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Unconstrained Thought as an Individual-Differences Variable

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This quasiexperimental study explores unconstrained thought as an individual-differences variable, examining its distinction from task-unrelated thought, its associations with performance on two sustained-attention tasks, psychopathology symptoms, effortful concentration, and topic switching, as well as its stability (i.e., test–retest reliability) across tasks. Data from 445 participants revealed that unconstrained thought, while overlapping with task-unrelated thought, offers some unique insights, particularly its relation with attention-deficit/hyperactivity disorder symptoms. However, relations between unconstrained thought and many of our measures fail to provide predictive power beyond task-unrelated thought. Contrary to prior hypotheses, more reports of depressive symptoms, rumination, state anxiety, and trait anxiety were associated with more reports of unconstrained thought. Unconstrained thought demonstrated test–retest reliability across two sustained-attention tasks. This study suggests the potential of unconstrained thought as an individual-difference variable, especially in relation to attention-deficit/hyperactivity disorder, but also highlights its functional overlap with task-unrelated thought.

Keywords: mind wandering, individual differences, unconstrained thought, task-unrelated thought, Dynamic Framework

Mind wandering has traditionally been defined as task-unrelated thought, which refers to thoughts unrelated to one's ongoing task (Smallwood & Schooler, 2015). Examples of task-unrelated thoughts include thinking about dinner plans while editing a video, reminiscing about a second-grade teacher during a college lecture, or trying to read a book in a coffee shop while also thinking about the music playing. Although most research on the topic has adopted this conceptualization of mind wandering (Mills et al., 2018), Christoff et al. (2016, p. 719) presented a different view. They argued that this definition "fails to capture what is arguably the key feature of mind wandering": the dynamic movement of thought. Christoff et al. suggested that the content of thoughts, or the extent to which thoughts are related to the current task, is not the defining feature of mind wandering. Instead, it is the movement, or dynamics, between thoughts that is. Christoff et al. thus introduced their Dynamic Framework of mind wandering, which posits that the degree of constraint (i.e., the degree to which a train of thought is dynamic) varies across experiences. This variability arises from both automatic processes, like being emotionally or sensorily overwhelmed, and deliberate processes, such as intentionally controlling one's

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thoughts during study, contributing at their respective levels.

Dissociating Thought Constraint From Task Relatedness

Three types of evidence support the dissociation between unconstrained and task-unrelated thought: intraindividual correlations, differential associations between thought reports and task performance, and electroencephalogram measures. All the studies in this section used intermittent thought probes (i.e., experience sampling) to measure thought constraint and task relatedness. Mills et al. (2018), using intraindividual correlation (Bakdash & Marusich, 2017), identified only a moderate positive correlation ($r_{\mathrm{rm}} = .24$, $N = 165$) between unconstrained and task-unrelated thought across participants. A subsequent study by Mills et al. (2021) corroborated these findings, demonstrating that task-unrelated thought accounted for less than 10% of the variance in unconstrained thought (Study 1). Kam et al. (2021) also observed that task-unrelated and unconstrained thought occurred at different rates (66% and 47%, respectively). Both O'Neill et al. (2021) and Alperin et al. (2021) provided more evidence of the decoupling between these thought types. O'Neill et al. asked participants to report the content (on-task or off-task) and the constraint (constrained or unconstrained) of their thoughts separately. They then computed the proportions of thoughts falling into each combination. The analysis identified a statistically significant proportion of thoughts reported as *unconstrained on-task* ($M = .40$, $p < .001$, $N = 111$) and *constrained off-task* ($M = .06$, $p < .001$), using zero as the null hypothesis for comparison. Similarly, in Alperin et al. (2021), task-unrelated thought was described as constrained approximately 30% of the time.

Regarding differential associations, O'Neill et al. (2021) found that task-unrelated but not unconstrained thoughts were strategically modulated as a function of predictable task demand changes. Also showing dissociation of the thought types, G. K. Smith et al. (2018) reported in an experience sampling study and a reanalysis of Mills et al. (2018) that unconstrained thought reports varied across the day, with more constraint in the morning and late afternoon and less constraint in the early afternoon and night; in contrast, task-unrelated thoughts increased throughout the day. Finally, using electroencephalogram, Kam et al. (2021) discovered that event-related parietal P300 activation was linked to task-unrelated but not unconstrained thought, again providing evidence for a dissociation.

Thought Constraint as an Individual-Differences Variable

Within their Dynamic Framework, Christoff et al. (2016) introduced the concept of thought constraint as a consistent individual-difference variable. This idea is grounded in their proposal that levels of thought constraint play a role in enduring psychological disorders (e.g., attention-deficit/hyperactivity disorder [ADHD]). By suggesting that the extent of unconstrained thought might not be merely circumstantial, but a stable trait, Christoff et al. provided a foundation for exploring how individual variations in thought constraint might predict a host of interesting variables (particularly those of clinical disorders). Given the proposition that unconstrained thought may serve as a stable trait-like characteristic, assessing its stability over time becomes crucial. Critically, Christoff et al. argue that a virtue of the dynamic framework account is its ability to "shed new light" on psychological disorders, including anxiety, depression, and ADHD. According to Christoff et al., these disorders are characterized by either extremely constrained or unconstrained thought. However, few studies have investigated the associates of unconstrained thought. Thus, in the present study, we aimed to elucidate the extent to which thought constraint is an informative individual-difference variable.

Proposed Associations Between Unconstrained Thought and Psychological Disorders

Christoff et al.'s (2016) Dynamic Framework proposed systematic relations between levels of unconstrained thought and various psychopathologies, with a particular focus on depressive disorders. They conceptualized depressive disorders as being characterized by excessive thought constraint and difficulties in disengaging from negative thought content. A defining feature of depression, according to their framework, is rumination, which they characterized as the largely involuntary, repetitive, passive focus on symptoms of distress and a fixation on one's problems and negative feelings. Therefore, the Dynamic Framework predicts that depression and rumination, both of which are said to be characterized by excessive thought constraint, should be negatively associated with unconstrained thinking.

Despite the widespread recognition of the Dynamic Framework (Christoff et al., 2016, has been cited 1,441 times on Google Scholar as of November 22, 2024), empirical examinations of its hypotheses, including those related to depression and rumination, remain sparse. A. P. Smith et al.'s (2022) study directly investigated this framework's predictions regarding depressive symptoms. However, A. P. Smith et al.'s findings did not support the hypothesized negative association between depressive symptoms and unconstrained thought. Crucially, while A. P. Smith et al.'s findings cast doubt on the Dynamic Framework's proposed link between thought constraint and depressive symptoms, it did not directly explore the aspect of rumination. Indeed, their study focused solely on depressive symptoms, as indexed by the Depression, Anxiety, and Stress Scale–21 (Lovibond & Lovibond, 1995), which does not include specific measures of rumination. Raffaelli et al. (2021), using a think-aloud protocol, found that people who scored higher on trait brooding (a subtype of rumination) produced thoughts that were considered conceptually narrower (as assessed with natural language processing techniques) than those who scored lower on that measure. While this finding aligns with the Dynamic Framework's predictions, more direct evidence is needed to establish a clear relationship between rumination and unconstrained thought.

In addition to its focus on depression, the Dynamic Framework also addresses the cognitive patterns in anxiety disorders. According to Christoff et al. (2016), anxiety disorders, like depression, are marked by a pattern of repetitive negative thoughts. These thoughts often include intense worry about potential future events, reflecting the excessive engagement of automatic constraints on thought (or, put differently, lower levels of unconstrained thought). Hence, according to the Dynamic Framework, anxiety ought to be negatively associated with unconstrained thought. This prediction, however, also failed to receive support from A. P. Smith et al. (2022).

Continuing the exploration of psychopathologies in the context of the Dynamic Framework, Christoff et al. (2016) offered insights into ADHD. They described ADHD as a disorder that is characterized by excessive variability of thought. This description suggests that individuals reporting higher levels of ADHD symptomatology should also tend to report higher levels of unconstrained thought. In an empirical test of this prediction, Alperin et al. (2021) conducted a study comparing the frequency of unconstrained thoughts in individuals with and without ADHD diagnoses. In support of the Dynamic Framework, the ADHD group (in addition to reporting more task-unrelated thought) differed more ($d = 5.86$) between constrained and unconstrained reports than the controls ($d = 2.71$), with the ADHD group having a numerically greater average percent of unconstrained thought and a numerically lesser average percent of constrained thought than the controls.

Conversely, the study undertaken by A. P. Smith et al. (2022) produced results that deviated from these earlier observations. In their study, A. P. Smith et al. sought to establish a link between unconstrained thought and ADHD symptoms, as measured by the Short Form of the Adult Self-Report ADHD Scale (Kessler et al., 2005). Contrary to Alperin et al.'s (2021) findings and the Dynamic Framework's predictions, they did not find a statistically significant positive association between unconstrained thought and ADHD symptom scores. Thus, whether ADHD is indeed related to unconstrained thoughts remains an open question. Notably, neither A. P. Smith et al. (2022) nor Alperin et al. provided specific association estimates for the hyperactivity and inattention symptoms of ADHD separately. This distinction is crucial as hyperactivity and inattention represent separate facets of ADHD, which could potentially exhibit different patterns with unconstrained thought. This lack of differentiation in the analysis might obscure more nuanced patterns within the ADHD spectrum, suggesting a need for further, more granular investigation.

In reflecting on the broader implications of their findings, A. P. Smith et al. (2022) considered potential methodological issues that might explain the inconsistencies observed in testing the Dynamic Framework's hypotheses. Central to their concerns was the thought probe methodology that is commonly employed in assessing unconstrained thought. For this methodology, during the completion of a cognitive task, participants are intermittently presented with “thought probes,” which consist of a single-item question asking participants to report whether (or the degree to which) their thoughts were, just prior to viewing each probe, unconstrained. Critically, before responding to any probes, participants are provided a multidimensional definition of unconstrained thought (Mills et al., 2018). As noted by A. P. Smith et al., such instructions to participants, because they refer to multiple dimensions of “unconstrained thought,” might not effectively distinguish between elements like effortful concentration and topical thought shifts. Importantly, as A. P. Smith et al. suggested, this lack of clarity in the probe measurement could obscure systematic associations with unconstrained thought. Consequently, this ambiguity in assessment might have compromised the validity of attempts to test the Dynamic Framework’s predictions, potentially explaining the observed results that are inconsistent with it.

The Present Study

Our study aimed to build upon and extend research on unconstrained thought in several ways. First, we sought to replicate previous findings showing dissociations of unconstrained and task-unrelated thought while also evaluating the test–retest reliability of unconstrained thoughts across different tasks. Moreover, in light of the mixed and sometimes contradictory results regarding the clinical correlates of unconstrained thought, we examined several clinical associations. These include associations with depression and ADHD. This reevaluation is crucial not only due to the inconsistent and sometimes negative findings reported in the literature but also in consideration of A. P. Smith et al.’s (2022) suggestion that previous results might have been influenced by methodological issues related to the probes used to measure unconstrained thought. As noted by A. P. Smith et al., these probes may have inadvertently conflated distinct cognitive processes, such as effortful concentration and topical thought shifts, which could have, in turn, produced invalid results. Thus, in our study, we employed both standard unconstrained thought probes and more nuanced probes that separately assessed effortful concentration and topical shifts, with the aim of providing a more accurate and comprehensive understanding of the dynamics of unconstrained thought and its clinical implications.

Method

This study was preregistered on February 6, 2020 (https://osf.io/74e92). Data collection began on February 6, 2020, and concluded on November 24, 2020. Data collection moved from in-person to online in April 2020 and stayed online through November 2020 due to the COVID-19 pandemic. A subset of the analyses presented here were executed for a dissertation project by the first author of this article. That dissertation can be found at https://thesiscommons.org/cxevt/. The proposed analyses for the dissertation were written after data collection but before analyses were conducted and can be found at https://osf.io/h5zqs. Changes from the preregistration to the proposed analyses reflect an update on our intentions regarding analyses.

Transitioning From In-Person to Online Data Collection

As specified in the preregistration, we 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., 2013) 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. We 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, we applied additional exclusions not included in the original preregistration as it was unknown that data collection would move online (numbers of exclusions provided below). We used response times to probes to screen data from people who participated online. We excluded data from all analyses from participants whose single probe response time exceeded 5 min. Moreover, we scored any probe response that took over 15 s as missing data. We also dropped from all analyses data from participants who did not provide at least six valid (i.e., responses in less than 15 s) probe responses for either the MRT or SART task. Like the MRT, we excluded, from all analyses, data from participants who did not respond to at least 10% of the SART trials. All exclusions were determined before any inferential tests were conducted.

Participants

From February 2020 to March 2020, we 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 psychology course and received partial credit toward a class requirement for their participation. We preregistered to stop collecting data at the end of a semester where we collected data from at least 250 people. We chose a sample size of at least 250 participants because 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, 627 participants completed informed consent. After exclusions (details provided in the Data Loss subheading), 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 (40%), 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 ($SD = 1$). Among the respondents who provided information about their race (excluding three participants who declined and one who responded erroneously), 341 identified as White (77%), 21 as Asian, 40 as Black, one as Native American, 19 as Hawaiian Native, eight as multiracial, and 11 as other.

General Procedure

In-Person Laboratory Sessions

Laboratory sessions had either one or two participants and lasted approximately 90 min. 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 providing informed consent, all participants completed tasks in the following order: Operation Complex Span (Unsworth et al., 2005), the SART (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 (BDI; Beck et al., 1996), the MRT (Seli et al., 2013), and then a brief demographics questionnaire. All tasks were computerized and administered on desktop computers using E-Prime software (Psychology Software Tools, 2016, Pittsburg, Pennsylvania).

Online Sessions

Participants completed the tasks on a laptop or desktop computer (they could not use a tablet or cell phone). The tasks were programmed in JavaScript/HTML/CSS. Because of the move to online testing, we dropped the operation and symmetry complex span tasks from the test battery due to validity concerns (e.g., using a calculator for math tasks or writing down items meant to be held in working memory). Thus, we did not use data from the complex span tasks in this study.

Measures

Sustained-Attention Tasks

SART. 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 four blocks, each containing three miniblocks of 45 trials. During each miniblock, 40 target stimuli (vegetables) and five nontarget stimuli (animals) appeared. Each word was presented for 300 ms immediately followed by a masking procedure (i.e., a blank screen with "xxx" in the center) for 1,500 ms. 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 response times to the animal trials (e.g., nontarget/"go"). To become oriented with the task, participants briefly practiced a 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. The SART task lasted approximately 20 min. Nine sets of thought probes were presented per block, with three probes occurring per miniblock (for a total of 36 probes). The probes appeared pseudorandomly after three out of five target words were presented per miniblock.

MRT. The MRT presented thought probes during a continuous task (Seli et al., 2013). Specifically, participants pressed the spacebar in sync with a metronome tone at the rate of one tone every 1,300 ms. 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 sets of thought probes presented pseudorandomly within the middle 40 trials of each 50-trial block (Seli et al., 2013). This task lasted for approximately 20 min. Response time variability was the dependent measure. Response times were the time between the tone presentation and the spacebar press.

Thought Probes. Participants were instructed to respond to the following probes: "Was your mind moving about freely?" Responses included 1 (*not at all*), 2 (*somewhat*), 3 (*very much*), and 4 (*I don't know*). We modified these 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, we simplified the scale, added labels to each numerical anchor, and added the "I don't know" response option. As per the preregistration, when aggregated, "not at all" was scored as 0, "somewhat" was scored as 1, and "very much" was scored as 2.

Previous studies examining thought constraint via probes had participants respond on a 7-point Likert-type scale (Mills et al., 2018) or make a dichotomous judgment about whether their thoughts were unconstrained (O'Neill et al., 2021; A. P. Smith et al., 2022). These studies presume that participants can accurately (and easily) assess this attribute of thought. The "I don't know" response allowed for assessing the epistemic certainty of these judgments. A. P. 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 unconstrained (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.

Following our preregistration, we aggregated the unconstrained thought variable in two ways: one with "I don't know" removed from only the numerator, and one with removal from both numerator and denominator. If these variables correlated >.90, we committed to using the former. SART: $r = .94$, MRT: $r = .92$. After realizing that including "I don't know" responses in the denominator would artificially lower the unconstrained thought estimate for people who reported "I don't know," we deviated from preregistration by using the aggregated measure with "I don't know" responses removed from the denominator and numerator.

After reporting on whether 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*), and 8 (*other*). Task-unrelated thought was the proportion of Probe Responses 3–8. Thinking about the task (Option 1) was scored as task-related thought. Thoughts of one's performance (Option 2) were categorized as task-related interference and scored as missing data (this is a common convention [e.g., Kane et al., 2016; McVay & Kane, 2009; Meier, 2021] because these reports are ambiguous in regard to being task-related or unrelated [Kane et al., 2021; Robison et al., 2019] and differentially related to task performance from on-task thought [McVay et al., 2013]); all other responses were interpreted as task-unrelated. Participants were then asked, "Were your thoughts shifting amongst multiple topics?" with response options 1 (*yes*), 2 (*no*), and 3 (*I don't know*). Finally, participants were asked, "Were you effortfully concentrating on your thoughts?" Responses were 1 (*yes*), 2 (*no*), and 3 (*I don't know*). The computer-based instructions and descriptions of response options provided to participants can be found at https://osf.io/29d57/.

Questionnaires

Ruminative Response Scale. 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). Response options were 1 (*almost never*), 2 (*sometimes*), 3 (*often*), and 4 (*almost always*). Scores were summed for an overall score, with higher scores indicating higher reports of rumination. Reported internal consistency ranges are solid, ranging from .99 to .92 (Treynor et al., 2003).

ADHD Self-Report Scale. Participants completed the ADHD Self-Report Scale (DuPaul et al., 1998), which assesses each inattentive and hyperactive symptom listed with the *Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision* criteria for ADHD. This scale has separate inattention and hyperactivity measures, allowing for explicit analyses regarding the relationship of inattentive versus hyperactive subtypes. Response options included 1 (*never or rarely*), 2 (*sometimes*), 3 (*often*), and 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. Participants completed the 40-item State-Trait Anxiety Inventory for Adults (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 $\alpha = .86–.95$ (Spielberger, 1983).

BDI–Second Edition. The BDI–II is a 21-item scale that assesses for depression (Beck et al., 1996). For this study, we excluded the suicidality item, making it a 20-item scale. The BDI–II has shown strong internal consistency ($\alpha = .91$) and test–retest reliability ($r = .73–.96$; 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. We later included this item in data collected online. Because of the item omission, scores for this measure were based on the 19 items provided to all people.

Mind Excessively Wandering Scale. The Mind Excessively Wandering Scale is a 12-item scale developed to measure excessive mind wandering in individuals who have ADHD (Mowlem et al., 2019). Responses include 0 (*not at all or rarely*), 1 (*some of the time*), and 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. The Mind Excessively Wandering Scale was included for exploratory purposes and is not discussed further in this article.

Data Analysis

Any analyses reported in this article that were not included in the preregistration or proposed analyses document were made in response to the data. We performed analyses in the R system for statistical analysis (R Core Team, 2019). Data, analysis code, and outputs are available at the link https://osf.io/29d57/.

Data Loss

We applied all exclusion criteria separately for online and in-the-lab participants and the SART and MRT. One hundred eight participants were dropped from the online SART data, and nine were dropped from in-the-lab SART data. After combining the remaining lab and online participants, we had 507 participants with complete

SART data. One hundred twelve participants were dropped from the online MRT data, and two were dropped from in-the-lab MRT data. After combining the remaining lab and online participants, we had 509 participants with complete MRT data.

Per the preregistration, we retained participants if they had both SART and MRT data. After applying this criterion, 445 participants remained and were used for the following analyses. We used the maximum amount of data possible for all analyses; thus, *N*s differ depending on the measure and modality.

Addressing Modality

We conducted linear mixed models with random intercepts to assess whether modality (i.e., online vs. in the lab) influenced the association between thought type and outcome variables. We included predictors for modality and the modality by thought report interaction in each model. If the interaction term was statistically significant, we computed the bivariate correlation for the thought report type only using the online sample (because correlation estimates with the lab sample size would be unstable; Schönbrodt & Perugini, 2013). These linear mixed models were not preregistered prior to data collection as the transition to online testing was unforeseen, but we committed to this approach in our proposed analyses document prior to data analysis.

Results

Descriptive statistics and correlations for all variables can be seen in Tables 1 and 2.

Associating Thought Constraint and Task Relatedness

To estimate the association between unconstrained and task-unrelated thought, we used a linear model with task relatedness as the predictor variable and thought constraint as the outcome variable. We conducted separate models for

Table 1
Descriptive Statistics

Measure	*M*	*SD*	Min	Max	Skew	Kurtosis	*N*
SART task-unrelated thought	0.57	0.26	0	1	−0.38	−0.61	444
SART unconstrained thought	0.92	0.40	0	2	0.03	−0.30	445
SART effortful concentration	0.50	0.29	0	1	0.00	−1.08	445
SART topic switching	0.48	0.26	0	1	0.05	−0.93	445
SART response time *SD*	175.23	74.38	60	498	1.60	2.99	445
SART *d′*	1.70	1.09	−2.54	4.10	−0.14	−0.59	445
MRT task-unrelated thought	0.77	0.28	0	1	−1.36	0.84	444
MRT unconstrained thought	1.30	0.56	0	2	−0.64	−0.56	445
MRT effortful concentration	0.40	0.36	0	1	0.47	−1.28	443
MRT topic switching	0.63	0.32	0	1	−0.58	−0.93	444
MRT response time variability (log)	10.90	1.37	7.11	12.66	−0.59	−0.92	445
ADHD total	20.49	11.34	0	54	0.62	−0.10	445
ADHD inattention	10.88	6.86	0	27	0.43	−0.77	445
ADHD hyperactivity	9.61	5.64	0	27	0.81	0.49	445
State anxiety	44.33	12.19	20	75	0.28	−0.61	445
Trait anxiety	45.68	12.27	20	74	0.16	−0.73	445
Rumination	49.95	15.52	23	87	0.30	−0.83	445
Depression	14.37	11.47	0	52	0.90	0.16	419
MEWS	19.10	9.92	0	36	0.10	−1.08	445

Note. Unconstrained thought and task-unrelated thought values are the average of participants' probe responses for each respective thought type (with all "I don't know" responses removed). Min = minimum; Max = maximum; SART = Sustained Attention to Response Task (Robertson et al., 1997); MRT = Metronome Response Task (Seli et al., 2013); *d′* = response to nontarget stimulus minus false alarm responses to the target stimulus; ADHD = attention-deficit/hyperactivity disorder; ADHD total = sum of all responses on ADHD Self-Report Scale; ADHD inattentive/ADHD hyperactive = sum of responses on each subscale of ADHD Self-Report Scale; 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); MEWS = Mind Excessively Wandering Scale.

Table 2

Simple Bivariate Correlations Among Participant-Level Measures (With Cronbach's α Point Estimates for Self-Report Psychopathology Measures on the Diagonal)

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. SART task-unrelated thought	—																		
2. SART unconstrained thought	.66	—																	
3. SART effortful concentration	−.20	−.21	—																
4. SART topic switching	.39	.56	.06	—															
5. SART response time *SD*	.10	.10	−.05	.03	—														
6. SART *d′*	−.10	−.11	.08	−.07	−.48	—													
7. MRT task-unrelated thought	.46	.30	−.13	.19	−.04	.09	—												
8. MRT unconstrained thought	.31	.40	−.14	.29	−.12	.11	.74	—											
9. MRT effortful concentration	−.05	−.06	.59	.09	.10	−.09	−.32	−.28	—										
10. MRT topic switching	.19	.27	−.02	.47	−.16	.13	.42	.64	−.04	—									
11. MRT response time *SD* (log)	.10	.09	.02	.13	.16	−.17	−.06	−.03	.02	−.07	—								
12. ADHD total	.09	.16	−.04	.17	.00	−.10	.06	.07	−.02	.11	.08	—							
13. ADHD inattention	.07	.15	−.06	.17	−.02	−.07	.10	.11	−.03	.13	.09	.92	.86						
14. ADHD hyperactivity	.10	.15	−.02	.13	.02	−.12	.01	.01	−.01	.05	.06	.89	.64	.77					
15. State anxiety	.12	.16	−.07	.11	−.05	−.07	.08	.05	−.05	.07	.09	.53	.54	.40	.93				
16. Trait anxiety	.09	.13	−.05	.13	−.10	−.05	.08	.06	−.05	.10	.02	.58	.62	.41	.78	.93			
17. Rumination	.13	.15	−.01	.14	−.12	.01	.06	.05	−.01	.12	.05	.60	.62	.46	.65	.77	.95		
18. Depression	.07	.12	−.02	.07	−.09	−.04	.09	.08	−.01	.08	.05	.59	.62	.44	.69	.83	.76	.94	
19. MEWS	.09	.15	−.01	.15	−.09	.01	.10	.11	−.01	.16	.04	.68	.66	.56	.52	.63	.61	.59	.91

Note. Unconstrained thought and task-unrelated thought values are the average of participants' probe responses for each respective thought type (with all "I don't know" responses removed). SART = Sustained Attention to Response Task (Robertson et al., 1997); MRT = Metronome Response Task (Seli et al., 2013); ADHD = attention-deficit/hyperactivity disorder; MEWS = Mind Excessively Wandering Scale.

thought reports collected via the SART and the MRT. In the first model, SART task relatedness was significantly associated with SART thought constraint ($b = 0.68$, $t = 5.5$, $p < .001$). The parameter for modality was as well ($b = -0.24$, $t = -2.8$, $p = .01$), signifying that unconstrained thought was reported less by our online sample. The interaction between modality and SART task relatedness was statistically significant ($b = 0.41$, $t = 3.0$, $p = .003$). Task-unrelated thought was more strongly associated with unconstrained thought online than in the lab. Thus, we 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 task-unrelated thought more often also were more likely to report unconstrained thought, $r(347) = .70$, $p < .001$, 95% confidence interval (CI) [.64, .75], Bayes factor $(\text{BF})_{10} = 3.13 \times 10^{48}$.

For the MRT, task relatedness was associated with thought constraint ($b = 1.67$, $t = 8.8$, $p < .001$). Modality ($b = 0.22$, $t = 1.3$, $p = .19$) and the interaction between modality and task relatedness were not significantly associated ($b = -0.27$, $t = -1.32$, $p = .19$); accordingly, we used the full sample for the interindividual estimate between task relatedness and thought constraint. Consistent with the SART findings, people with more reports of task-unrelated thought also reported more unconstrained thought, $r(442) = .73$, $p < .001$, CI [.68, .77], $\text{BF}_{10} = 3.95 \times 10^{69}$.

We also computed intraindividual correlations between thought constraint and task relatedness. A repeated measures correlation is one suitable approach for comparing paired measures on multiple occasions, particularly in studies aiming to examine intraindividual associations (i.e., associating thought constraint and task relatedness at the trial level; Bakdash & Marusich, 2017). Unconstrained thought and task-unrelated thought were coded dichotomously for these analyses. For task-unrelated thought probes, Responses 3–8 were scored as task-unrelated thought, Response 1 was scored as task-related, and Response 2 was scored as missing data. For unconstrained thought probes, responses of "not at all" were scored as 0, and responses of "somewhat" and "very much" were scored as 1. Like Kam et al. (2021; $r_{\text{rm}} = .51$), we found the average correlation between unconstrained and task-unrelated thought across participants was strong in both the SART and MRT, SART: $r_{\text{rm}}(10428) = .61$, CI [.60, .62], $p < .001$; MRT: $r_{\text{rm}}(5619) = .53$, CI [.51, .55], $p < .001$.

Stability of Thought Constraint and Task Relatedness

When assessing the stability of unconstrained and task-unrelated thought, we conducted two linear models to determine if modality was a moderating variable. Here, "stability" refers to thought constraint as a relatively stable characteristic of individuals, akin to test–retest reliability, wherein thought patterns remain consistent across different tasks and contexts. We included terms for modality, thought type, and the interaction between modality and thought type. MRT thought constraint was significantly associated with SART thought constraint ($b = 0.22$, $t = 2.7$, $p = .01$). Terms for modality and the interaction between modality and MRT thought constraint were not statistically significant ($b = -0.08$, $t = -0.6$, $p = .53$; $b = 0.09$, $t = 1.0$, $p = .32$, respectively). Thus, the full sample was used to estimate the association. Consistent with previous research suggesting that unconstrained thought is a stable individual-differences variable (O'Neill et al., 2021), unconstrained thought was strongly correlated across the MRT and the SART, $r(443) = .41$, $p < .001$, CI [.33, .48], $\text{BF}_{10} = 3.92 \times 10^{16}$.

MRT task-unrelated thought was statistically significantly associated with SART task-unrelated thought ($b = 0.27$, $t = 3.5$, $p < .001$). Neither modality ($b = -0.08$, $t = -0.8$, $p = .45$) nor the interaction between modality and MRT task relatedness was statistically significant ($b = 0.16$, $t = 1.4$, $p = .17$). Consistent with prior research that has shown that task-unrelated thought propensity for subjects is correlated across tasks (e.g., Kane et al., 2007, 2016; Welhaf & Kane, 2024), task-unrelated thought strongly correlated across the MRT and the SART, $r(441) = .45$, $p < .001$, CI [.37, .52], $\text{BF}_{10} = 2.32 \times 10^{20}$.

Unconstrained Thought, Task-Unrelated Thought, and Psychological Disorders

We used linear models and bivariate correlations to test the directional predictions from Christoff et al. (2016) for the associations between unconstrained thought and self-reported symptoms of depression, rumination, anxiety, and ADHD. Like previous analyses, the linear models were used to identify if there was a significant interaction between modality and thought type. Then, after determining whether to use the full or online sample, we estimated associations between thought type and questionnaire. Finally, we used linear regression models to determine if thought constraint explained unique variance beyond (i.e., incremental validity) that of task relatedness. Tests of incremental validity were conducted when there were statistically significant associations between thought type and the self-report questionnaire. In these models, we entered task relatedness in the first step and thought constraint in the second step. In cases where we used the online sample for an association estimate, we used the online sample for tests of incremental validity.

Depression

In separate models, SART unconstrained thought and SART task-unrelated thought were not significantly associated with scores on the BDI (unconstrained thought: $b = -2.46$, $t = -0.6$, $p = .53$; task-unrelated thought: $b = -8.84$, $t = -1.6$, $p = .12$). Modality was not significantly associated with BDI scores in either model (unconstrained thought: $b = -4.30$, $t = -1.1$, $p = .29$; task-unrelated thought: $b = -5.62$, $t = -1.6$, $p = .12$). The interaction between SART unconstrained thought and modality was not statistically significant ($b = 6.76$, $t = 1.6$, $p = .12$), but the interaction between SART task-unrelated thought and modality was ($b = 13.83$, $t = 2.3$, $p = .02$), reflecting that the association between SART task relatedness and BDI scores was stronger for data collected online. Using the full sample to assess the association, more unconstrained thought positively correlated with more depressive symptoms, $r(417) = .12$, $p = .02$, CI [.02, .21], $BF_{10} = 2.11$. Using the online sample, those who more frequently endorsed task-unrelated thought reported more depressive symptoms, $r(347) = .11$, $p = .04$, CI [.01, .21], $BF_{10} = 1.02$. The positive association between depressive symptoms and unconstrained thought contradicts predictions made by Christoff et al. (2016); however, the positive association between task-unrelated thought and depressive symptoms is consistent with previous research (Deng et al., 2014; Hoffmann et al., 2016; Smallwood et al., 2007, 2009). Unconstrained thought did not explain unique variance above and beyond task relatedness ($R^2\Delta = .01$, $p = .09$).

In distinct models, MRT unconstrained thought ($b = 1.54$, $t = 0.5$, $p = .59$) and MRT task-unrelated thought ($b = 4.15$, $t = 0.6$, $p = .53$) were not associated with BDI scores. Modality was also not significantly associated with BDI scores in either model ($b = 1.60$, $t = 0.37$, $p = .72$; $b = 2.45$, $t = 0.43$, $p = .67$). The interactions between modality and MRT unconstrained thought ($b = 0.32$, $t = 0.10$, $p = .92$) and MRT task-unrelated thought ($b = -0.40$, $t = -0.06$, $p = .95$) were not significant. Neither MRT unconstrained thought, $r(417) = .09$, $p = .08$, CI [−.01, .18], $BF_{10} = 0.55$, nor MRT unconstrained thought was significantly associated with the BDI, $r(416) = .09$, $p = .07$, CI [−.01, .18], $BF_{10} = 0.61$.

Rumination

Neither SART unconstrained thought ($b = -0.81$, $t = -0.2$, $p = .84$) nor SART task-unrelated thought ($b = -1.60$, $t = -0.3$, $p = .80$) was significantly associated with rumination scores. Modality was not significantly associated with rumination scores in either model (thought constraint: $b = -1.66$, $t = -0.4$, $p = .71$; $b = -0.82$, $t = -0.2$, $p = .85$). We did not find a significant interaction between modality and thought type (SART unconstrained thought: $b = 7.19$, $t = 1.61$, $p = .11$; SART task-unrelated thought: $b = 10.23$, $t = 1.5$, $p = .14$). Inconsistent with Christoff et al.'s (2016) speculation, unconstrained thought was positively associated with rumination scores, $r(443) = .13$, $p = .01$, CI [.04, .22], $BF_{10} = 4.29$. Task-unrelated thought was positively associated with rumination, $r(442) = .11$, $p = .02$, CI [.02, .20], $BF_{10} = 1.82$. When assessing incremental validity, unconstrained thought did not account for unique variance ($R^2\Delta = .004$; $p = .17$).

Neither MRT unconstrained thought nor MRT task-unrelated thought was associated with rumination scores ($b = 4.23$, $t = 1.2$, $p = .22$ and $b = 9.00$, $t = 1.2$, $p = .24$, respectively). In neither model was modality significantly associated with rumination ($b = 8.96$, $t = 1.7$, $p = .09$; $b = 9.78$, $t = 1.5$, $p = .15$). We found no evidence of a Modality and Thought Type interaction in either model (MRT unconstrained thought: $b = -2.84$, $t = -0.8$, $p = .44$; MRT task-unrelated thought: $b = -5.59$, $t = -0.7$, $p = .49$). Neither MRT unconstrained thought nor MRT *t* task-unrelated thought was significantly associated with rumination, $r(443) = .06$, $p = .23$, CI [−.04,

.15], $BF_{10} = 0.23$; $r(442) = .06$, $p = .21$, CI [−.03, .15], $BF_{10} = 0.24$, respectively.

ADHD

Total ADHD Score. In separate models, neither SART unconstrained nor task-unrelated thought was significantly associated with total ADHD scores ($b = 2.23$, $t = 0.8$, $p = .44$; $b = -4.59$, $t = -1.0$, $p = .31$). In neither model was modality significantly associated with total ADHD scores ($b = 1.49$, $t = 0.46$, $p = .64$; $b = -1.89$, $t = -0.61$, $p = .55$). Modality did not significantly interact with thought type in either model (SART unconstrained thought: $b = 2.38$, $t = 0.73$, $p = .47$; SART task-unrelated thought: $b = 10.00$, $t = 1.96$, $p = .051$). Supporting predictions made by Christoff et al. (2016), people who reported more unconstrained thought reported more ADHD symptoms, $r(443) = .15$, $p = .002$, CI [.05, .24], $BF_{10} = 13.85$. SART task-unrelated thought was not significantly associated with total scores of ADHD, $r(442) = .08$, $p = .09$, CI [−.01, .17], $BF_{10} = 0.46$. Unconstrained thought accounted for unique variance beyond task relatedness ($R^2\Delta = .02$; $p = .01$).

Neither MRT unconstrained thought ($b = 2.15$, $t = 0.9$, $p = .39$) nor MRT task-unrelated thought ($b = 2.83$, $t = 0.5$, $p = .61$) was associated with total ADHD score. Modality also did not significantly associate with total ADHD scores in either model ($b = 4.75$, $t = 1.2$, $p = .22$; $b = 4.01$, $t = 0.8$, $p = .42$). The interactions between modality and MRT unconstrained thought ($b = -0.66$, $t = -0.3$, $p = .81$) and modality and task-unrelated thought ($b = -0.08$, $t = -0.01$, $p = .99$) were not significant. In the full sample, both MRT unconstrained thought, $r(443) = .07$, $p = .14$, CI [−.02, .16], $BF_{10} = 0.32$, and MRT task-unrelated thought, $r(442) = .06$, $p = .25$, CI [−.04, .15], $BF_{10} = 0.22$, did not significantly associate with total ADHD scores.

Inattention ADHD Score. Neither SART unconstrained nor task-unrelated thought was significantly associated with inattention scores ($b = 0.99$, $t = 0.6$, $p = .57$; $b = -3.12$, $t = -1.1$, $p = .26$). In neither model was modality associated with inattentive symptoms ($b = 1.32$, $t = 0.7$, $p = .50$ and $b = -0.48$, $t = -0.3$, $p = .80$). The interactions between modality and SART unconstrained ($b = 1.50$, $t = 0.8$, $p = .45$) and SART task-unrelated thought ($b = 5.71$, $t = 1.9$, $p = .07$) were also not significant. SART unconstrained thought was significantly associated with scores of inattention, $r(443) = .13$, $p = .01$, CI [.04, .22], $BF_{10} = 4.54$. Those reporting more unconstrained thoughts in the SART reported more inattentive symptoms. SART task-unrelated thought was not significantly associated with inattention symptoms, $r(442) = .06$, $p = .22$, CI [−.04, .15], $BF_{10} = 0.24$. Unconstrained thought ($R^2\Delta = .01$; $p = .01$) accounted for unique variance above and beyond task relatedness in predicting inattentive symptoms.

In different models, MRT unconstrained thought and task-unrelated thought were not significantly associated with ADHD inattention scores ($b = 1.94$, $t = 1.3$, $p = .20$ and $b = 2.35$, $t = 0.7$, $p = .49$, respectively). Additionally, modality was not significantly associated with inattention scores in either model ($b = 3.64$, $t = 1.6$, $p = .12$; $b = 2.74$, $t = 0.93$, $p = .36$). The interaction between modality and thought type was not significant in either model (MRT unconstrained thought interaction: $b = -0.60$, $t = -0.4$, $p = .71$; MRT task-unrelated thought: $b = 0.21$, $t = 0.06$, $p = .95$). MRT unconstrained thought was significantly associated with scores of inattention, $r(443) = .11$, $p = .03$, CI [.01, .20], $BF_{10} = 1.34$. Those reporting more unconstrained thought reported more inattention symptoms. MRT task-unrelated thought was not associated with scores of inattention, $r(442) = .09$, $p = .06$, CI [−.01, .18], $BF_{10} = 0.60$. Unconstrained thought did not demonstrate incremental validity beyond task relatedness ($R^2\Delta = .01$; $p = .15$).

Hyperactivity ADHD. Neither SART unconstrained thought nor task-unrelated thought significantly associated with hyperactivity ($b = 1.24$, $t = 0.9$, $p = .39$; $b = -1.41$, $t = -0.6$, $p = .52$). Modality did not associate significantly with hyperactivity symptoms in either model ($b = 0.17$, $t = 0.1$, $p = .91$; $b = -1.41$, $t = -0.9$, $p = .37$). The interaction between modality and thought type, in either case, was not significant (SART unconstrained thought: $b = 0.89$, $t = 0.54$, $p = .59$; SART task-unrelated thought: $b = 4.29$, $t = 1.68$, $p = .09$). More unconstrained thought reports were associated with more hyperactivity symptoms, $r(443) = .14$, $p = .003$, CI [.05, .23], $BF_{10} = 8.10$. Task-unrelated thought reports were not associated with hyperactivity symptoms, $r(442) = .09$, $p = .06$, CI [−.003, .18], $BF_{10} = 0.67$. Unconstrained thought accounted for unique variance beyond that of task-unrelated thought ($R^2\Delta = .01$; $p = .03$).

Neither MRT unconstrained thought ($b = 0.21$, $t = 0.2$, $p = .87$) nor task-unrelated thought ($b = 0.48$, $t = 0.1$, $p = .86$) was significantly associated with hyperactivity scores. Terms for modality were also not associated with hyperactivity symptoms ($b = 1.11$, $t = 0.6$, $p = .57$; $b = 1.27$, $t = 0.51$, $p = .61$). The interaction between modality and thought type was not statistically significant in either model (MRT unconstrained thought: $b = -0.01$, $t = -0.1$, $p = .96$; MRT task-unrelated thought: $b = -0.29$, $t = -0.1$, $p = .92$). MRT unconstrained thought was not associated with scores of hyperactivity, $r(443) = .01$, $p = .83$, CI [−.08, .10], $BF_{10} = 0.11$. Likewise, MRT task-unrelated thought was not associated with symptoms of hyperactivity, $r(442) = .004$, $p = .94$, CI [−.09, .10], $BF_{10} = 0.11$.

Anxiety

State Anxiety. Neither SART unconstrained thought nor SART task-unrelated thought was associated with state anxiety ($b = -2.85$, $t = -0.9$, $p = .36$; $b = -4.63$, $t = -1.0$, $p = .34$). In neither case was modality associated with state anxiety ($b = -3.39$, $t = -1.0$, $p = .33$; $b = -2.11$, $t = -0.63$, $p = .53$). The interaction between modality and thought type was significant for SART unconstrained thought ($b = 8.59$, $t = 2.5$, $p = .014$). The association between unconstrained thought and state anxiety was stronger for online data. Likewise, the association between SART task-unrelated thought and modality ($b = 11.75$, $t = 2.2$, $p = .03$) was significant. The association between task-unrelated thought and state anxiety was also stronger for online data. Contrary to the predictions made by Christoff et al. (2016), SART unconstrained thought was positively associated with state anxiety scores, $r(348) = .19$, $p < .001$, CI [.08, .28], $BF_{10} = 54.43$. Individuals who endorsed more unconstrained thoughts reported higher levels of state anxiety. There was a positive association between state anxiety and task-unrelated thought, $r(347) = .15$, $p = .01$, CI [.04, .25], $BF_{10} = 5.48$. Unconstrained thought predicted variance beyond that accounted for by task-unrelated thought ($R^2\Delta = .01$; $p = .04$).

MRT unconstrained thought was not significantly associated with state anxiety ($b = 1.90$, $t = 0.7$, $p = .48$), nor was task-unrelated thought ($b = 8.86$, $t = 1.5$, $p = .13$). Modality was also not associated with state anxiety in either model ($b = 5.39$, $t = 1.3$, $p = .20$ and $b = 8.99$, $t = 1.7$, $p = .09$). The interactions between MRT unconstrained thought and modality ($b = -0.58$, $t = -0.2$, $p = .84$), as well as MRT task-unrelated thought and modality ($b = -5.16$, $t = -0.8$, $p = .41$), were not significant. MRT unconstrained thought was not associated with state anxiety, $r(443) = .06$, $p = .25$, CI [−.04, .15], $BF_{10} = 0.22$, nor was MRT task-unrelated thought, $r(442) = .08$, $p = .08$, CI [−.01, .17], $BF_{10} = 0.53$.

Trait Anxiety. In independent models, neither SART unconstrained thought ($b = -4.46$, $t = -1.4$, $p = .16$) nor task-unrelated thought was significantly associated with trait anxiety ($b = -3.50$, $t = -0.7$, $p = .48$). In the unconstrained thought model, the term for modality was significant ($b = -7.64$, $t = -2.2$, $p = .03$). Scores of trait anxiety were lower for those who participated online. Additionally, the interaction between modality and unconstrained thought ($b = 9.59$, $t = 2.7$, $p = .01$) was significant. Online participants reported a stronger relationship between unconstrained thought and trait anxiety; consequently, the online sample was used for the association estimate. SART task-unrelated thought, however, did not significantly interact with modality ($b = 9.96$, $t = 1.8$, $p = .07$), nor was the term for modality significant ($b = -4.45$, $t = -1.3$, $p = .19$), so the full sample was used for the association estimate. Both SART unconstrained thought, $r(348) = .17$, $p = .002$, CI [.06, .26], $BF_{10} = 16.02$, and SART task-unrelated thought, $r(442) = .09$, $p = .05$, CI [.01, .18], $BF_{10} = 0.75$, were positively associated with trait anxiety. When predicting (statistically) trait anxiety, unconstrained thought did not account for unique variance above and beyond that of task-unrelated thought ($R^2\Delta = .01$; $p = .09$).

MRT unconstrained thought ($b = 2.54$, $t = 0.9$, $p = .35$) and task-unrelated thought ($b = 6.67$, $t = 1.1$, $p = .27$) were not associated with trait anxiety. In neither model was the term for modality significant ($b = 2.95$, $t = 0.7$, $p = .49$; $b = -3.10$, $t = -0.5$, $p = .63$). The interaction between modality and thought type was not significant in either model (MRT unconstrained thought: $b = -1.25$, $t = -0.4$, $p = .67$; MRT task-unrelated thought: $b = -3.10$, $t = -0.5$, $p = .63$). Trait anxiety was not significantly associated with either MRT unconstrained thought, $r(443) = .07$, $p = .17$, CI [−.03, .16], $BF_{10} = 0.28$, or MRT task-unrelated thought, $r(442) = .09$, $p = .07$, CI [−.01, .17], $BF_{10} = 0.57$.

Task Performance Associations

We tested for differential associations between unconstrained thought, task-unrelated thought, 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, 2019). 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 unconstrained thought, modality, and their interaction; one with task-unrelated thought, modality, and their interaction; and finally, one with unconstrained thought, task-unrelated thought, and their interaction. In these models, task-unrelated thought was dichotomously coded as on- or off-task. Unconstrained thought responses were mean-centered within each subject. Per our proposed analyses document (https://osf.io/h5zqs), if interaction terms were not significant in both models, the third model included task-unrelated thought, unconstrained thought, and their interaction as predictors across testing modalities. If the interaction terms were significant in either of the first two models, we incorporated testing modality and its interaction terms with all other predictors in the third model.

The first set of models examined the relationship between SART accuracy, unconstrained thought, and task-unrelated thought. In separate models, unconstrained thought predicted variance in response accuracy ($b = -0.58$, $Z = -7.4$, $p < .001$), as did task-unrelated thought ($b = -1.10$, $Z = -8.8$, $p < .001$). Both thought reports associated with poorer accuracy. In both models, SART accuracy was negatively associated with testing online (unconstrained thought: $b = -0.53$, $Z = -3.2$, $p = .001$; task-unrelated thought: $b = -0.51$, $Z = -2.9$, $p = .004$). The interaction terms for unconstrained thought and modality ($b = -0.06$, $Z = -0.7$, $p = .51$) and task-unrelated thought and modality ($b = 0.02$, $Z = 0.2$, $p = .85$) were not statistically significant; as such, these interaction terms were not included in the model that predicted SART accuracy from unconstrained thought, task-unrelated thought, and their interaction. In this model, both unconstrained thought ($b = -0.41$, $Z = -7.4$, $p < .001$) and task-unrelated thought ($b = -0.69$, $Z = -11.1$, $p < .001$) predicted unique variance in accuracy. The interaction between task-unrelated and unconstrained thought did not ($b = 0.01$, $Z = 0.2$, $p = .88$).

The second set of models examined the relationship between SART response time variability, unconstrained, and task-unrelated thought. As with the above, separate models were conducted within this set. The first model included unconstrained thought, modality, and their interaction as predictors. The second model incorporated task-unrelated thought, modality, and their interaction as predictors. Lastly, the third model featured unconstrained, task-unrelated thought, and their interaction as predictors. Unconstrained thought was not associated with unique variance in response time variability ($b = 8.0$, $t = 1.9$, $p = .06$), while task-unrelated thought was ($b = 19.0$, $t = 3.1$, $p = .002$). In both models, online testing modality was associated with more response time variability (unconstrained: $b = 13.0$, $t = 2.4$, $p = .02$; task-unrelated: $b = 15.0$, $t = 2.2$, $p = .03$). The interaction between thought probe type and modality was not significant in either model (unconstrained: $b = -3.0$, $t = -0.6$, $p = .57$; task-unrelated: $b = 8.0$, $t = -1.2$, $p = .26$). Thus, we did not include a term for modality in the model. Unconstrained thought did not predict unique variance in response time variability ($b = -0.60$, $t = -1.5$, $p = .13$); however, task-unrelated ($b = 14.0$, $t = 3.9$, $p < .001$) and the interaction between unconstrained and task-unrelated thought were significant predictors ($b = 11.0$, $t = 2.2$, $p = .03$). The interaction term reflects an increase in response time variability between when a subject reports an unrelated and unconstrained thought than compared to when they report on-task and constrained thought.

The third set of models examined the relationship between MRT response time variability, unconstrained, and task-unrelated thought. As with the above, three separate models were conducted within this set. Unconstrained thought was a significant predictor of MRT response time variability ($b = 0.24$, $t = 2.6$, $p = .01$), while task-unrelated thought was not ($b = 0.27$, $t = 1.9$, $p = .06$). Data collected online were associated with greater response time variability for both unconstrained ($b = 1.50$, $t = 10.2$, $p < .001$) and task-unrelated thought ($b = 1.40$, $t = 6.9$, $p = .01$). In neither model was the thought probe by modality interaction statistically significant (unconstrained: $b = 0.03$, $t = 0.2$, $p = .81$; task-unrelated: $b = 0.20$, $t = 1.2$, $p = .24$). Because the interaction terms were not significant, modality was not included in the following model. In the model that predicted MRT response time variability from unconstrained, task-unrelated thought, and their interaction, both unconstrained (b = 0.23, t = 2.2, p = .03) and task-unrelated thought (b = 0.24, t = 2.5, p = .01) were associated with greater response time variability. The interaction between unconstrained and task-unrelated thought was not statistically significant (b = −0.08, t = −0.6, p = .53).

What Does Thought Constraint Mean to Participants?

To better understand the thought features associated with unconstrained thought responses, we conducted linear mixed models with responses to the probes asking about effortful concentration and topic switching as predictors of unconstrained thought. We used separate models for SART and MRT. "I don't know" responses were excluded for effortful concentration and topic shifting probes. Responses were scaled so that a "no" response was scored as zero and a "yes" response was scored as one for both probe types. As with previous analyses, we evaluated if modality affected associations. In models in which a statistically significant interaction was found, subsequent models used online data. As per the preregistration, three models were run for each task: one with effortful concentration as the predictor, one with topic switching as the predictor, and a third with both and their interaction as predictors.

In both tasks, effortful concentration was negatively associated with unconstrained thought (SART: b = −0.42, t = −8.3, p < .001; MRT: b = −0.32, t = −7.6, p < .001). The modality parameter estimate was not statistically significantly associated in either model (SART: b = −0.42, t = −8.3, p < .001; MRT: b = −0.32, t = −7.6, p < .001), nor was the interaction between effortful concentration and modality (SART: b = 0.05, t = 0.9, p = .36; MRT: b = −0.03, t = −0.6, p = .52). Topic shifting, in both tasks, was positively associated with unconstrained thought (SART: b = 0.77, t = 17.4, p < .001; MRT: b = 0.63, t = 18.9, p < .001), and modality was not associated with unconstrained thought (SART: b = 0.10, t = 1.9, p = .07; MRT: b = −0.04, t = −0.6, p = .56). The interaction between topic shifting and unconstrained thought was statistically significant in the SART (b = −0.12, t = −2.4, p = .02), but not in the MRT (b = −0.02, t = −0.6, p = .56). The interaction in the SART indicated that topic shifting and unconstrained thought were less associated in the online sample relative to the lab sample.

In the SART model with effortful concentration, topic switching, and their interaction, all parameters were statistically significant (topic shifting: b = 0.66, t = 19.4, p < .001; effortful concentration: b = −0.21, t = −5.6, p < .001; topic shifting by effortful concentration interaction: b = −0.11, t = −2.3, p = .02). The interaction here indicates that reports of topic shifting that co-occurred with an effortful concentration report were less associated with unconstrained thought. In the corresponding MRT model, all parameters were again statistically significant (topic shifting: b = 0.55, t = 23.5, p < .001; effortful concentration: b = −0.28, t = −9.6, p < .001; topic shifting by effortful concentration interaction: b = −0.08, t = 2.3, p = .02). Here, the interaction suggests a pattern opposite that of the SART model where when topic shifting and effortful concentration reports co-occur, there is a stronger association with unconstrained thought.

To further contextualize these linear mixed models, we conducted repeated measures correlation analyses to provide estimates of the co-occurrence of effortful concentration and topic switching responses. In the SART, the association was estimated at $r_{rm}(9376)$ = −.16, CI [−.19, −.13], p < .001, and in the MRT, the estimate of association was $r_{rm}(5072)$ = −.18, CI [−.21, −.16], p < .001, providing evidence that reports of effortful concentration and topic switching are not redundant. Moreover, we estimated the associations among effortful concentration, topic switching, and thought probe responses, looking for possible dissociations. In both tasks, there was little separation between association estimates. In the SART, task-unrelated thought associated with effortful concentration at $r_{rm}(9625)$ = −.32, CI [−.34, −.30], p < .001, and topic switching at $r_{rm}(9625)$ = .33, CI [.31, .35], p < .001, while unconstrained thought associated with effortful concentration at $r_{rm}(9376)$ = −.25, CI [−.27, −.23], p < .001, and topic switching at $r_{rm}(9376)$ = .38, CI [.36, .40], p < .001. In the MRT, task-unrelated thought associated with effortful concentration at $r_{rm}(5072)$ = −.25, CI [−.27, −.32], p < .001, and topic switching at $r_{rm}(5072)$ = .39, CI [.37, .42], p < .001. While unconstrained thought reports associated with effortful concentration at $r_{rm}(5072)$ = −.20, CI [−.22, −.17], p < .001, and topic switching at $r_{rm}(5072) = .38$, CI [.36, .40], $p < .001$.

Discussion

We investigated unconstrained thought as a potential individual-differences variable, complementing 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, 2021; O'Neill et al., 2021; A. P. Smith et al., 2022; G. K. Smith et al., 2018). Specifically, our objectives were to investigate the dissociability of unconstrained from task-unrelated thought, examine the stability of unconstrained thought over time, estimate the associations between psychopathology symptoms and unconstrained thought, compare the impact of unconstrained thought on task performance with that of task-unrelated thought, and explore potential underlying factors behind unconstrained thought probe responses (i.e., what more granular characteristics of thought may produce them) through additional probes assessing topic switching and effortful concentration.

Dissociating Unconstrained Thought From Task-Unrelated Thought

A critical factor in evaluating unconstrained thought's value as an individual-difference variable is whether it constitutes a unique and dissociable quality of thought beyond task-unrelated thought (i.e., does it demonstrate discriminant validity). Consistent with recent publications (Alperin et al., 2021; Kam et al., 2021; Mills et al., 2018, 2021; O'Neill et al., 2021; G. K. Smith et al., 2018), participants did not always report task-unrelated thoughts when they reported unconstrained thought, suggesting that they are not entirely redundant qualities. Notably, although there was not complete overlap between thought constraint and task relatedness, interindividual correlations revealed that participants reporting more task-unrelated thoughts also reported higher levels of unconstrained thought ($rs = .70, .73$). Additionally, intraindividual correlations demonstrated substantial overlap between probe responses at the trial level ($rs_{rm} = .61, .53$), consistent with Kam et al. (2021), and higher than the findings of Mills et al. (2018).

In certain instances, unconstrained thought exhibited incremental validity, particularly in predicting total ADHD and state anxiety symptoms. However, it did not exhibit similar validity when predicting symptoms of depression, rumination, or trait anxiety. Where thought constraint showed incremental validity, the values, while statistically significant, were considerably small (e.g., $R^2\Delta$ ranging from .01 to .02).

As the first study investigating test–retest reliability of unconstrained thought within a structured setting, we found a strong correlation between participant reports of unconstrained thought (and task-unrelated thought) across the SART and MRT measures, indicating stability over a short period of time (<2 hr). We consider this a minimal test, which would have been more informative if stability was not found, but insufficient to make strong, broad claims about unconstrained thought reliability. Further research is needed to determine if unconstrained thought maintains stability over extended time frames, multiple contexts, and real-life settings.

Unconstrained Thought and Psychopathology

We tested Christoff et al.'s (2016) predictions pertaining to different psychological symptoms and their associations with unconstrained thought. To recap, Christoff et al. (2016) hypothesized that individuals experiencing more depressive symptoms, rumination, and anxiety would tend to exhibit less unconstrained thought. In turn, those reporting more ADHD symptoms ought to report, on the whole, more unconstrained thought. To date, the results have been mixed regarding the accuracy of these predictions (Alperin et al., 2021; Mills et al., 2021; A. P. Smith et al., 2022).

Corroborating Christoff et al. (2016) and Alperin et al. (2021), we found a positive association ($r = .16$) between more unconstrained thought and overall ADHD scores in the SART. Additionally, we found a positive association between unconstrained thought in the SART and scores on both the inattentive and hyperactive subscales. All BFs were moderately to strongly ($BF_{10} = 4.54$–13.85) in favor of the alternative hypothesis for ADHD symptom measures. Unconstrained thought demonstrated incremental validity beyond task-unrelated thought when predicting ADHD symptoms combined, hyperactivity, and inattention. Perhaps driving this incremental validity finding is the anomalous lack of association between task-unrelated thought and ADHD symptoms in this study. Prior work has reported positive associations between task-unrelated thought and ADHD symptoms (e.g., Beikmohamadi & Meier, 2024; Franklin et al., 2017; Meier, 2021; Seli et al., 2015). With respect to the predictions made by Christoff et al. relating to depressive symptoms, rumination, and anxiety, our results were in the opposite direction. In the SART, more frequent reports of unconstrained thought related to more reports of depression and ruminative symptoms. Also, in the SART, unconstrained thought positively associated with trait and state anxiety.

While some of our findings differ from Christoff et al.'s (2016) predictions, they align with other models that link cognitive processes in mood and anxiety disorders. Individuals with depression and anxiety often struggle with cognitive inhibition, planning, and problem solving (LeMoult & Gotlib, 2019; Visu-Petra et al., 2013), which may impair their ability to control and restructure unhelpful thoughts (Hoffmann et al., 2016; Marchetti et al., 2016; Rostami et al., 2022). This difficulty in exerting cognitive control may lead to more unconstrained thought (Nolen-Hoeksema et al., 2008; Rostami et al., 2022).

Task Differences and Thought Probe Responses

A potentially noteworthy finding in the present study is the lack of significant associations between psychological symptoms and thought probe responses during the MRT, except inattentive symptoms. This contrasts with the stability of thought constraint across both measures of sustained attention. One possible explanation is that the task demands of the SART (e.g., discriminating between target and nontarget stimuli) differed from those of the MRT (e.g., pressing a spacebar in sync with a metronome), which may have engaged attention differently, thus affecting thought probe responses. Additionally, participant fatigue toward the end of the testing session may have influenced thought constraint, while boredom during the MRT could have contributed to more acquiescent responses.

Task Performance and Unconstrained Thought

We examined the relationship between thought report type and task performance on two measures of sustained attention. Unconstrained thought was associated with unique variance within SART performance (as were task-unrelated thought reports). Unconstrained thought reports immediately preceding a target were associated with inaccurate responses to that target. Unconstrained thought reports were not associated with more varying response times in the SART but were in the MRT. Additionally, in the SART, participants' response time variability increased when they reported their thoughts being task-unrelated and unconstrained than when they reported their thoughts being task-related and more constrained. Consistent with A. P. Smith et al.'s (2022) findings when employing a two-back task, our study provides further evidence that when individuals' thoughts are unconstrained, their task performance suffers.

What Does Unconstrained Thought Mean to Participants

To better understand how people responded to thought constraint probes, we examined their relation to effortful concentration and topic switching. Unconstrained thought reports were associated with less effortful concentration and more topic shifts. When topic shifts and effortful concentration were reported together, there was a stronger association with unconstrained thought reports. These findings align with suggestions of unconstrained thought reports being multiply determined (A. P. Smith et al., 2022). However, given that effortful concentration and topic switching similarly related to task-unrelated thought reports (as expected, given the strong associations between task-unrelated and unconstrained thought), these analyses are insufficient to make definitive claims about the unique basis of unconstrained thought reports. Instead, they provide additional evidence of overlap (and similar placement in the nomological network) between task-unrelated and unconstrained thought.

Potential Unconstrained Thought Measurement Issues

Assessing thought content (i.e., task-unrelated thought) through thought probes is a widely employed method that has accrued evidence as a valid measure of individual differences (e.g., Kane et al., 2016, 2021; Welhaf et al., 2023). Because thought dynamics (i.e., unconstrained thought reports) have not been studied as much as thought content, the psychometric properties of measuring thought dynamics are poorly understood. In these early days of thought dynamic investigations, discrepancies between studies or contradictions with theoretical work may ultimately stem from measurement issues. Concerns arise regarding the construction, scoring, frequency, quantity, order of probe delivery in each instance, and how well people can access their thought dynamics.

For example, previous studies used different methods to assess the thought probe "Was your mind moving about freely?" For instance, Alperin et al. (2021), Kam et al. (2021), and Mills et al. (2018) used a seven-item Likert-type scale but scored responses dichotomously. Conversely, G. K. Smith et al. (2018) applied the same scale but scored responses continuously, while Mills et al. (2021) opted for a six-item scale. O'Neill et al. (2021) and A. P. Smith et al. (2022) simplified their approach, presenting and scoring the item dichotomously. In our study, we chose a four-item Likert-type scale with specific labels to make responding easier for participants. We then scored these responses in two ways: dichotomously for some analyses and continuously for others. This diverse range of methodologies across studies may yield distinct outcomes.

Determining an optimal probe frequency is also a consideration. Infrequent thought probes may not be enough to permit a valid measure, while excessive probes may disrupt the task and distort estimates (Konishi & Smallwood, 2016; Welhaf et al., 2023). The number of probe sets in the present study (36 in the SART and 18 in the MRT) may not be ideal. Moreover, our thought probes indexed multiple characteristics of thought each time they were asked: task relatedness, thought constraint, effortful concentration, and topic shifts. Participants may have thus conflated their ratings or had difficulty discriminating between these different characteristics. Indeed, rating thoughts on four separate characteristics may have changed how thoughts were remembered. Future studies should examine how probe frequency, quantity, and order affect results.

Challenges in Comprehension and Access to Thought Dynamics

Furthermore, participants may have difficulty comprehending the concept of unconstrained thoughts, even when provided with examples (see examples provided to participants in probe instructions at https://osf.io/29d57/). Although we attempted to enhance probe response validity by including an "I don't know" response (which was minimally endorsed [3.8% in SART and 2.8% in MRT of total responses]; a document containing descriptive statistics of "I don't know" responses can be found at https://osf.io/29d57/), the thought probes themselves and participants' potential (mis)interpretation of thought constraint may add noise and contribute to inconsistent findings across studies (as suggested by A. P. Smith et al., 2022). Critically, if not all participants respond based on a shared (with researchers and other participants) and accurate understanding of thought constraint, the thought probe's validity suffers. In addition to methodological and conceptual considerations, it is essential to address the fundamental question of participants' access to their thought dynamics. It is plausible that participants face difficulties in providing accurate reports of their thought dynamics or may not consistently have access to them. Moreover, although we instructed participants to describe their thoughts "just before" the probe screen appeared, assessing the movement of thought necessitates retrospection over an unspecified period, further obscuring its assessment (Kane et al., 2021).

While we acknowledge these above challenges (measurement and comprehension) within our study, it is important to understand that these constraints are not unique to us but are intrinsic to the Dynamic Framework. This observation is not meant to deflect responsibility but to accurately locate the source of these challenges. Thus, these challenges are a call to action for further refinement of the Dynamic Framework. By highlighting them, we aimed to contribute constructively to the ongoing dialogue and encourage enhancements that will benefit future research endeavors within this framework.

Conclusion

The present study is the first to examine the associations among unconstrained thought and specific psychological variables (i.e., state anxiety, trait anxiety, and inattentive/hyperactive subtypes of ADHD). Inferences from any single study are limited in strength and scope. However, this study contributes to the existing body of knowledge, ultimately facilitating more efficient progress. Importantly, unconstrained thought reports exhibited stability across two sustained-attention tasks, suggesting that it is not just a task-driven construct. Furthermore, we found that although unconstrained and task-unrelated thought were often redundant by examining intra- and interindividual correlations, there were occasions where they diverged. Unconstrained thought was uniquely associated with various measures of task performance. Most of our findings contradicted predictions concerning the association between unconstrained thought and different psychological symptoms (Christoff et al., 2016) or did not reach statistical significance. The most promising and potentially fruitful domain for unconstrained thought's associations, corroborating a prediction from Christoff et al. and prior work by Alperin et al. (2021), lies in its positive associations with ADHD symptoms. Refining thought constraint instructions and probe characteristics through further research could bolster these associations, improve unconstrained thought's discriminant validity from task-unrelated thought, and reveal new associations. This study highlights unconstrained thought as an emerging individual-differences variable, necessitating ongoing research to comprehensively understand its role in cognitive and psychological processes.

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