attention to

Response Task (Robertson et al., 1997), the Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991), the ADHD Self-Report Questionnaire (DuPaul et al., 1998), Symmetry Complex Span (Kane et al., 2004), the State-Trait Anxiety Inventory for Adults (Spielberger, 1983), the Mind Excessively Wandering Scale (Mowlem et al., 2019), the Beck Depression Inventory (Beck et al., 1996), the Metronome Response Task (Seli et al., 2013a), and then a brief demographics questionnaire. Data obtained from the Mind Excessively Wandering Scale was collected for exploratory purposes and was not used in the current study (see Appendix I) for a description of this measure). All tasks were computerized and administered on desktop computers using E-Prime software (Psychology Software Tools, Pittsburg, PA).

Online Sessions

Participants completed the tasks on a laptop or desktop computer (they could not complete the study on a tablet or cell phone). The tasks were programmed in JavaScript/HTML/CSS. Because of the move to online testing, I dropped the operation complex span and the symmetry complex span tasks due to validity concerns (e.g., using a calculator for math tasks or writing down items meant to be held within one's working memory). Because of this, I did not use data from the complex span tasks in this study. The operation and symmetry span tasks are described in Appendix A and Appendix B, respectively.

Measures

Sustained Attention Tasks

Sustained Attention to Response Task (Appendix C)

The SART is a go/no go task where participants are instructed to withhold responses to a specific target and to respond to all nontargets by quickly hitting the spacebar (Robertson et al., 1997). In this version of the task, participants were instructed to hit the spacebar when the name of an animal (the nontarget stimulus) appeared (e.g., amphibians, fish, bugs; 89% of trials), but not when they were presented with the name of a vegetable (the target stimulus; 11% of trials). The SART consisted of 540 trials, divided into 4 blocks, each containing 3 mini-blocks of 45 trials. During each mini-block, 40 target stimuli (vegetables) and 5 nontarget stimuli (animals) appeared. Each word was presented for 300ms immediately followed by a masking procedure (i.e., a blank screen with "xxx" in the center), for 1500ms. The dependent measures for this task are *d*' (the rate of response to nontarget stimulus minus false alarm responses to the target stimulus), and the standard deviation of reaction times to the animal trials (e.g., nontarget/"go"). To become oriented with the task, participants engaged in a brief practice round where they withheld responses to girls' names (the target stimulus) and were instructed to hit the space bar for boys' names only (the nontarget stimulus). Following the practice SART task, participants were made familiar with the thought probes they would encounter throughout the task.

Participants were instructed to respond to the following probes (Appendix D): "Was your mind moving about freely?" Responses included 1) *Not at all,* 2) *Somewhat,* 3) *Very much,* 4) *I don't know*. I modified these probes from the probes described by Mills et al. (2018), where the participants responded to a scale from 1) *Not at all* to 7) *Very much* (and items 2-6 did not have labels). Here, I simplified the scale and added labels to each numerical anchor. I also added the option of "*I don't know*" to our thought constraint probe.

Previous studies examining thought constraint via probes either had participants respond on a seven-point Likert-type scale (Mills et al., 2018) or make a dichotomous judgment about whether their thoughts were freely moving (O'Neill et al., 2020; Smith et al., 2022). These studies presume that subjects can accurately (and easily) assess this attribute of thought. The "*I don't know*" response allowed for the assessment of the epistemic certainty of these judgments.

Smith et al. (2022) hypothesized that a potential reason for not finding associations between thought constraint and various psychological disorder symptomologies may be that participants had difficulty operationalizing and accurately reporting if their thoughts were freely moving (i.e., the thought probes were not valid thought constraint measures). Here, providing participants with an option of "*I don't know*" had the potential to provide a more accurate measurement of thought constraint by eliminating guessing.

After reporting on if their mind was moving about freely, participants were asked "What were you just thinking about?" and response options included: "1) *The task*, 2) *Task experience/performance*, 3) *Everyday things*, 4) *Current state of being*, 5) *Personal worries*, 6) *Daydreams*, 7) *External environment*, 8) *Other*. Participants were then asked, "Were your thoughts shifting amongst multiple topics?" with response options: 1) *Yes*, 2) *No*, 3) *I don't know*. Finally, participants were asked, "Were you effortfully concentrating on your thoughts?" Responses were: 1) *Yes*, 2) *No*, 3) *I don't know*. Data about thought shifting and effortfulness in concentration is part of a larger project and were not analyzed in this study. The SART task lasted approximately 20 minutes. Nine probes were presented per block, with three probes occurring per mini-block (for a total of 36 probes). The probes appeared pseudorandomly after three out of five target words were presented per mini-block. Definitions of each response option to the thought probes provided to participants are in Appendix E.

Metronome Response Task (Figure 13)

The MRT presented thought probes during a continuous task (Seli et al., 2013a). Specifically, participants pressed the spacebar in sync with a metronome tone at the rate of one tone every 1,300ms. Participants were instructed to keep their eyes open and focus on a single target on a black screen. Participants completed 18 blocks of 50 trials (these blocks are not apparent to participants) for a total of 900 trials. Throughout the task, participants responded to 18 thought probes presented pseudorandomly within the middle 40 trials of each 50-trial block (Seli, 2013a). Participants responded to the identical thought probes used in the SART and were asked to follow the same instructions (Figure 13). This task lasted for approximately 20 minutes. Response time variability was the dependent measure. Response times were the difference in the timing of the presentation of the tone and the spacebar press.

Questionnaires

Ruminative Response Scale (Appendix F)

The Ruminative Response Scale is a 22-item scale measuring ruminative response styles (Nolen-Hoeksema & Morrow, 1991). The scale includes items that focused on one's distress, the causes, and the consequences of distress (Nolen-Hoeksema & Morrow, 1991). Responses range from 1) *Almost never*, 2) *Sometimes*, 3) *Often*, 4) *Almost always*. Scores were summed for an overall score, with higher scores indicating higher reports of rumination. Internal consistency ranges are solid, ranging from .99 to .92 (Treynor et al., 2003).

ADHD Self-Report Scale (Appendix G)

Participants completed the ADHD Self-Report Scale (DuPaul et al., 1998), which assesses each inattentive and hyperactive symptom listed with the DSM-IV-TR criteria for ADHD. This scale has separate inattention and hyperactivity measures, allowing for explicit analyses regarding the relationship of inattentive vs. hyperactive subtypes. Response options included 1) *Never or rarely*, 2) *Sometimes*, 3) *Often*, 4) *Very often*. Scores are summed for an overall score, with higher scores indicating higher levels of ADHD symptomology. Strong internal consistency ($\alpha = .9$), and adequate test-retest reliability (.85 over 4 weeks; DuPaul et al., 1998) have been reported for this measure.

State-Trait Anxiety Inventory for Adults (Appendix H)

Participants also completed the 40-item State-Trait Anxiety Inventory for Adults (STAI; Spielberger, 1983). The measure contains two subscales, with 20 items each: State Anxiety and Trait Anxiety. The State Anxiety subscale measures the anxiety levels experienced by participants when completing the questionnaire. The Trait Anxiety subscale measures their general anxiety levels or general predisposition to anxiety. Subscales were scored separately, with higher scores indicating higher levels of anxiety. For this measure, reports of test-retest reliability estimates have ranged from .65 to .75, and internal consistency has been reported with the range of α = .86 to .95 (Spielberger, 1983).

Beck Depression Inventory – Second Edition (Appendix J)

The Beck Depression Inventory–II is a 21-item scale that assesses for depression (Beck et al., 1996). For this study, I excluded the suicidality item, making it a 20-item scale. The Beck Depression Inventory – II has shown strong internal consistency (α = .91) and test-retest reliability (r = .73 to .96; Wang & Gorenstein, 2013). For the in-person data collected between February and March 2020, the item that assessed for agitation was omitted by experimenter error, making it a 19-item scale. I later included this item in data collected online, to make it a 20-item scale. Because of the item omission, scores for this measure were based on the 19 items provided to all people.

CHAPTER THREE: RESULTS

Most analyses and exclusions were pre-registered before the start of data collection (https://osf.io/74e92?view_only=f88092516b4d494d92ad5dfaf93226c9). Subsequent changes to exclusionary criteria and analyses were made due to the transition to online data collection and were included in this study's proposal, which took place in February 2021 and before any data analysis. Unless otherwise noted, analyses were conducted using IBM SPSS Statistics (Version 28.0.1) predictive analytics software. Bayes Factors, 95% confidence intervals for correlations, and figures were done with JASP (2022).

Data Loss

Before data analysis, I conducted all exclusions as outlined in the pre-registration. Because of the lack of experimental control in the online sessions, I added additional exclusions to limit the influence of uncontrollable factors on the data (i.e., there is no way of knowing if participants fell asleep, watched videos, used their phones, etc. while completing the study). I decided (before any inferential tests) to code individual probe responses that took over 15 seconds as missing data. These long responses may indicate that the participant was doing something other than I intended (or would be done by a participant in the lab), resulting in biased retrospective or fallacious probe responses. I dropped participants who did not have at least six valid probe responses (i.e., responses less than 15 seconds) from all analyses. Additionally, I dropped participants who took over 5 minutes responding to any given probe from all analyses. As with the MRT, I excluded participants who did not respond to at least 10% of responses in the SART to reduce error variance.

I applied all exclusion criteria separately for online and in-the-lab participants and the SART and MRT. One hundred and eight participants were dropped from the online SART data, and nine were dropped from in-the-lab SART data (a loss of 117 participants). After combining the remaining lab and online participants, I had 507 participants with complete SART data. One hundred and twelve participants were dropped from the online MRT data, and two were dropped from in-the-lab MRT data (a total loss of 114 participants). After combining the remaining lab and online participants, I had 509 participants with complete MRT data.

Per the preregistration, I retained participants if they had *both* SART and MRT data. After applying this criterion, 445 subjects remained and were used for the following analyses. I used the maximum amount of data possible for all analyses; thus, Ns differ depending on the measure and modality. Descriptive statistics and correlations for all variables can be seen below in Table 1 and Table 2 below.

Table 1

Descriptive Statistics

Measure	N	Mean	Std. Deviation	Minimum	Maximum	Skewness	Kurtosis
SART Task Relatedness	444	0.57	0.27	0.00	1.00	-0.38	-0.59
SART Thought Constraint	445	0.92	0.40	0.00	2.00	0.03	-0.27
MRT Task Relatedness	444	0.77	0.28	0.00	1.00	-1.37	0.88
MRT Thought Constraint	445	1.30	0.56	0.00	2.00	-0.65	-0.55
SART RTSD	445	175.23	74.38	59.64	498.23	1.62	3.07
SART d'	445	1.70	1.09	-2.54	4.10	-0.14	-0.58
MRT LogV	445	10.90	1.37	7.11	12.66	-0.59	-0.90
ADHD: Combined	445	20.49	11.34	0.00	54.00	0.62	-0.08
ADHD: Inattentive	445	10.88	6.86	0.00	27.00	0.44	-0.75
ADHD: Hyperactive	445	9.61	5.64	0.00	27.00	0.81	0.52
State Anxiety	445	44.33	12.19	20.00	75.00	0.28	-0.59
Trait Anxiety	445	45.68	12.27	20.00	74.00	0.16	-0.72
Rumination	445	49.95	15.52	23.00	87.00	0.30	-0.82
Depression	419	14.37	11.47	0.00	52.00	0.90	0.19

Note: SART = Semantic Sustained Attention to Response Task (Robertson et al., 1997); MRT = Metronome Response Task (Seli et al., 2013a); Thought constraint and task relatedness values are the average of participants' probe responses for each respective thought type (with all *"I don't know*" responses removed); RTSD = response time standard deviation; d' = the rate of response to nontarget stimulus minus false alarm responses to the target stimulus; LogV = log of MRT response time variability; ADHD Combined = sum of all responses on ADHD Self-Report Scale (DuPaul et al., 1998); ADHD Inattentive/ADHD Hyperactive = sum of responses on each subscale of ADHD Self-Report Scale, respectively (DuPaul et al., 1998); State/Trait Anxiety =

sum of items on each subscale of State-Trait Anxiety Inventory (Spielberger, 1983); Rumination = sum of all items on Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991); Depression = sum of BDI measure with 19 items (Beck et al., 1996).

Table 2

Correlations

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. SART Task Relatedness	--													
2. SART Thought Constraint	0.64	--												
3. MRT Task Relatedness	0.45	0.29	--											
4. MRT Thought Constraint	0.31	0.41	0.73	--										
5. SART RTSD	0.11	0.11	-0.04	-0.11	--									
6. SART d'	-0.10	-0.09	0.08	0.10	-0.45	--								
7. MRT LogV	0.08	0.09	-0.08	-0.04	0.16	-0.15	--							
8. ADHD: Combined	0.08	0.15	0.06	0.07	0.00	-0.08	0.10	--						
9. ADHD: Inattentive	0.06	0.13	0.09	0.11	-0.02	-0.05	0.11	0.93	--					
10. ADHD: Hyperactive	0.09	0.14	0.00	0.01	0.02	-0.11	0.07	0.89	0.64	--				
11. State Anxiety	0.10	0.13	0.08	0.05	-0.04	-0.06	0.09	0.52	0.53	0.41	--			
12. Trait Anxiety	0.09	0.10	0.09	0.06	-0.09	-0.03	0.02	0.58	0.62	0.41	0.78	--		
13. Rumination	0.11	0.13	0.06	0.06	-0.11	0.03	0.07	0.61	0.62	0.46	0.64	0.77	--	
14. Depression	0.07	0.12	0.09	0.09	-0.09	-0.04	0.05	0.60	0.62	0.45	0.70	0.84	0.76	--

Measuring Thought Constraint

In accordance with the preregistration, I coded the thought constraint variable in two ways: one version with "*I don't know*" removed from only the numerator, and one version with *"I don't know"* removed from both the numerator and the denominator. If the two variables correlated >.90, I originally committed to using the scores where "*I don't know"* was removed only from the numerator. For the SART, the two variables were correlated $r(505) = .94$. For the MRT, the two variables correlated $r(506) = .92$. After further consideration of the *"I don't know"* variable, I decided to remove all *"I don't know"* responses from both the numerator and the denominator, which is a departure from the preregistration and prospectus. To illustrate the rationale for this decision, when removing "*I don't know*" from only the numerator, participants' aggregated thought constraint responses actually appeared more constrained (i.e., less freely moving), even though there was clearly some endorsement of uncertainty via the "*I don't know"* response. Removing the response entirely allowed for more accurate measurement of thought constraint, which is particularly important given existing concerns with its measurement (Kane et al., 2021; Smith et al., 2021). Thus, participants' scores for the thought constraint variable were aggregated across all probes for a singular score (ranging from 0-2). See Appendix K for additional details and descriptive statistics for the "*I don't know*" response. Due to the limited endorsement of the "*I don't know"* option, no additional exploratory analyses with this variable were conducted.

Addressing Modality and Bayes Factors

Data collection moved from in-person to online due to the COVID-19 pandemic in March 2020. To assess whether modality influenced the association between thought type and outcome variables, I conducted linear mixed models to determine whether the combined participant pool (i.e., data collected online *and* in-person) or only the online participant pool should be used in bivariate correlations. I included parameters for modality and modality by thought interaction in each model. These linear mixed models were not pre-registered as the transition to the online modality was unforeseen.

In addition to null-hypothesis significance testing, I calculated Bayes Factors (BF) for each correlation to determine if the associations were more consistent with either the null or the alternative hypothesis. Accordingly, BF that are less than one support the null (i.e., nill) hypothesis; BF from one to three suggests anecdotal evidence; BF greater than three suggests solid evidence.

Associating Thought Constraint and Task Relatedness

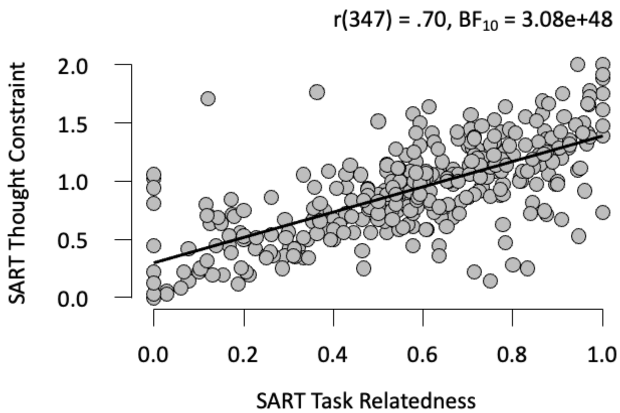
To estimate the association between thought constraint and task relatedness, I used a linear model with task relatedness as the predictor variable and thought constraint as the outcome variable. I conducted separate models for thought reports collected via the SART and the MRT. In the first model, SART task relatedness was significantly associated with SART thought constraint (b = .68, $t = 5.50$, $p < .001$). Modality was also significantly associated with thought constraint (b = -.24, $t = -2.78$, $p = .01$), signifying that data collected online is associated with more constrained (i.e., less freely-moving) thought reports. The interaction between modality and SART task relatedness was significant (b = .41, $t = 2.95$, $p = .003$), meaning off-task thought is more strongly associated with freely-moving thought in the online modality compared to the lab.

Thus, I used the online sample for the following interindividual correlation. Consistent with, but much stronger than, the interindividual correlation found by Mills et al. (2018; $r = .16$), people who reported being off-task were more likely to report freely-moving thought (i.e., less constrained thought), *r*(347) = .70, *p* <.001, 95% *Confidence Interval (CI)*[.64, .75], BF_{10} = 3.08e+48 (see Figure 1). I also computed the means of intraindividual correlations between thought constraint and task relatedness. A repeated measures correlation is the most appropriate analysis when comparing paired measures on multiple occasions (i.e., associating thought constraint and task relatedness at the trial level for multiple trials; Bakdash & Marusich, 2017). Thought constraint was coded dichotomously (i.e., either freely-moving or not at all; task-relatedness was also a dichotomous variable, either on- or off-task). Like Kam et al. (2021; r_{rm} = .51), I found the average correlation between thought constraint and task relatedness across participants was strong (r_{rm}[10428] = .61, 95% CI [.60, .62], p < 0.001).

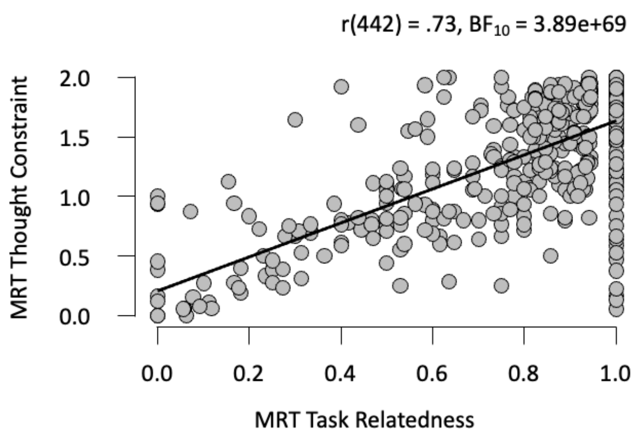
For the MRT, task relatedness was associated with thought constraint (b = 1.67, *t* = 8.79, *p* < .001); however, modality was not (b = .22, *t* = 1.31, *p* = .19). The interaction between modality and task relatedness was not significant (b = -.27, *t* = -1.31, *p* = .19); accordingly, I used the full sample for the interindividual estimate between task relatedness and thought constraint. Consistent with the above findings, higher reports of task-unrelated thought were associated with higher rates of freely-moving thought (i.e., less constrained thought), *r*(442) = .73, *p* < .001, 95% *CI* [.67, .76], BF_{10} = 3.89e+69 (see Figure 1). As with the SART data, an intraindividual correlation was also conducted between thought types. The average correlation across participants was strong, r_{rm}(5619) = .53, 95% CI [.51, .55], p < 0.001, and quite similar to that of Kam et al. (2021). Across both the SART and MRT data, participants in the current study are reporting a substantial number of thoughts that are both off-task and freely-moving.

Figure 1

Correlations Between Thought Constraint and Task Relatedness for SART and MRT



(A)



(B)

Note: (A) Correlation for thought constraint and task relatedness via the SART, (B) correlation for thought constraint and task relatedness via the MRT. The line is the line of best fit. X-axis values represent the average aggregate response per participant on task relatedness probes, and Y-axis values represent the average aggregate response per participant on thought constraint probes for the SART and MRT, respectively.

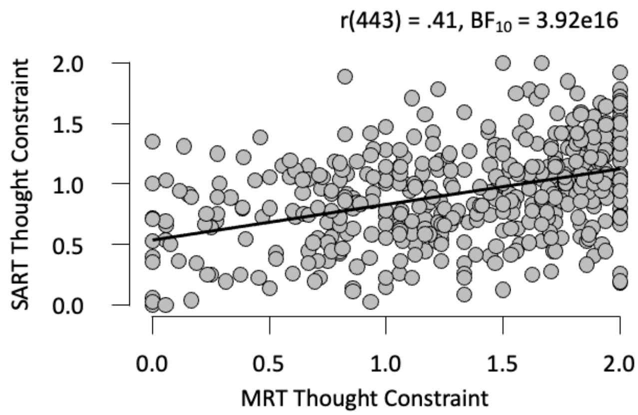
Rank Order Stability of Thought Constraint and Task Relatedness

Before assessing the rank order stability of thought constraint and task relatedness, I conducted two separate linear models to determine if modality was a moderating variable. I included terms for modality, thought type, and the interaction between modality and thought type. MRT thought constraint was significantly associated with SART thought constraint (b = .22, t = 2.71, p = .01). Terms for modality and the interaction between modality and MRT thought constraint were not statistically significant (b = -.08, t = -.63, p = .53 and b = .09, t =1.00, p = .32, respectively), meaning the full sample was used to estimate the association. Consistent with previous research suggesting that thought constraint is a stable individual differences variable (O'Neill et al., 2020), thought constraint was strongly correlated across the MRT and the SART $r(443) = .41$, $p < .001$, 95% *CI* [.33, .48], BF_{10} = 3.92e16 (see Figure 2).

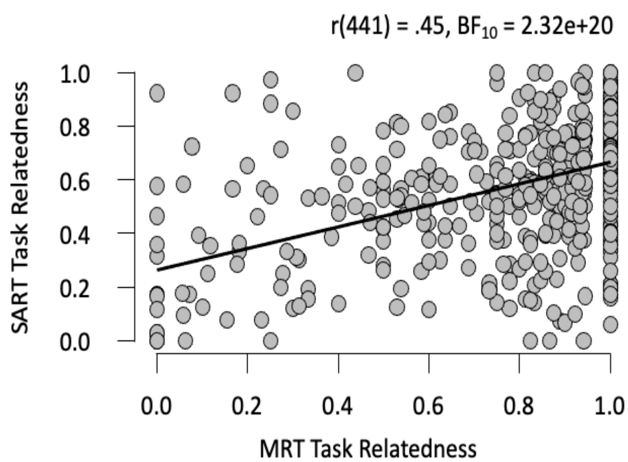
Task relatedness measured by the MRT was significantly associated with SART task relatedness (b = .27, t = 3.50, $p < .001$). The interaction between modality and MRT task relatedness was not significant (b = .16, t = 1.37, p = .17). Modality alone was also not significantly associated with SART task relatedness (b = -.08, t = -.76, p = .45). Using the full sample, task relatedness was strongly correlated across the MRT and the SART $r(441) = .45$, $p < .001$, 95% *CI* [.37, .52], BF_{10} = 2.32e+20, (see Figure 2). This finding is consistent with previous research that has demonstrated task relatedness as a stable individual difference (Kane et al., 2007; McVay & Kane, 2009; Randall et al., 2014; Robison et al., 2020). To test for a significant difference between thought constraint stability and task relatedness stability, I tested the correlations against each other using Cohen and Cohen (1983)'s formula via a calculator provided by Preacher (2002; http://quantpsy.org/corrtest/corrtest.htm). The stability of task relatedness and thought constraint were not significantly different from one another (Z = -.73, *p* = .47).

Figure 2

Rank Order Stability of Thought Constraint and Task Relatedness



(A)



(B)

Note. (A) rank-order stability of thought constraint. X and Y-axes represent the average of thought constraint probe responses per person for the MRT and SART, respectively. (B) rank-order stability of task relatedness. X and Y-axes are the average of task relatedness probe responses per person for the MRT and SART, respectively.

Thought Constraint, Task Relatedness, and Psychological Disorders

I used linear models and correlations to test the directional predictions from Christoff et al. (2016) for the associations between thought constraint and symptoms of depression, anxiety, rumination, and ADHD. Like previous analyses, the linear models were used to identify whether there was a significant interaction between modality and thought type. Then, after determining whether to use the full or online sample, I conducted correlations between thought type and questionnaire. Finally, I used linear regression models to determine if thought constraint helped explain unique variance above and beyond that of task relatedness in different reports of psychological symptoms. Tests of incremental validity were conducted in instances where there were significant associations between thought type and the self-report questionnaire. In this model, I entered task relatedness in the first step and thought constraint in the second step, with scores of each respective measure of psychological symptoms as the outcome variable. In cases where I used only the online sample for an estimate, I used the online sample for tests of incremental validity. Results for each self-report measure are reported separately for the SART and the MRT.

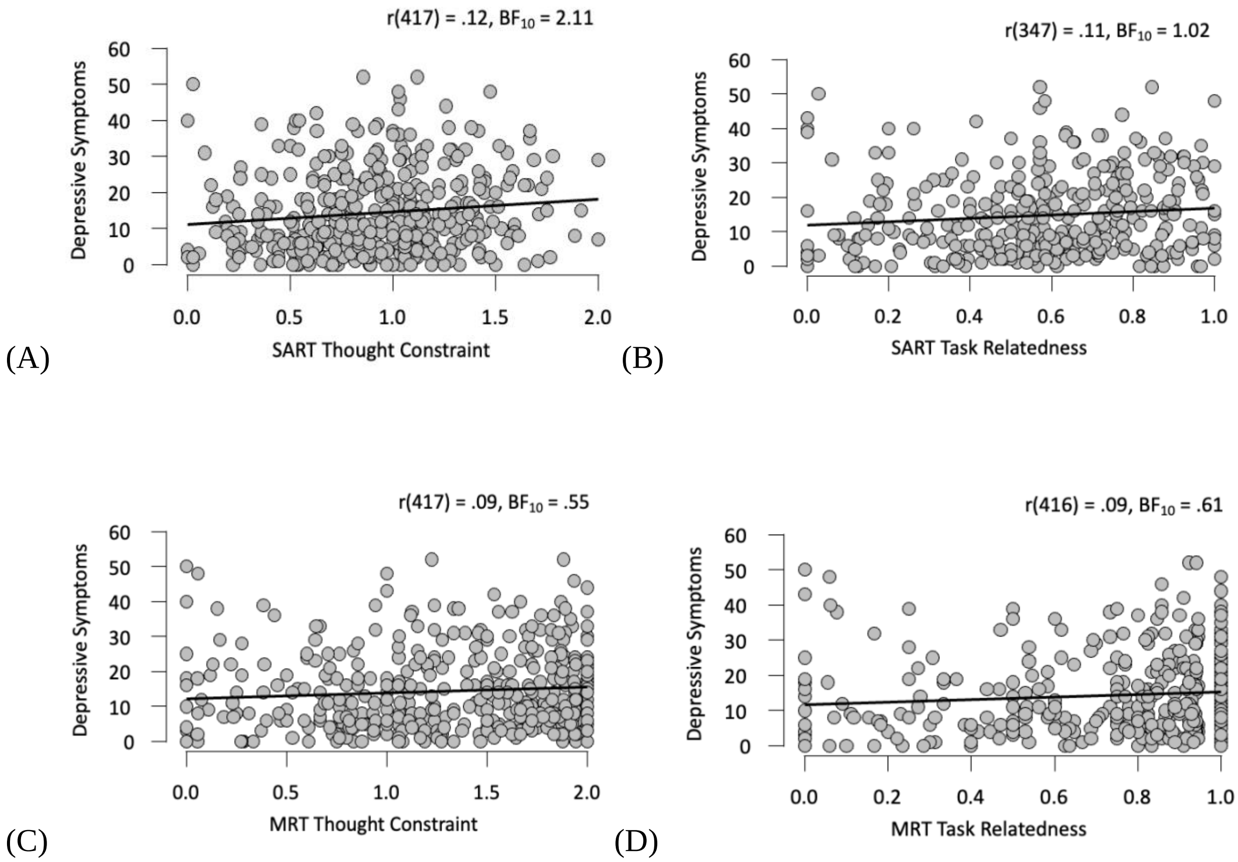
Depression

In separate models, SART thought constraint and SART task relatedness were not significantly associated with scores on the BDI-19 (thought constraint: b = -2.46, t = -.64, p = .53; task relatedness: b = -8.84, t = -1.58, p = .12). Modality was not significantly associated with BDI-19 scores in either model (b = -4.30, t = -1.10, p = .29; b = -5.62, t = 1.57, p = .12). The interaction between SART thought constraint and modality was not statistically significant (b = 6.76, t = 1.62, p = .12). The interaction between SART task relatedness and modality was significant (b = 13.83, t = 2.27, p = .02), meaning that the association between SART task relatedness and BDI-19 scores was stronger for data collected online. Using the full sample to assess the association, higher rates of unconstrained thought reported via the SART weakly correlated with higher reports of depressive symptoms $r(417) = .12$, $p = .02$, 95% *CI* [.02, .21], $BF_{10} = 2.11$ (see Figure 3). Using the online sample, those who were more frequently off-task reported higher rates of depressive symptoms $r(347) = .11$, $p = .04$, 95% *CI* [.01, .21], $BF_{10} = 1.02$ (see Figure 3). The positive association between depressive symptoms and thought constraint is counter to predictions made by Christoff et al. (2016); however, the positive association between task relatedness and depressive symptoms is consistent with previous research (Deng et al., 2014; Hoffman et al., 2016; Marchetti et al., 2018; Smallwood et al., 2007; Smallwood et al., 2009). To further explore the relationship between thought constraint and task relatedness, I conducted a linear regression model with the online sample and found that thought constraint did not explain unique variance above and beyond task relatedness ($R^2\Delta = .01$, $p = .09$).

In separate models, MRT thought constraint (b = 1.54, $t = .54$, $p = .59$) and MRT task relatedness (b = 4.15, $t = .63$, $p = .53$) were not associated with scores on the BDI-19. Modality was also not significantly associated with BDI-19 scores in either model (b = 1.60, $t = .37$, $p = .72$; b = 2.45, $t = .43$, $p = .67$). The interactions between modality and MRT thought constraint (b = .32, $t = .10$, $p = .92$) and MRT task relatedness (b = -.40, $t = -.06$, $p = .95$) were not significant. I used the full sample for the following correlations. MRT thought constraint was not significantly correlated with scores on the BDI-19, $r(417) = .09$, $p = .08$, 95% *CI* [-.01, .18], $BF_{10} = .55$, (see Figure 3). MRT task relatedness was also not significantly associated with the BDI-19, $r(416) = .09$, $p = .07$, 95% *CI* [-.01, .18], $BF_{10} = .61$, (see Figure 3).

Figure 3

Associations Between Thought Constraint, Task Relatedness, and Depression via the SART and MRT



Note. (A) association between thought constraint and depression symptoms via the SART, (B) association between task relatedness and depression symptoms via the SART, (C) association between thought constraint and depression symptoms via the MRT, (D) association between task relatedness and depression symptoms via the MRT. All X-axes represent the average probe response per participant for either the SART or MRT. Y-axes represent total sum score on the depression measure.

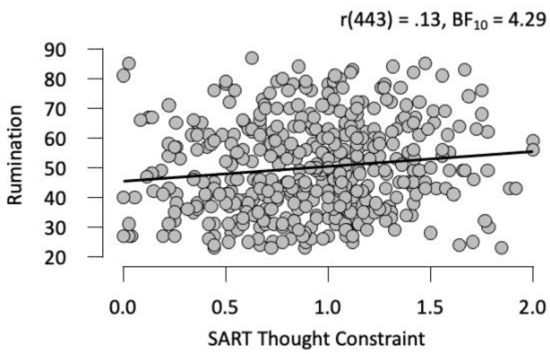
Rumination

Neither SART thought constraint (b = -.81, t = -.20, p = .84) nor SART task relatedness (b = -1.60 t = -.258, p = .80) were significantly associated with rumination scores. Modality was not significantly associated with rumination scores in either model (b = -1.66, t = -.38, p = .71; b = -.82, t = .19, p = .85). I did not find a significant interaction between modality and thought type (SART thought constraint: b = 7.19, t = 1.61, p = .11; SART task relatedness: b = 10.23, t = 1.47, p = .14), leading me to use the combined sample for the following correlations. SART thought constraint was associated with scores on the rumination measure, $r(443) = .13$, p = .01, 95% *CI* [.04, .22], BF_{10} = 4.29, as was SART task relatedness, $r(442) = .11$, p = .02, 95% *CI* [.02, .20], BF_{10} = 1.82, (Figure 4). Consistent with prior work, individuals who reported more rumination and depressive symptoms also endorsed more task-unrelated thought (Deng et al., 2014; Hoffman et al., 2016; Marchetti et al., 2018; Smallwood et al., 2007; Smallwood et al., 2009).When assessing for incremental validity, thought constraint did not account for unique variance above and beyond that of task relatedness ($R^2\Delta$ = .004; p = .17).

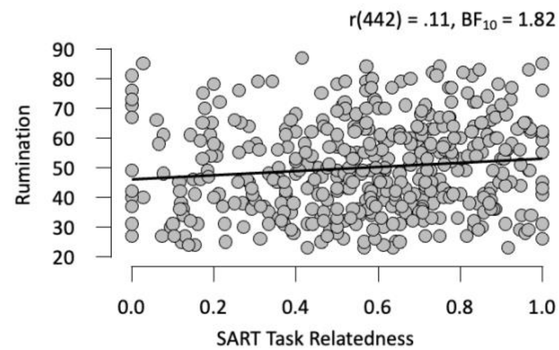
Neither MRT thought constraint nor MRT task relatedness were associated with rumination scores (b = 4.23, t = 1.24, p = .22 and b = 9.00, t = 1.19, p = .24, respectively). In neither model was modality significantly associated with rumination (b = 8.96, t = 1.69, p = .09 and b = 9.78, t = 1.45, p = .15). Because I did not find evidence of an interaction effect between modality and thought type in either model (MRT thought constraint: b = -2.84, t = -.77, p = .44; MRT task relatedness: b = -5.59, t = -.70, p = .49), I used the combined sample for the following correlations. Neither MRT thought constraint nor MRT task relatedness were correlated with rumination ($r(443) = .06$, p = .23, 95% *CI* [-.04, .15], BF_{10} = .23; $r(442) = .06$, p = .21, 95% *CI* [-.03, .15], BF_{10} = .24, respectively; Figure 4).

Figure 4

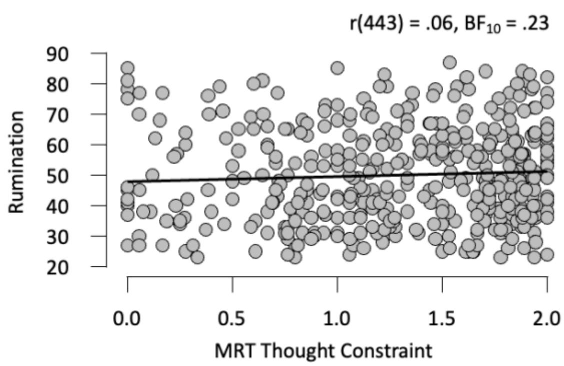
Associations Between Thought Constraint, Task Relatedness, and Total Rumination Scores via the SART and MRT



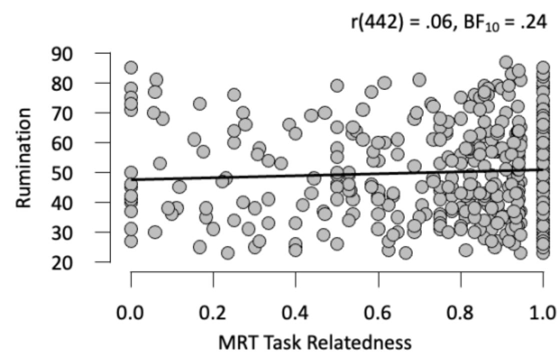
(A)



(B)



(C)



(D)

Note. (A) association between thought constraint and rumination via the SART, (B) association between task relatedness and rumination via the SART, (C) association between thought constraint and rumination via the MRT, (D) association between task relatedness and rumination via the MRT. All X-axes represent the average probe response per participant for either the SART or MRT. Y-axes represent total sum score on rumination measure.

Attention-Deficit/Hyperactivity Disorder

Total Combined ADHD Score

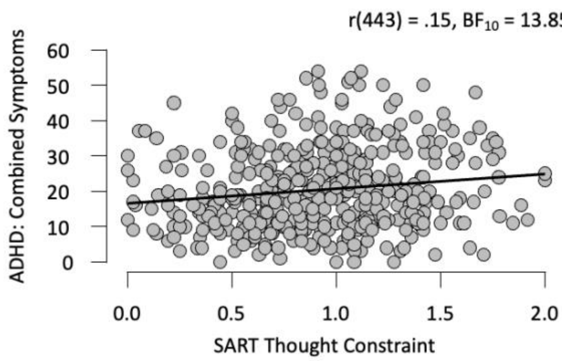
In separate linear models, SART thought constraint nor task relatedness were significantly associated with total ADHD scores (i.e., inattention and hyperactivity combined; b = 2.23, t = .77, p = .44; b = -4.59, t = -1.01, p = .31). In neither model was modality alone significantly associated with total ADHD scores (b = 1.49, t = .46, p = .64; b = -1.89, t = -.61, p = .55). I used the combined sample for the following correlations because modality did not significantly interact with thought type in either model (SART thought constraint: b = 2.38, t = .73, p = .47; SART task relatedness: b = 10.00, t = 1.96, p = .051). In support of predictions made by Christoff et al.(2016), subjects who reported less constrained thought reported experiencing more ADHD symptoms, $r(443) = .15$, p = .002, 95% *CI* [.05, .24], BF_{10} = 13.85 (Figure 5). Inconsistent with previous research (Alperin et al., 2021; Franklin et al., 2017; Lanier et al., 2019; Meier, 2020; Seli et al., 2015b), SART task relatedness was not associated with total scores of ADHD, $r(442) = .08$, p = .09, 95% *CI* [-.01, .17], BF_{10} = .46 (Figure 5). Thought constraint accounted for unique variance above and beyond task relatedness within the model (R^2 Δ = .02; p = .01) when predicting overall scores of ADHD.

Neither MRT thought constraint (b = 2.15, t = .86, p = .39) nor MRT task relatedness (b = 2.83, t = .51, p = .61) were associated with total ADHD scores in the linear model. Modality also did not significantly associate with total ADHD scores in either model (b = 4.75, t = 1.22, p = .22 and b = 4.01, t = .81, p = .42). The interactions between modality and MRT thought constraint (b = -.66, t = -.25, p = .81) and modality and MRT task relatedness (b = -.08, t = -.01, p = .99) were not significant. In the full sample both MRT thought constraint ($r(443)$ = .07, p =

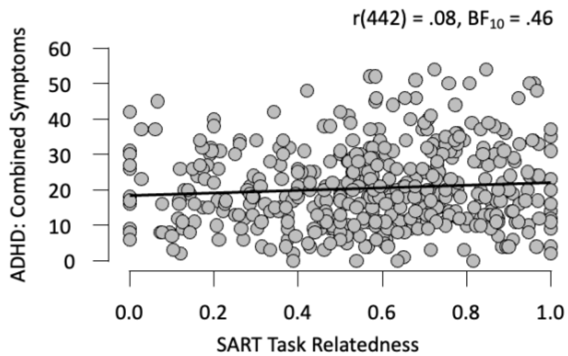
.14, 95% *CI* [-.02, .16], BF_{10} = .32) and MRT task relatedness ($r(442) = .06$, $p = .25$, 95% *CI* [-.04, .15], BF_{10} = .22) were not associated with total ADHD scores (Figure 5).

Figure 5

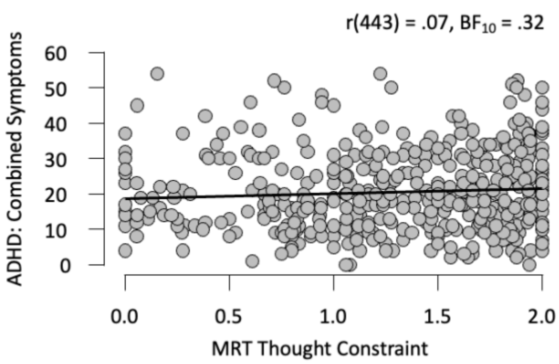
Associations Between Thought Constraint, Task Relatedness, and Combined ADHD Scores via the SART and MRT



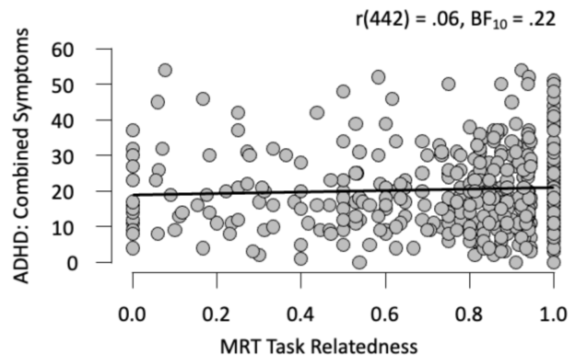
(A)



(B)



(C)



(D)

Note. (A) association between thought constraint and total ADHD scores via the SART, (B) association between task relatedness and total ADHD scores via the SART, (C) association between thought constraint and total ADHD scores via the MRT, (D) association between task relatedness and total ADHD scores via the MRT. All X-axes are the average response per participant for thought constraint and task-relatedness probes, respectively. Y-axes represent the total sum of scores on ADHD measure.

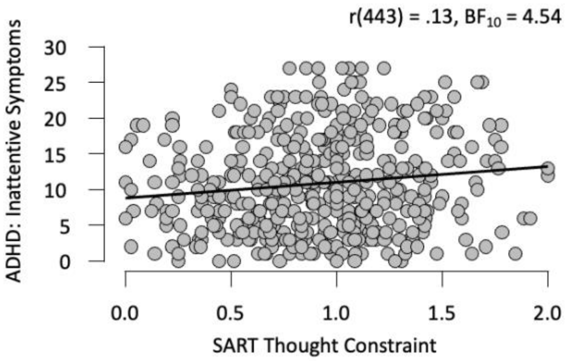
Inattention

Neither SART thought constraint nor SART task relatedness were significantly associated with ADHD inattention scores (b = .99, *t* = .57, *p* = .57; b = -3.12, *t* = -1.14, *p* = .26). In neither model was modality alone associated with ADHD inattentive symptoms (b = 1.32, *t* = .68, *p* = .50 and b = -.48, *t* = -.25, *p* = .80). The interactions between modality and SART thought constraint (b = 1.50, *t* = .76, *p* = .45) and SART task relatedness (b = 5.71, *t* = 1.85, *p* = .07) were not significant. I used the full sample to estimate the following associations. SART thought constraint was significantly associated with scores of inattention, *r*(443) = .13, *p* = .01, 95% *CI* [.04, .22], BF_{10} = 4.54 (Figure 6). In other words, those reporting more unconstrained thoughts via the SART also reported higher inattentive symptoms. SART task relatedness was not associated with symptoms of inattention, *r*(442) = .06, *p* = .22, 95% *CI* [-.04, .15], BF_{10} = .24 (Figure 6). Thought constraint ($R^2 \Delta$ = .01; *p* = .01) accounted for unique variance above and beyond task relatedness in predicting inattentive symptoms.

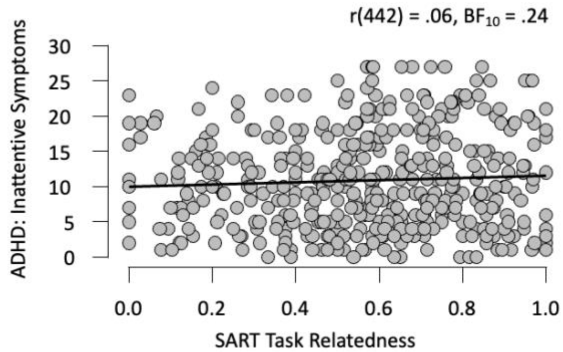
In separate models, MRT thought constraint and MRT task relatedness were not significantly associated with ADHD inattentive scores (b = 1.94, *t* = 1.30, *p* = .20 and b = 2.35, *t* = .71, *p* = .49, respectively). Additionally, modality was not significantly associated with inattention scores in either model (b = 3.64, *t* = 1.60, *p* = .12 and b = 2.74, *t* = .93, *p* = .36). The interaction between modality and thought type was not significant in either model, meaning the full sample was used for the following associations (MRT thought constraint interaction: b = -.60, *t* = -.37, *p* = .71; MRT task relatedness interaction: b = .21, *t* = .06, *p* = .95). MRT thought constraint was significantly associated with scores of inattention, *r*(443) = .11, *p* = .03, 95% *CI* [.01, .20], BF_{10} = 1.34 (Figure 6). Consistent with the above, those reporting less constrained thoughts (i.e., more freely moving) in the MRT reported more inattention symptoms. MRT task relatedness was not associated with scores of inattention, *r*(442) = .09, *p* = .06, 95% *CI* [-.01, .18], BF_{10} = .60 (Figure 6). Thought constraint did not demonstrate incremental validity above and beyond that of task relatedness ($R^2 \Delta$ = .01; *p* = .15).

Figure 6

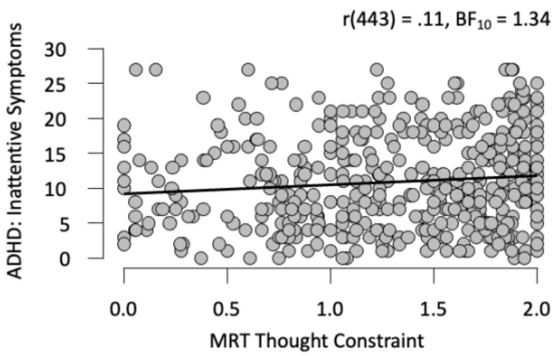
Associations Between Thought Constraint, Task Relatedness, and Inattentive Acores via the SART and MRT



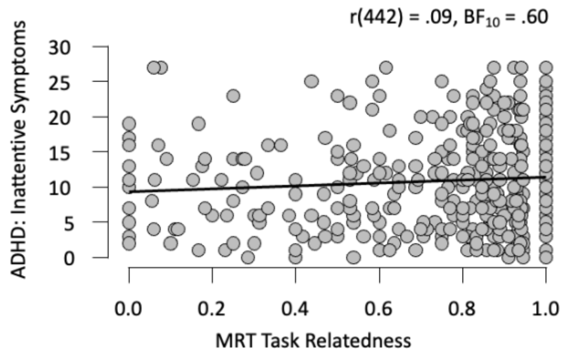
(A)



(B)



(C)



(D)

Note. (A) association between thought constraint and inattentive scores via the SART, (B) association between task relatedness and inattentive scores via the SART, (C) association between thought constraint and inattentive scores via the MRT, (D) association between task relatedness and inattentive scores via the MRT. All X-axes are the average probe response per participant for thought constraint and task relatedness, respectively. Y-axes represent the total summed score of items on the inattentive subscale.

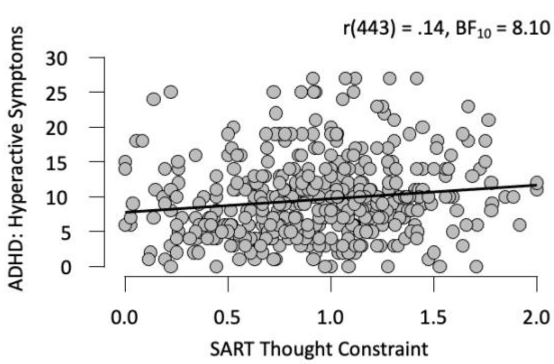
Hyperactivity

In separate models, SART thought constraint nor SART task relatedness significantly associated with hyperactivity (b = 1.24, t = .85, p = .39; b = -1.41, t = -.65, p = .52). Modality alone did not associate significantly with symptoms of hyperactivity in either model (b = .17, t = .12, p = .91 and b = -1.41, t = -.91, p = .37). The interaction between modality and thought type, in either case, was not significant (SART thought constraint: b = .89, t = .54, p = .59; SART task relatedness: b = 4.29, t = 1.68, p = .09). Thus, I used the full sample for the following associations. Reports of less constrained thoughts (i.e., more freely-moving thoughts) were associated with higher reports of hyperactivity, $r(443) = .14$, $p = .003$, 95% *CI* [.05, .23], BF_{10} = 8.10 (Figure 8). Conversely, SART task relatedness was not associated with hyperactivity symptoms $r(442) = .09$, $p = .06$, 95% *CI* [-.003, .18], BF_{10} = .67 (Figure 7). A test of incremental validity found that thought constraint accounted for unique variance above and beyond that of task relatedness ($R^2\Delta = .01$; $p = .03$).

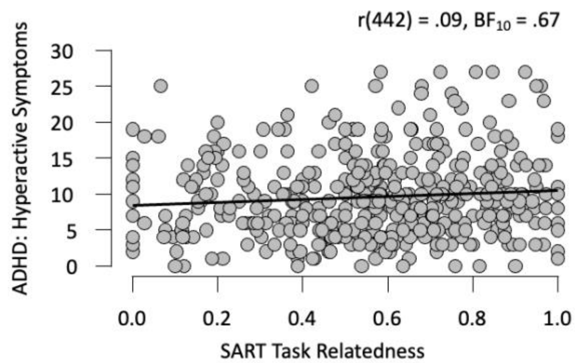
Neither MRT thought constraint (b = .21, t = .17, p = .87) nor MRT task relatedness (b = .48, t = .12, p = .86) were significantly associated with hyperactivity scores. Terms for modality were also not associated with symptoms of hyperactivity in either model (b = 1.11, t = .57, p = .57 and b = 1.27, t = .51, p = .61). I used the full sample for the following associations, as the interaction between modality and thought type was not statistically significant in either model (MRT thought constraint: b = -.01, t = -.05, p = .96; MRT task relatedness: b = -.29, t = -.10, p = .92). MRT thought constraint was not associated with scores of hyperactivity, $r(443) = .01$, p = .83, 95% *CI* [-.08, .10], BF_{10} = .11 (Figure 7). Likewise, MRT task relatedness was not associated with symptoms of hyperactivity, $r(442) = .004$, $p = .94$, 95% *CI* [-.09, .10], BF_{10} = .11, (Figure 7).

Figure 7

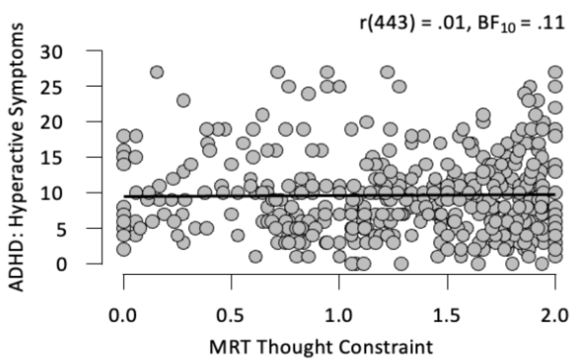
Associations Between Thought Constraint, Task Relatedness, and Hyperactivity via the SART and MRT



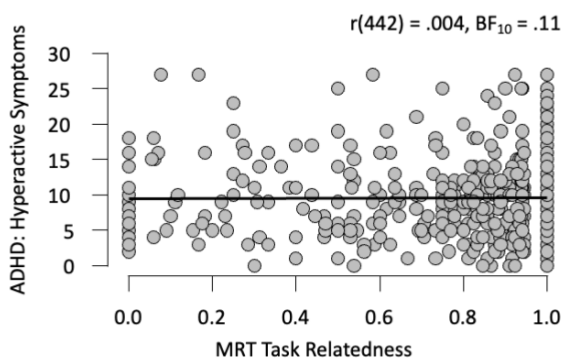
(A)



(B)



(C)



(D)

Note. (A) association between thought constraint and hyperactivity scores via the SART, (B) association between task relatedness and hyperactivity scores via the SART, (C) association between thought constraint and hyperactivity scores via the MRT, (D) association between task relatedness and hyperactivity scores via the MRT. X-axes are the average probe response for thought constraint and task relatedness per participant, respectively. Y-axes represent the total sum of scores for the hyperactivity subscale.

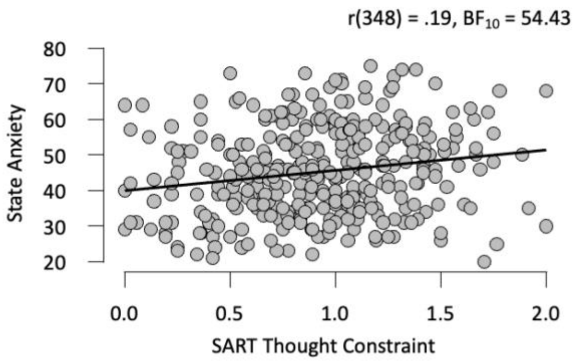
Anxiety

State Anxiety. Neither SART thought constraint nor SART task relatedness were associated with state anxiety (b = 2.85, *t* = -.92, *p* = .36; b = -4.63, *t* = -.95, *p* = .34). In neither case was modality associated with state anxiety (b = -3.39, *t* = -.98, *p* = .33; b = -2.11, *t* = -.63, *p* = .53). The interaction between modality and thought type was significant for SART thought constraint (b = 8.59, *t* = 2.48, *p* = .014), meaning the association between thought constraint and state anxiety was stronger for data collected online. Likewise, the association between SART task relatedness and modality (b = 11.75, *t* = 2.15, *p* = .03) was significant, suggesting that the association between task relatedness and state anxiety was also stronger for data collected online. Accordingly, the online sample only was used to test the following associations. Opposite of predictions made by Christoff et al. (2016), SART thought constraint was weakly positively associated with scores of state anxiety, $r(348) = .19$, $p < .001$, 95% *CI* [.08, .28], $BF_{10} = 54.43$ (Figure 8), those who endorsed more unconstrained thoughts also reported higher state anxiety levels. More reports of off-task thought via the SART were also weakly associated with higher rates of state anxiety, $r(347) = .15$, $p = .01$, 95% *CI* [.04, .25], $BF_{10} = 5.48$ (Figure 8). Adding thought constraint in the second step in my test of incremental validity yielded significant results (R^2 Δ = .01; *p* = .04).

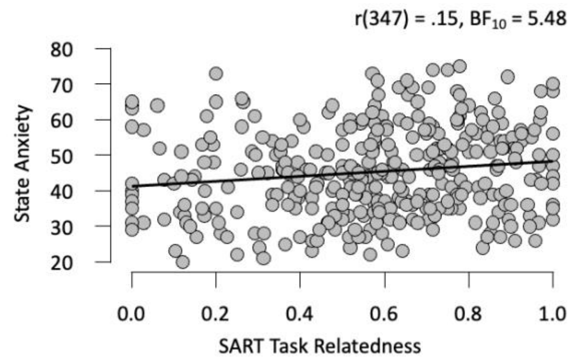
MRT thought constraint was not significantly associated with state anxiety (b = 1.90, *t* = .71, *p* = .48), nor was task relatedness (b = 8.86, *t* = 1.50, *p* = .13). Modality was also not associated with state anxiety in either model (b = 5.39, *t* = 1.29, *p* = .20 and b = 8.99, *t* = 1.70, *p* = .09). The interactions between MRT thought constraint and modality (b = -.58, *t* = -.20, *p* = .84), as well as MRT task relatedness and modality (b = -5.16, *t* = -.82, *p* = .41), were not significant, so I used the full sample for the following correlations. MRT thought constraint was not associated with state anxiety ($r(443) = .06$, $p = .25$, 95% *CI* [-.04, .15], $BF_{10} = .22$) nor was MRT task relatedness ($r(442) = .08$, $p = .08$, 95% *CI* [-.01, .17], $BF_{10} = .53$ (Figure 8).

Figure 8

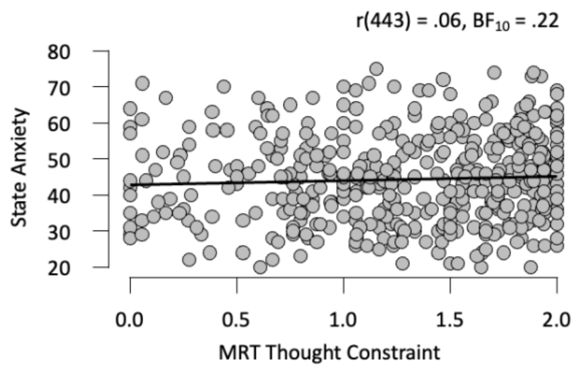
Associations Between Thought Constraint, Task Relatedness, and State Anxiety via the SART and MRT



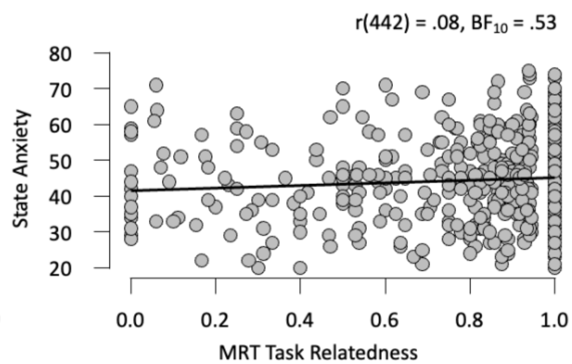
(A)



(B)



(C)



(D)

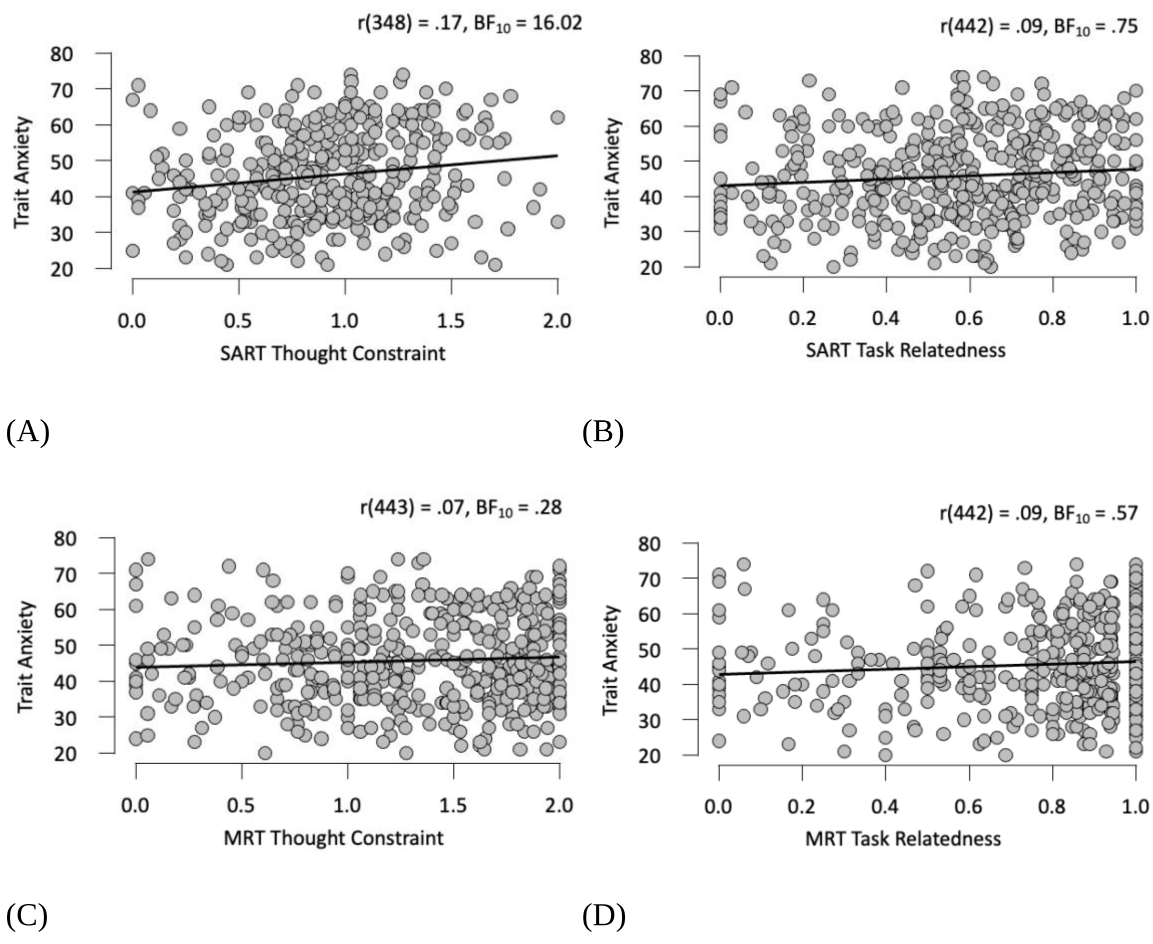
Note. (A) association between thought constraint and state anxiety via the SART, (B) association between task relatedness and state anxiety via the SART, (C) association between thought constraint and state anxiety via the MRT, (D) association between task relatedness and state anxiety via the MRT. X-axes represent average thought constraint or task relatedness probe responses per participant. Y-axes represent the total summed score on the measure of state anxiety.

Trait Anxiety. In two separate models, neither SART thought constraint (b = -4.46, t = -1.41, p =.16) nor SART task relatedness were significantly associated with trait anxiety (b = -3.50, t = -.71, p = .48). In the thought constraint model, the term for modality was significant when predicting trait anxiety (b = -7.64, t = -2.18, p = .03). Scores of trait anxiety were lower for those who participated online. Additionally, the interaction between modality and thought constraint (b = 9.59, t = 2.71, p = .01) was significant, meaning that participants in the online condition reported a stronger relationship between thought constraint and trait anxiety; consequently, the online sample was used for the association below. SART task relatedness, however, did not significantly interact with modality (b = 9.96, t = 1.79, p = .07), nor was the term for modality alone significant (b = -4.45, t = -1.31, p = .19), so the full sample was used for the association estimate. Both SART thought constraint (r(348) = .17, p = .002, 95% *CI* [.06, .26], BF_{10} = 16.02; Figure 9) and SART task relatedness (r(442) = .09, p = .05, 95% *CI* [.01-.18], BF_{10} = .75; Figure 9) were associated with trait anxiety (i.e., higher reports of lesser constrained and off-task thoughts were associated with higher trait anxiety). Thought constraint did not account for unique variance above and beyond that of task relatedness ($R^2 \Delta$ = .01; p = .09) when predicting trait anxiety.

Neither MRT thought constraint (b = 2.54, t = .94, p = .35) nor MRT task relatedness (b = 6.67, t = 1.11, p = .27) were associated with trait anxiety. In neither model was the term for modality significant (b = 2.95, t = .70, p = .49; b = -3.10, t = -.49, p = .63). The interaction between modality and thought type was not significant in either model, suggesting the use of the full sample for both of the following associations (MRT thought constraint: b = -1.25, t = -.42, p = .67; MRT task relatedness: b = -3.10, t = -.49, p = .63). Trait anxiety was not significantly associated with either MRT thought constraint (r(443) = .07, p = .17, 95% *CI* [-.03, .16], BF_{10} = .28; Figure 9) or MRT task relatedness (r(442) = .09, p = .07, 95% *CI* [-.01, .17], BF_{10} = .57; Figure 9).

Figure 9

Associations Between Thought Constraint, Task Relatedness, and Trait Anxiety via the SART and MRT



Note. (A) association between thought constraint and trait anxiety via the SART, (B) association between task relatedness and trait anxiety via the SART, (C) association between thought constraint and trait anxiety via the MRT, (D) association between task relatedness and trait anxiety via the MRT. All X-axes represent average probe responses per participant for thought constraint and task relatedness, respectively. Y-axes represent the total sum of scores on the trait anxiety scale.

Thought Constraint, Task Relatedness, and Task Performance

I tested for differential associations between thought constraint, task relatedness, and performance in the SART and MRT tasks with linear mixed models. Linear mixed models were conducted using the lme4 package (v1.1-26; Bates et al., 2015) in R (R Core Team, 2020). SART accuracy, SART response time variability, and MRT variability were outcomes for each set of linear models. Each set contained three models: one with predictors of thought constraint, modality, and their interaction; one with task relatedness, modality, and their interaction; and finally, one with thought constraint, task relatedness, and their interaction. In these models, task relatedness was dichotomously coded as either on or off-task. Responses were mean centered within each subject for thought constraint.

The first set of models examined the relationship between SART accuracy, thought constraint, and task relatedness. In separate models, thought constraint predicted variance in response accuracy (b = .58, Z = -7.40, p < .001) as did task relatedness (b = -1.10, Z = -8.80, p < .001). In both models, SART accuracy was negatively associated with testing online (thought constraint: b = -.53, Z = -3.20, p = .001; task relatedness: b = -.51, Z = -2.90, p = .004). The potential influence of modality was examined to determine whether modality should be included as an interaction term in the final model. The interaction terms between thought constraint and modality (b = -.06, Z = -.70, p = .51) and task relatedness and modality (b = .02, Z = .20, p = .85) were not significant; as such, these interaction terms were not included in the model that predicted SART accuracy from thought constraint, task relatedness, and their interaction. In this model, both thought constraint (b = -.41, Z = -7.40, $p > .001$) and task relatedness (b = -.69, Z = 11.10, $p < .001$) predicted unique variance in accuracy. The interaction between task relatedness and thought constraint did not (b = .01, Z = .20, $p = .88$).

The second set of models examined the relationship between SART response time variability, thought constraint, and task relatedness. As with the above, separate models were conducted within this set (one model with thought constraint, modality, and their interaction as predictors, another with task relatedness, modality, and their interaction as predictors, and thought constraint, task relatedness, and their interaction as predictors). Thought constraint was not associated with unique variance in response time variability (b = 8.0, $t = 1.90$, $p = .06$), while task relatedness was (b = 19.0, $t = 3.10$, $p = .002$). In both models, online testing modality was associated with more response time variability (thought constraint: b = 13.0, $t = 2.4$, $p = .02$; task relatedness: b = 15.0, $t = 2.20$, $p = .03$). The interaction between thought probe type and modality was not significant in either model (thought constraint: b = -3.0, $t = -.70$, $p = .48$; task relatedness: b = 8.0, $t = -1.20$, $p = .24$). Thus, I did not include modality in the model. Thought constraint did not predict unique variance in response time variability (b = -.60, $t = -1.50$, $p = .13$); however, task relatedness (b = 14.0, $t = 3.90$, $p < .001$) and the interaction between thought constraint and task relatedness were significant predictors (b = 12.0, $t = 2.40$, $p = .02$). The interaction term reflects an increase in response time variability between when a subject reports more off-task and freely-moving thoughts than usual compared to when they report on-task and constrained thoughts.

The third set of models examined the relationship between MRT response time variability, thought constraint, and task relatedness. As with the above, three separate models were conducted within this set. Thought constraint was a significant predictor of MRT response time variability (b = .24, t = 2.60, p = .01), while task relatedness was not (b = .27, t = 1.90, p = .06. Data collected online was associated with greater response time variability for both thought constraint (b = 1.50, t = 10.20, p < .001) and task relatedness (b = 1.40, t = 6.90, p = .01). In neither model was the thought probe by modality interaction statistically significant (thought constraint: b = .03, t = .20, p = .81; task relatedness: b = .20, t = 1.2, p = 2.4). Because the interaction terms were not significant, they were not included in the following model. In the model that predicted MRT response time variability from thought constraint, task relatedness, and their interaction, both thought constraint (b = .23, t = 2.20, p = .03) and task relatedness (b = .24, t = 2.50, p = .01) were associated with greater response time variability. The interaction between thought constraint and task relatedness was not statistically significant (b = -.08, t = -.60, p = .53).

CHAPTER FOUR: DISCUSSION

This study investigated thought constraint as a potential individual differences variable, complimenting other recent studies (Alperin et al., 2021; Christoff et al., 2016; Girn et al., 2020; Kam et al., 2021; Konjedi & Maleeh, 2021; Mills et al., 2018; Mills et al., 2021; O'Neill et al., 2020; Smith et al., 2018; Smith et al., 2022). Specifically, I wanted to know whether thought constraint was dissociable from task relatedness, whether thought constraint showed stability over time, to estimate associations between psychopathology symptoms and thought constraint, and if thought constraint impacts task performance differently than task-unrelated thought.

Dissociating Thought Constraint from Task Relatedness

A critical factor in considering thought constraint as an individual differences variable is if it is a unique and dissociable quality of thought beyond task relatedness (i.e., does it demonstrate discriminant validity). Consistent with several recent publications (Alperin et al., 2021; Kam et al., 2021; Mills et al., 2018; Mills et al., 2021; O'Neill et al., 2020; Smith et al., 2018), participants did not always report being off-task when they report having freely-moving thoughts (and vice versa), suggesting that they are not completely redundant. Notably, while there was not 100% overlap between thought constraint and task relatedness, interindividual correlations found that participants who report more off-task thought also reported more freely-moving thought (r = .70). Additionally, intraindividual correlations showed substantial overlap (r_{rm} = .61 and r_{rm} = .53; which is consistent with Kam et al., 2021 and much higher than Mills et al., 2018).

In some cases, thought constraint demonstrated incremental validity (i.e., with combined inattentive and hyperactivity symptoms, hyperactivity symptoms alone, inattentive symptoms alone, and state anxiety), but did not when predicting symptoms of depression, rumination, or trait anxiety. Even in the cases where thought constraint showed incremental validity, the values, while significant, were quite small (e.g., $R^2\Delta$ ranging from .01-.02). Given the high co-occurrence of thought constraint and task relatedness found in this study (and others), it is still unclear what processes *specifically* make the two types of thought distinct. To further investigate thought constraint as a potential individual differences variable, future studies should consider identifying other metrics that can disentangle freely-moving from off-task thought (e.g., neurophysiological measures, different thought probes, differing presentation of thought probes; as suggested by Alperin et al., 2021).

I also found that participant reports of thought constraint (and, separately, task relatedness) were strongly correlated across the SART and MRT, meaning that each thought type showed stability over time. When correlations were tested against each other, they were not statistically different (i.e., thought constraint was no more stable than task relatedness across the two measures). This is the first study investigating test-retest stability of thought constraint across multiple measures within a structured setting. While the current findings help illuminate thought constraint as a stable trait, research is needed to determine if thought constraint maintains stability over more extended time frames, multiple contexts, and within real-life settings. More specifically, future research should build upon Mills et al. (2018) and Smith et al. (2018)'s experience-sampling methodology by examining participants' reports of thought constraint and task relatedness during varying activities (e.g., in-class, at work, in social settings, etc.), as consistency across contexts is a vital assumption of an individual difference.

Thought Constraint and Dysfunctional Psychological Phenomena

To further explore thought constraint as a potential individual differences variable, I tested predictions made by Christoff et al. (2016) about different psychological symptoms and their association with thought constraint. To review, Christoff et al. (2016) hypothesized that individuals experiencing more depressive symptoms, rumination, and anxiety would have more constrained (i.e., less freely moving) thoughts. In turn, those reporting more ADHD symptoms would have less constrained (i.e., more freely moving) thoughts. To date, the results are mixed regarding the accuracy of these predictions (Alperin et al., 2021; Mills et al., 2021, Smith et al., 2022). In the current study, I unexpectedly found results in the opposite direction of the predictions made by Christoff et al. relating to depressive symptoms, rumination, and anxiety. In the SART, more freely-moving thought was positively associated with symptoms of depression and rumination (i.e., higher reports of unconstrained thought were related to higher reports of depression and ruminative symptoms). Also, in the SART, more freely-moving thought positively associated with trait anxiety and state anxiety.

Interestingly, while these results were not in the predicted direction, Bayes Factors were moderately to strongly in favor of the alternative hypothesis for the relationship between thought constraint and rumination ($BF_{10} = 4.29$), state anxiety ($BF_{10} = 54.43$), and trait anxiety ($BF_{10} = 16.02$); thought constraint did not provide incremental validity when predicting rumination or trait anxiety). Although the correlation between depressive symptoms and thought constraint was statistically significant, the Bayes Factors indicates that the evidence for this association is not strong and should be only considered anecdotal ($BF_{10} = 2.11$; alternative hypothesis favored over the null by a factor of 2), and in fact, thought constraint did not show incremental validity above and beyond task relatedness when predicting symptoms of depression.

This is the first study to explicitly examine the associations among rumination, state anxiety, trait anxiety, and thought constraint. While it is not clear why my results relative to depression, rumination, and anxiety were in the opposite direction of some of the predictions made by Christoff et al. (2016), future research should continue to investigate the role of arousal and thought constraint (as in Mills et al., 2021). Mills et al. (2021; Study 1) found that unconstrained thought was positively associated with arousal. I may have picked up on a subtype of individuals with anxious and depressive symptoms that are more consistent with racing thoughts (as opposed to ruminative thoughts; Benazzi, 2003; Piguet et al., 2010). Given the high degree of shared symptoms across different psychological disorders (for example, depression, anxiety, and rumination), future studies may find it helpful to focus more on transdiagnostic characteristics such as affect and arousal rather than specific diagnoses.

Consistent with Christoff et al. (2016) and Alperin et al. (2021), I found a positive (albeit weak) association between more freely-moving thought and overall ADHD scores in the SART (i.e., those reporting more overall ADHD symptomology reported more unconstrained thought). Additionally, I found a positive association between more freely-moving thought and higher scores on both the inattentive and hyperactive subscale in the SART (and for the inattentive subtype via the MRT). All Bayes Factors were moderately to strongly (BF_{10} = 4.54-13.85) in favor of the alternative hypothesis for all ADHD symptom measures, and thought constraint demonstrated incremental validity above and beyond task relatedness when predicting ADHD symptoms combined, hyperactivity, and inattention (with the exception of the association between the MRT and inattention). This is the first time that ADHD subtypes were explicitly investigated in relation to thought constraint. While the current study did not explicitly screen for individuals presenting with clinically significant symptomology, there were indeed some individuals who scored highly on symptom measures. To further explore the relationship between thought constraint and psychological symptoms (and potentially reveal additional, or stronger, associations), future studies should compare thought constraint between those with clinically significant psychological symptoms and non-clinical counterparts, as thought constraint may present differently in clinical populations (as in Alperin et al., 2021).

An interesting finding (or lack thereof) in the current study is that there were almost no significant associations between psychological symptoms and thought probe responses collected during the MRT (with the exception of inattentive symptoms), despite thought constraint showing stability across both measures of sustained attention. One reason for this could be that the task requirements of the SART (e.g., having to discriminate between target and non-target stimulus) were different than that of the MRT (i.e., pressing a spacebar in sync to a metronome), which may have captured attention differently, thus impacting probe responses. Also, participants may have been fatigued toward the end of the testing session, impacting thought constraint. Potential boredom during the MRT could have also led to acquiescent thought probe responses.

Task Performance and Thought Constraint

To further delineate thought constraint from task performance, I examined the relationship between thought type and task performance on two measures of sustained attention. Thought constraint was associated with unique variance within SART performance (consistent with Smith et al., 2022). In other words, the more unconstrained one's thoughts were, the more inaccurate their responses on the SART. Thought constraint was also positively associated with greater response time variability via the MRT, meaning that higher reports of unconstrained thoughts were associated with more inconsistent response times. Additionally, participants became more variable in their response time during the SART when they reported more off-task and freely-moving thoughts than usual than when they reported their thoughts to be on-task and constrained. Consistent with Smith et al. (2022), this study provides evidence that individuals who experience more freely-moving thought perform more poorly on sustained attention tasks.

Conclusions

The introduction of thought constraint to conceptualize mind wandering sparked investigation into its potential as an individual differences variable (Alperin et al., 2021; Christoff et al., 2016; Kam et al., 2021; Mills et al., 2018; Mills et al., 2021; O'Neill et al., 2020; Smith et al., 2018; Smith et al., 2022). In the current study, I found that thought constraint and task relatedness were not completely redundant characteristics of thought by examining intra- and interindividual correlations. Thought constraint was also uniquely associated with various measures of task performance. Reports of thought constraint exhibited rank-order stability across two separate sustained attention tasks. Regarding the relationship between thought constraint and various psychological symptoms, the majority of my results were either in the opposite direction of predictions made by Christoff et al. (2016) or were not significant. Here, the only exception was the positive association between thought constraint and overall ADHD symptoms, inattention, and hyperactivity. Taken together, thought constraint is showing promise as an individual differences variable however, there are also some critical areas to be fleshed out before it can be confidently classified as such.

For one, the way that thought constraint has been measured, both in the current and previous studies, may significantly impact results. Previous studies either assigned a 7-item Likert scale to the thought probe, *"Was your mind moving about freely?"* or scored the item dichotomously (i.e., Alperin et al., 2021; Kam et al., 2021; Mills et al., 2018, 2021; O'Neill et al., 2020; Smith et al., 2018; Smith et al., 2022). In my study, I used a 4-item Likert scale with specific labels to simplify participant responding (as Mills et al., 2018 did not provide labels to responses 1-7). While my aim was not to ascertain which methodology is the best for examining thought constraint, it is possible that a thought probe, "*Was your mind moving about freely?*" with a 4-point scale did not accurately measure what was intended, or, that it led to different results than may have been found if I had used the same probe responses used in previous studies, or different thought probes altogether.

Participants may have also had difficulty rating the content or process of their own thoughts (Kane et al., 2021). In other words, participants may not be able to identify how freely moving their thoughts were, forcing them to choose a probe response that does not reflect their thought dynamics. In addition, participants may not have understood what constitutes a freely-moving thought, despite being provided examples. While I attempted to minimize participant uncertainty by including an "*I don't know*" response (which was minimally endorsed), the thought probes themselves and participants' potential (mis)interpretation of thought constraint may contribute to inconsistent findings across studies (as suggested by Smith et al., 2022). Critically, if not all participants are responding based on an accurate understanding of thought constraint, it is possible that the thought probe, regardless of how responses are scaled, is not measuring thought constraint (O'Neill et al., 2020; Smith et al., 2022).

This issue of how accurately probe responses capture thought constraint is evident across studies and makes cross-study comparisons challenging. More recently, Kam et al. (2021) included four different thought probes that indexed task relatedness, thought constraint, deliberate constraint, and automatic constraint along with taking concurrent EEG measurements, which was novel. Moving forward, the inclusion of deliberate or automatic constraint (and, where possible, with neurophysiological measures) when assessing thought constraint could potentially be helpful in further elucidating thought constraint as a construct. Additionally, as suggested by Smith et al. (2022), it would be interesting to compare automatic/deliberate constraint with existing concepts such as spontaneous/deliberate off-task thought, as this may help to reveal potential redundancies (and differences) between thought constraint and task relatedness. To further investigate thought constraint as a potential individual differences variable, studies should identify other metrics that can disentangle freely-moving from off-task thought (e.g., neurophysiological measures, different thought probes, differing presentation of thought probes; as suggested by Alperin et al., 2021 and Smith et al., 2022).

The use of thought probes to assess thought content is a commonly used method and has been found to be a valid individual differences measure (at least as it relates to task relatedness; e.g., Kane et al., 2016; Unsworth et al., 2020; Welhaf et al., 2023). Although thought probe methodology is common, there is not necessarily a standardized approach for how frequent and how many probes need to be administered in any given task to obtain an accurate measure of one's thought processes. Infrequent thought probes may not provide enough reports to provide a valid measure; too many probes may be disruptive to the task and may impact estimates (Konishi & Smallwood, 2016; Welhaf et al., 2023). Welhaf et al. (2023) suggest that using eight thought probes within the SART is enough to obtain a valid assessment of task relatedness. Participants in this study responded to 36 probes within the SART alone. While there are not yet any studies that have investigated this type of probing methodology as it pertains to thought constraint, it is possible that the number of probes that participants responded to within the sustained attention tasks may have influenced thought reports. Similarly, our thought probes indexed multiple characteristics of thought each time they were asked: task relatedness, thought constraint, effortfulness, and shifting. It possible that participants may have conflated their ratings or had difficulty discriminating between these different types of thought. Rating thoughts on four separate characteristics may have also changed how they remembered their thoughts prior the probes appearing, which could have influenced results. As such, along with finding a purer measure of thought constraint, future studies should consider the interaction between the frequency of thought probes, the quantity of thought probes, and the potential impact on the measure of thought constraint.

At the time of the current study's publication, the relationship between thought constraint and other cognitive variables (e.g., working memory capacity, sluggish cognitive tempo, etc.) has yet to be investigated. For thought constraint to more robustly be considered as an individual differences variable, it seems important to identify other stable individual differences with which it would covary, so more could be understood about how it may meaningfully impact an individual.

While there may be varying hypotheses for why the current study did not reveal all the predicted associations between thought constraint and psychological symptoms (e.g., measurement issues, uncertainty in participant responding, fatigue, etc.), a final point of consideration is that some of the original claims made about thought constraint may have been wrong. Although thought constraint as a concept was initially introduced by Christoff et al. (2016), there have only been a handful of studies in the past 7 years that have explicitly investigated the relationship between thought constraint and other psychological variables (Alperin et al., 2021; Mills et al., 2021; Smith et al., 2022). In several instances, the current study is the *only* study to have examined the association between thought constraint and specific psychological variables (i.e., rumination, state anxiety, trait anxiety, and inattentive/hyperactive subtypes of ADHD). Additional research is needed to elucidate the cause of the discrepant findings between the original predicted associations between thought constraint and depression, rumination, and anxiety found and this study and others (i.e., Smith et al., 2022). In sum, thought constraint seems to be a stable characteristic of thought that has been delineated from task relatedness both thought report and task performance; however, the predicted relationship between thought constraint and certain psychological symptoms (e.g., depression, anxiety, rumination) has yet to be consistently supported and perhaps should be considered inaccurate until proven otherwise.

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Appendix A

Operation Complex Span Task (OSPAN; Unsworth et al., 2005)

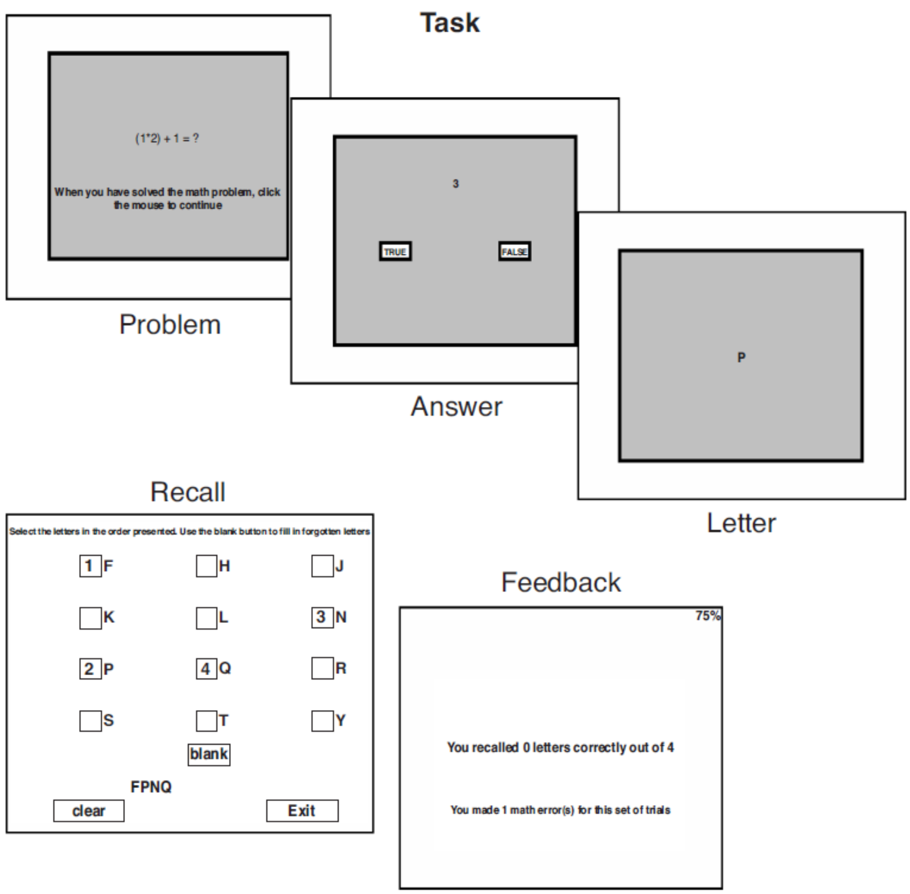
Operation Complex Span Task (In-Person Data Collection)

The operation complex span task assessed working memory capacity (Unsworth et al., 2005). This task was only completed by participants who were present in the lab. To reduce the length of the lab session and maximize the number of participants each semester, a shortened version of this task was used (Foster et al., 2015). The task required individuals to memorize letters presented on the computer screen while solving simple math problems. Before beginning scored trials, participants completed practice rounds that had them memorize letters, verify solutions to simple math problems, and then a combined practice where they memorized letters while solving the math problems. Participants' average response time for math problems was recorded during the math problem practice to create a personalized response deadline. The participants' response deadline to the math problems was based on their average response time in the practice rounds (plus 2.5 *SD*s; Unsworth et al., 2005). If their response time exceeded the deadline, the screen proceeded to the letter to remember, with the math problem being counted as an incorrect response.

In scored trials, the task first presented participants with a math problem. After they responded to the math problem (or the response deadline was reached), participants were given a letter to remember (presented for one second). The number of math problems and letters to remember varied with set sizes ranging from three to seven letters per trial (with a total of five trials). One set of each size was administered in random order. After being administered a set of math problems and letters, participants were presented with a grid of the 12 possible letters they saw and were asked to recall the letters by clicking the letters in order. Participants were encouraged to maintain an accuracy of 85% on the math problems to minimize the tradeoff between focusing on the math problem versus the letter to remember (Unsworth et al., 2005). All responses were made with a computer mouse. This task lasted roughly 15 minutes. Scores will be calculated by summing the letters correctly recalled in serial order, with a maximum score of 25 (i.e., partial credit scoring; Conway et al., 2005;). Cronbach's alpha for this task has been reported as .69 (Foster et al., 2015)

Figure 10

Visual Depiction of Operation Complex Span (OSPAN) Task



Appendix B

Symmetry Complex Span Task (SYMSPAN; Kane et al., 2004)

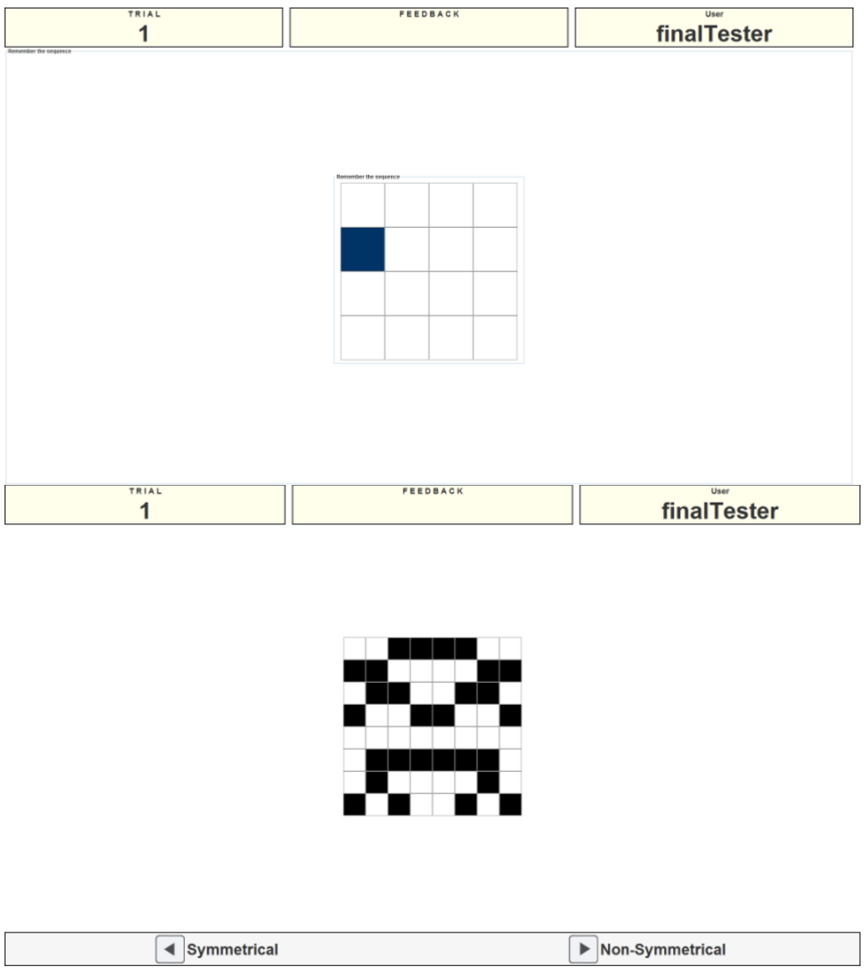
The shortened symmetry complex span task is another task designed to assess working memory capacity (Foster et al., 2015; Kane et al., 2004). It was only completed by participants in the lab. In this task, participants were asked to remember the serial order and placement of red squares in a 4x4 grid interleaved with determining if images were vertically symmetrical. Participants first practiced the square recall task. Each square was presented for 650ms. Next, participants were guided through a series of instructions that demonstrated what a (vertically) symmetrical vs. an asymmetrical picture looked like on an 8x8 grid. They were then shown images made of black and white squares and had to determine if they were symmetrical. During the practice round, the participants' average response time to the symmetry judgment task was calculated. Following the two separate practice rounds, participants then practiced the symmetry judgment task followed by the square placement task combined. After the practice rounds, participants completed the task by responding to symmetry problems followed by recalling the placement of squares on a blank 4x4 grid.

The participants' response deadline to the symmetry judgment task was their average response time based on practice rounds plus 2.5 *SD*. If they did not respond within the deadline, the nonresponse was counted as an error (as in the Operation Span task above). Set sizes were randomized and ranged from two to five items per set, with one trial per set. This task lasted roughly 10 minutes and participants completed one block of the task. Scores were calculated by summing the amount of correctly identified squares in the correct order, with partial credit allowed; the maximum score was 14 (scores on this task are considered the dependent variable;

Foster et al., 2015; Kane et al., 2004). Foster et al. (2015) reported Cronbach’s alpha for this measure is .61.

Figure 11

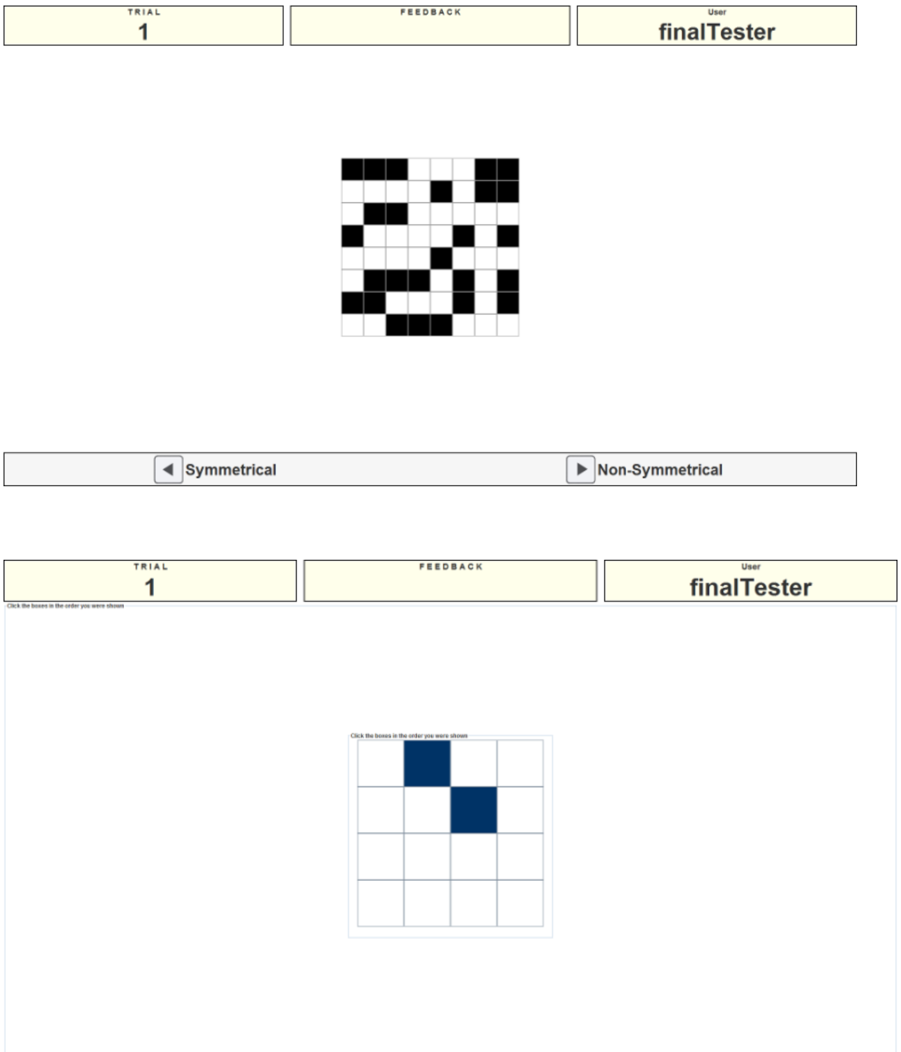
Visual Depiction of Symmetry Complex Span (SYMSPAN) Task



Note. Presentation phase.

Figure 11

Visual Depiction of Symmetry Complex Span (SYMSPAN) Task



Note. Recall phase.

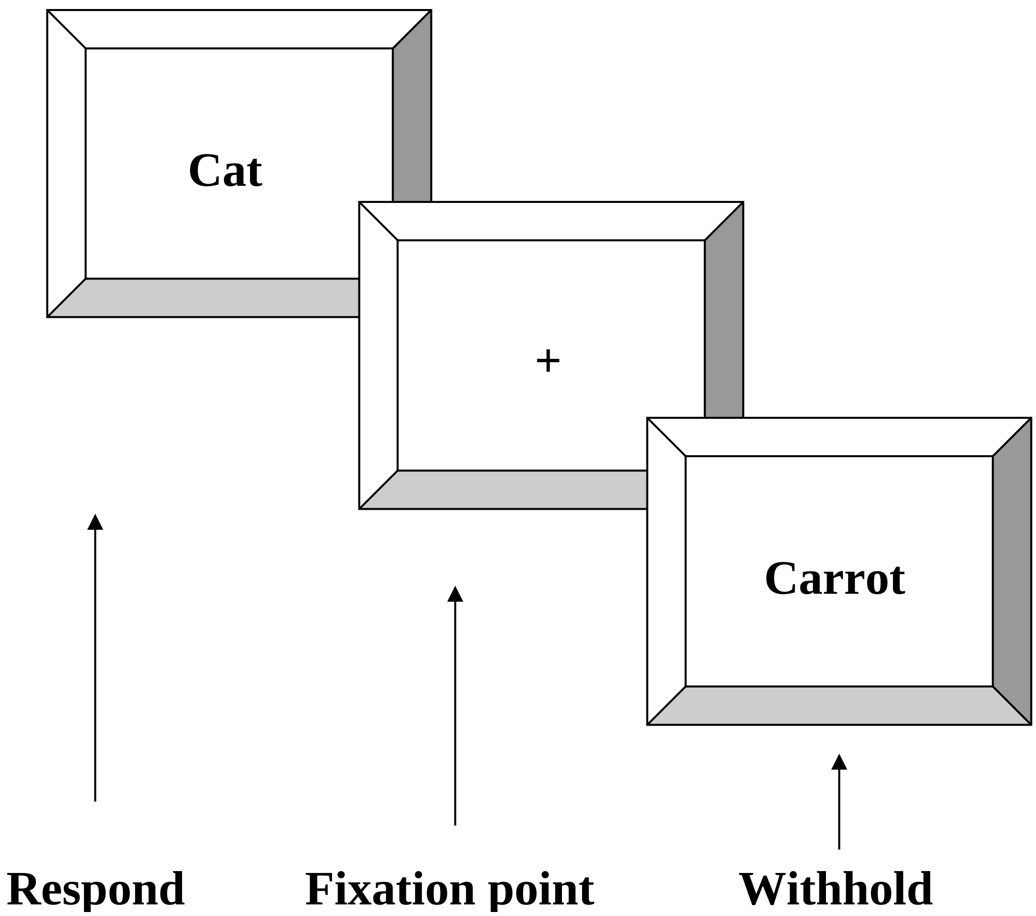
Appendix C

Semantic Sustained Attention to Response Task (SART; Robertson et al., 1997)

Figure 12

Visual Depiction of the SART Task

SART assessment



Appendix D

Thought Probes

Participants were presented with the following probes and response choices during the SART and the MRT. All probes followed the sequence below:

Was your mind moving about freely? (probe 1)

1. Not at all
2. Somewhat
3. Very much
4. I don’t know

What were you just thinking about? (probe 2)

1. The task
2. Task experience/performance
3. Everyday things
4. Current state of being
5. Personal worries
6. Daydreams
7. External environment
8. Other

Were your thoughts shifting amongst multiple topics? (probe 3)

1. Yes
2. No
3. I don’t know

Were you effortfully concentrating on your thoughts? (probe 4)

1. Yes
2. No
3. I don’t know

Appendix E

Definitions of Thought Probe Responses Provided During Tasks (based on Mills et al., 2018)

Instruction screen one: This is a task that includes thought questions. During the task, you may find yourself thinking about something other than the task. We are interested in what types of things people think about during a task like this. In order to examine this, the computer will periodically ask you what you were *just* thinking about. It is perfectly normal to think about things that are not related to the task. We will give you several categories of things that people might think about during a task like this. Please try your best to honestly assess your thoughts and choose an answer that best describes your thoughts at the time when we ask.

The first question you will periodically be asked is: Was your mind moving about freely?

Your thoughts move freely when:

• They seem to wander around, flowing from one thing to another

• There is no overarching purpose or direction to your thinking. Although there may still be some connection between one thought and the next

• Images and memories seem to spontaneously come into your mind

• Your attention lands spontaneously on things in your environment

• Your mind may spontaneously drift between things in the external environment and internal images so it may go back and forth.

• Your thoughts move freely when it feels like your thoughts could land on pretty much anything

• Or that your thoughts seem to flow with ease

Next screen: Here's an example of a freely moving mind: you're on the bus going home, you picture yourself having dinner that evening, then wonder if you've been eating too much fast food recently, then notice the faint music playing from another passenger's headphones, and that reminds you of a song you've heard at a party the night before. Your thoughts can also move freely around a particular topic such as a current event, or something you're currently interested in. For example, you think of the bike you just bought, then think yourself biking down a trail next weekend, then picture your friend riding next to you, then remember the first bike you got for your 10th birthday and so on. So in this example your thoughts share the same topic but are moving freely. Thought can also move freely in the external environment. So as you sit here, you may notice your mind shifting to various features of this room such as the quality of light or sound.

Another example of freely moving thoughts may look like this: you are focusing on the task we are doing right now, the name of a vegetable that you enjoy pops up, you think about the last time you ate that vegetable, how you need to go grocery shopping, and then you shift your thoughts back to the task.

Next screen: You will see the following response to the "Was your mind moving about freely?" question:

1. Not at all
2. Somewhat
3. Very Much
4. I don't know

Choose the answer that best describes your thoughts *just before* the screen that asked you about what you were thinking about appeared.

Press the space bar to continue...

Next screen: Following that question, you will see a screen like this:

What were you just thinking about?

Please press a number on the keyboard.

1. The task

2. Task experience/performance

3. Everyday things

4. Current state of being

5. Personal worries

6. Daydreams

7. External environment

8. Other

Press the space bar to continue...

Next screen: When you are asked what you are thinking, please take a moment to reflect on your thoughts before you answer.

The choices are:

1. The task

Select this number if your thoughts were about the words or categories of words that you just saw

Press the space bar to continue.

Next screen: 2. Task experience or performance

Select this number if your thoughts were about how well or poorly you are doing on the task or how many you are getting right or wrong.

Press the space bar to continue...

Next screen: 3. Everyday things

Select this number if your thoughts were about normal, routine, everyday things you did recently or that you'll be doing sometime later. Examples of these types of thoughts may include planning your upcoming weekend activities, a conversation you had with a friend earlier in the day, or when you will do your laundry.

Press the space bar to continue…

Next screen: 4. Current state of being

Select this number if you were thinking about your own current state, such as thinking about being sleepy, cheerful, hungry, or bored.

Press the space bar to continue…

Next screen: 5. Personal worries

Select this number if your thoughts were about life concerns or worries. Examples of these types of thoughts include worries about your health, concerns about a relationship with a friend or family member, worry about passing your next exam, or concerns about a goal you have yet to achieve.

Press the space bar to continue…

Next screen: 6. Daydreams

Select this number for fantasies or thoughts disconnected from reality. For example, thoughts about being at the beach instead of doing this task might be considered daydreaming.

Press the space bar to continue…

Next screen: 7. External environment

Select this number if you were thinking about something in your environment, other than this task. For example, you would select this choice if you were thinking about the hum of the computer or the quality of light in the room.

Press the space bar to continue…

Next screen: 8. Other

Select "other" ONLY if your thoughts do not fit into any of the other category options

1. The task

2. Task experience/performance

3. Everyday things

4. Current state of being

5. Personal worries

6. Daydreams

7. External environment

8. Other

Press the space bar to continue…

Next screen: Next you will be asked, "Were your thoughts shifting amongst multiple topics?" Please select the number between 1 and 3 that best describes your thoughts.

1. Yes

2. No

3. I don’t know

Please press the spacebar to continue...

Next screen: Finally, you will be asked, "Were you effortfully concentrating on your thoughts?" If you were effortfully concentrating (i.e., you were intentionally/effortfully trying to control what you were thinking about), please respond "yes.” If your thoughts were more spontaneous (e.g., you were not attempting to control them), please respond "no." If you are unable to answer the question, respond "I don't know." The screen will look like this:

1. Yes

2. No

3. I don’t know

Please press the space bar to continue...

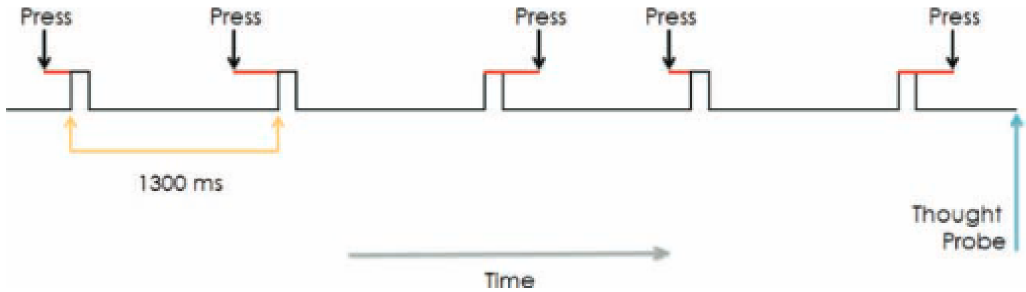
Next screen: Remember, when you see screens like these, please respond based on what you were thinking *just before* the initial probe screen appeared. Do not try to reconstruct what you were thinking during the preceding words on the screen, and please select the categories that best describes your thoughts as accurately as you can. Remember that it is quite normal to have any of these kinds of thoughts during an ongoing task.

If you have any questions about this task or the questions we ask you about your thoughts, please ask me now.

Press the space bar to continue.

Figure 13

Visual Depiction of the Metronome Response Task (Seli et al., 2013, p.2)



Note. Visual depiction of the sequence of events in the metronome response task. Vertical black bars represent metronome tones (which lasted 75ms). The red horizontal lines represent examples of when participants' initiate the spacebar press in relation to the tone (e.g., right before, during, or after the tone).

Appendix F

Ruminative Response Scale (Nolen-Hoeksema & Morrow, 1991)

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you *generally* do, not what you think you should do.

1 = almost never, 2 = sometimes, 3 = often, 4 = almost always

1. Think about how alone you feel
2. Think "I won't be able to do my job if I don't snap out of this"
3. Think about your feelings of fatigue and achiness
4. Think about how hard it is to concentrate
5. Think "What am I doing to deserve this?"
6. Think about how passive and unmotivated you feel.
7. Analyze recent events to try to understand why you are depressed
8. Think about how you don't seem to feel anything anymore
9. Think "Why can't I get going?"
10. Think "Why do I always react this way?"
11. Go away by yourself and think about why you feel this way
12. Write down what you are thinking about and analyze it
13. Think about a recent situation, wishing it had gone better
14. Think "I won't be able to concentrate if I keep feeling this way."
15. Think "Why do I have problems other people don't have?"
16. Think "Why can't I handle things better?"

17. Think about how sad you feel.

18. Think about all your shortcomings, failings, faults, mistakes

19. Think about how you don't feel up to doing anything

20. Analyze your personality to try to understand why you are depressed

21. Go someplace alone to think about your feelings

22. Think about how angry you are with yourself

Appendix G

ADHD Self-Report Scale (DuPaul et al., 1998)

You will now be asked some questions. For the following questions, please respond by clicking the button that best describes your behavior in the last 6 months.

1 = never or rarely, 2 = sometimes, 3 = often, 4 = very often

1. During childhood, I often failed to give close attention to details and made careless mistakes in my work
2. As a child, I fidgeted a lot with hands or feet and I squirmed in my seat
3. During childhood, I had difficulty sustaining my attention in tasks or fun activities
4. As a child, I would often leave my seat in situations in which remaining seated was expected
5. During childhood, I often didn't listen when spoken to directly
6. When I was young, I frequently felt restless (running about or climbing excessively)
7. During childhood, I often didn't follow through on instructions and I failed to finish my work
8. As a child, I had a lot of difficulty engaging in leisurely activities or doing fun things quietly
9. When I was young, I tended to have difficulty organizing tasks and activities
10. During childhood, I often felt "on the go" or "driven by a motor"
11. As a child, I often avoided, disliked, or felt reluctant to engage in work that required sustained mental effort
12. When I Was young, I talked excessively
13. During childhood, I frequently lost things necessary for tasks and activities
14. As a child, I would often blurt out answers before questions had been completed
15. When I was young, I was very easily distracted
16. During childhood, I tended to have difficulty awaiting my turn

17. When I was young, I was often forgetful in daily activities

18. During childhood, I often interrupted or intruded on others

Appendix H

State-Trait Anxiety Inventory for Adults (Spielberger, 1983)

State Anxiety:

A number of statements which people have used to describe themselves will be on the screens that follow. Read each statement and then choose the appropriate response to indicate HOW YOU FEEL RIGHT NOW, that is, AT THIS MOMENT. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your PRESENT feelings best.

1= not at all, 2 = somewhat, 3 = moderately so, 4 = very much so

1. I feel calm
2. I feel secure
3. I am tense
4. I feel strained
5. I feel at ease
6. I feel upset
7. I am presently worrying over possible misfortunes
8. I feel satisfied
9. I feel frightened
10. I feel comfortable
11. I feel self-confident
12. I feel nervous
13. I am jittery

14. I feel indecisive

15. I am relaxed

16. I feel content

17. I am worried

18. I feel confused

19. I feel steady

20. I feel pleasant

Trait Anxiety:

A number of statements which people have used to describe themselves follow. Read each statement and then choose the appropriate response to indicate how you GENERALLY feel.

1= not at all, 2 = somewhat, 3 = moderately so, 4 = very much so

1. I feel pleasant
2. I feel nervous and restless
3. I feel satisfied with myself
4. I wish I could be as happy as others seem to be
5. I feel like a failure
6. I feel rested
7. I feel "calm, cool, and collected"
8. I feel that difficulties are piling up so that I cannot overcome them
9. I worry too much over something that really doesn't matter

10. I am happy

11. I have disturbing thoughts

12. I lack self-confidence

13. I feel secure

14. I make decisions easily

15. I feel inadequate

16. I am content

17. Some unimportant thought runs through my mind and bothers me

18. I take disappointments so keenly that I can't put them out of my mind

19. I am a steady person

20. I get in a state of tension or turmoil as I think over my recent concerns and interests

Appendix I

Mind Excessively Wandering Scale

The Mind Excessively Wandering Scale is a 12-item scale developed to measure excessive mind wandering in individuals with ADHD (Mowlem et al., 2019). Responses include 0) *Not at all or rarely*, 1) *Some of the time*, 3) *Nearly all of the time or constantly*. The scale has shown strong internal consistency ($\alpha > .9$), high sensitivity (.9), and high specificity (.9) for making ADHD diagnoses when compared to other ADHD symptom rating scales. Several of the items on this scale seem to assess for task-unrelated thought (e.g., "I find my thoughts are distracting and prevent me from focusing on what I am doing," "I try to distract myself from my thoughts by doing something else or listening to music) while others may be assessing thought constraint (e.g., "I find myself flitting back and forth between different thoughts," "I have difficulty slowing my thoughts down and focusing on one thing at a time," "My thoughts are disorganized and 'all over the place'"). Scores on the Mind Excessively Wandering Scale are not included in main hypotheses of this study and are for exploratory purposes only.

Mind Excessively Wandering Scale

Please read the following statements and answer to indicate how you and your thoughts relate to the statement.

1= not at all or rarely, 2 = some of the time, 3 = most of the time 4 = nearly all of the time or constantly

1. I have difficulty controlling my thoughts
2. I find it hard to switch my thoughts off
3. I have two or more different thoughts going on at the same time
4. My thoughts are disorganized and "all over the place"
5. My thoughts are "on the go" all of the time
6. I experience ceaseless mental activity
7. I find it difficult to think about one thing without another thought entering my mind
8. I find my thoughts are distracting and prevent me from focusing on what I am doing
9. I have difficulty slowing my thoughts down and focusing on one thing at a time
10. I find it difficult to think clearly, as if my mind is in a fog
11. I find myself flitting back and forth between different thoughts
12. I can only focus my thoughts on one thing at a time with considerable effort

Appendix J

Beck Depression Inventory (Beck et al., 1996)

You will now see 20 groups of statements. Please read each group of statements carefully, and then pick out the one statement in each group that best describes the way you have been feeling during the past two weeks, including today. If several statements in the group seem to apply equally well, select the highest number for that group that applies.

Sadness

0 = I do not feel sad

1 = I feel sad much of the time

2 = I am sad all of the time

3 = I am so sad or unhappy that I can't stand it

Pessimism

0 = I am not discouraged about my future

1 = I feel more discouraged about my future than I used to

2 = I do not expect things to work out for me

3 = I feel my future is hopeless and will only get worse

Failure

0 = I do not feel like a failure

1 = I have failed more than I should have

2 = As I look back, I see a lot of failures

3 = I feel I am a total failure as a person

Loss of Pleasure

0 = I get as much pleasure as I ever did from the things I enjoy

1 = I don't enjoy things as much as I used to

2 = I get very little pleasure from the things I used to enjoy

3 = I can't get any pleasure from the things I used to enjoy

Guilty Feelings

0 = I don't feel particularly guilty

1 = I feel guilty over many things I have done or should have done

2 = I feel quite guilty most of the time

3 = I feel guilty all of the time

Punishment Feelings

0 = I don't feel I am being punished

1 = I feel I may be punished

2 = I expect to be punished

3 = I feel I am being punished

Self-Dislike

0 = I feel the same about myself as ever

1 = I have lost confidence in myself

2 = I am disappointed in myself

3 = I dislike myself

Criticism

0 = I don’t criticize or blame myself more than usual

1 = I am more critical of myself than I used to be

2 = I criticize myself for all of my faults

3 = I blame myself for everything bad that happens

Crying

0 = I don’t cry anymore than I used to

1 = I cry more than I used to

2 = I cry over every little thing

3 = I feel like crying, but I can’t

Agitation

0 = I am no more restless or wound up than usual

1 = I feel more restless or wound up than usual

2 = I am so restless or agitated, it’s hard to stay still

3 = I am so restless or agitated that I have to keep moving or doing something

Loss of Interest

0 = I have not lost interest in other people or activities

1 = I am less interested in other people or things than before

2 = I have lost most of my interest in other people or things

3 = It’s hard to get interested in anything

Indecisiveness

0 = I make decisions about as well as ever

1 = I find it more difficult to make decisions than usual

2 = I have greater difficulty in making decisions than I used to

3 = I have trouble making any decisions

Worthlessness

0 = I do not feel I am worthless

1 = I don’t consider myself as worthwhile and useful as I used to

2 = I feel more worthless as compared to others

3 = I feel utterly worthless

Loss of Energy

0 = I have as much energy as ever

1 = I have less energy than I used to have

2 = I don’t have enough energy to do very much

3 = I don’t have energy to do anything

Change in Sleeping

0 = I have not experienced any change in my sleeping

1 = I sleep somewhat more than usual OR I sleep somewhat less than usual

2 = I sleep a lot more than usual OR I sleep a lot less than usual

3 = I sleep most of the day OR I wake up 1-2 hours early and can’t get back to sleep

Irritability

0 = I am not more irritable than usual

1 = I am more irritable than usual

2 = I am much more irritable than usual

3 = I am irritable all the time

Appetite

0 = I have not experienced any change in appetite

1 = My appetite is somewhat less than usual OR my appetite is somewhat greater than usual

2 = My appetite is much less than before OR my appetite is much greater than usual

3 = I have no appetite at all OR I crave food all of the time

Concentration

0 = I can concentrate as well as ever

1 = I can’t concentrate as well as usual

2 = It’s hard to keep my mind on anything for very long

3 = I can’t concentrate on anything

Fatigue

0 = I am no more tired or fatigue than usual

1 = I get more tired or fatigued more easily than usual

2 = I am too tired or fatigued to do a lot of the things I used to do

3 = I am too tired or fatigued to do most of the things I used to do

Sex

0 = I have not noticed any recent change in my interest in sex

1 = I am less interested in sex than I used to be

2 = I am much less interested in sex now

3 = I have lost interest in sex completely

Appendix K

Examining the "I don't know" Response

I decided to include an "*I don't know*" response option when measuring thought constraint to allow for participants to indicate uncertainty in their thought reports. This decision was made given previous concerns regarding participants' ability to accurately and easily rate their depth of thought report, and/or potential confusion regarding the definition of thought constraint, which may have confounded previous studies of thought constraint (Kane et al., 2021; Smith et al., 2022). If participants have been guessing about how constrained their thoughts might be, as opposed to being able to honestly answer "*I don't know,*" previous data regarding thought constraint may be skewed.

Interestingly, my study's overall percentage of responses endorsed as *"I don't know"* was low. Given that the low response rate for this option, additional exploratory analyses were not conducted. Descriptive statistics will be reported below.

Descriptive Statistics

The percentage of *"I don't know*" responses provided during the SART was minimal and consistent across modality. For participants who completed the SART in-person (i.e., in the laboratory), three percent of the total thought constraint probe responses were endorsed as *"I don't know."* Twenty-four out of 99 participants reported at least one *"I don't know"* response, and the average number of responses was three for those who indicated at least one "I don't know" response. One subject reported nine total *"I don't know" responses.* Similar rates of *"I don't know"* responses were reported by participants who completed the SART online (i.e., 4%). One-hundred and twenty five out of 489 participants had at least one *"I don't know*" response, and similar to the above, and for those participants, the average amount of *"I don't know"* responses was three. One participant who provided online SART data reported 13 *"I don't know"* responses.

Rates of *"I don't know"* responses provided during the MRT were similar to that of the SART. Three percent of the total responses on the MRT for the in-person sessions were *"I don't know."* Eighteen out of 105 subjects had at least one *"I don't know"* response, with an average of three *"I don't know*" responses per person who reported them. Two participants reported eight *"I don't know"* responses. Four percent of responses on the online MRT were *"I don't know."* One hundred out of 482 participants had at least one *"I don't know*" response. Of those who reported *"I don't know,"* the average amount was three. One subject responded to all 18 thought probes within the MRT as *"I don't know."*