How consistent is mind wandering across situations and tasks?—A latent state–trait analysis

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Abstract

Mind wandering is often defined as the phenomenon of one's attention drifting away from the current activity toward inner thoughts and feelings. In the laboratory, mind wandering is most frequently assessed with thought reports that are collected while people perform some ongoing activity. It is not clear, however, inasmuch the resulting mind-wandering reports are reflective of person-consistent mind-wandering tendencies and/or situation-driven fluctuations in mind-wandering behavior. To shed light on this question, we tested how consistent mind-wandering reports are across different measurement occasions and tasks to investigate to which extent they indicate individual differences in mind wandering. Results from a latent state–trait analysis showed that mind-wandering reports are occasion-consistent to some extent and also somewhat task-specific. Theoretical implications of these findings are that mind wandering in the laboratory is less affected by situational factors than often assumed, but that individual differences in mind wandering partly depend on the currently ongoing task. Future research should investigate the origins of task-specificity effects on mind wandering and researchers should further incorporate the idea of task-specificity in future theory building.

Keywords: mind wandering; task-unrelated thoughts; latent state–trait analysis; psychometrics; trait consistency; task specificity

How consistent is mind wandering across situations and tasks?—A latent state–trait analysis

Mind wandering describes the everyday experience of one’s attention drifting away from the here and now towards inner thoughts or feelings (Smallwood & Schooler, 2006, 2015). In the psychology literature, the term mind wandering is often used as an umbrella term covering a wide range of phenomena such as thoughts that are “unrelated to currently ongoing activities,” thoughts that occur “independent of any external stimulus,” or simply thoughts that appear to be “mentally unguided” (Seli et al., 2018). Most frequently, mind wandering is conceptualized as task-unrelated thoughts (TUTs), that is, thoughts that occur while one is engaged in some kind of ongoing task but which have nothing to do with this particular task (Mills et al., 2018; Smallwood & Schooler, 2006). For the present investigation, we followed this conceptualization and, consequently, we use the terms mind wandering and TUTs interchangeably.

Our primary research question was to investigate how consistent mind wandering indexed as TUTs is across situations and tasks. From a theoretical standpoint, this is a crucial question, because consistency is a core feature of any behavior that indicates a psychological trait (e.g., Steyer et al., 1992). Additionally, the question of to which extent the most commonly used mind-wandering measure reflects individual trait differences in mind wandering is also relevant for the interpretation of the findings reported for this measure.

Mind Wandering Assessment—Current Practices

In most laboratory studies, mind-wandering is assessed with online thought probes requiring participants to report on their current thought status from time to time while performing some kind of ongoing task (Weinstein, 2018). Previous research suggests that thought probes provide a relatively reliable and valid measure of mind wandering. For example, the method does not seem to reactively affect ongoing-task performance (Wiemers & Redick, 2019) and mean

TUT rates correlate with objective task criteria, such as mean error-rates (Mrazek et al., 2012), mean response-times (McVay & Kane, 2012), particular eye-movements patterns (Steindorf & Rummel, 2020), and neurophysiological markers (Arnau et al., 2020; Mittner et al., 2016; Poerio et al., 2017). Furthermore, although probe-framing and probe-frequency effects have been shown to affect mean TUT-rates (Seli et al., 2013; Weinstein et al., 2018), the individual rank order on the TUT continuum is relatively robust against these effects (Schubert et al., 2019).

However, from a psychometric perspective, it is unclear whether the observed mind wandering states are mostly reflective of stable mind-wandering tendencies that are consistent across different situations, of situation-driven momentary fluctuations of mind wandering, or a combination of the two.

It has been argued that most psychological constructs comprise both situation- and time-independent and situation- and time-dependent components (Hertzog & Nesselroade, 1987). When assessing psychological constructs, it is thus important to know to which extent the observed psychological states are reflective of individuals' general predispositions to behave consistently in a certain manner and to which extent they are reflective of momentary deviations from this general predisposition (Eid et al., 1999). Accordingly, enduring predispositions to behave in a consistent manner across many situations are considered psychological traits (Allport, 1937), whereas reversible short-term fluctuations around an individual's trait score are considered intra-individual variability (Nesselroade, 1991). To further illustrate this trait concept, we can think of the common distinction between trait and state anxiety (Endler & Kocovski, 2001). A person scoring high on trait anxiety is generally expected to behave in a more anxious fashion than a person scoring low on trait anxiety in various different situations. Of course, that does not mean that the absolute anxiety score of both persons will not vary from situation to

situation. For instance, both the anxious and the not so anxious person might feel less anxious while watching TV at home and more anxious while taking an exam at the university. Critically, however, the rank order of the two persons on the latent anxiety continuum is *not* expected to vary systematically from situation to situation. That is, there should be a relative consistency in the sense that the anxious person behaves more anxiously than the not-so-anxious person in most situations (but there might be few situations there traits cannot manifest as behaviors; Endler & Kocovski, 2001). Critically, under certain circumstances, the not-so-anxious person may nevertheless temporarily behave more anxiously in a specific situation than the anxious person (e.g., she recently changed street sides when encountering a dog because she was attacked by a dog the week before). Such situational deviations from behavior predicted by the trait would qualify as residual state variance as they represent variability in the observed behavior that cannot be attributed to trait differences in anxiety. In the anxiety example, it is obvious that the differentiation between traits and state residuals is of high interest as the former are particularly relevant from a clinical perspective.

Similarly, for the assessment of mind wandering, this differentiation is not only a technical issue or mental exercise but also one of general theoretical interest. The interpretation of findings will depend on whether variability in TUT states can mostly be attributed to individual differences in a mind-wandering trait or to situational factors. For example, TUTs can only be expected to be regularly correlated with indicators of conceptually related cognitive traits such as working-memory capacity (WMC) or sustained-attention abilities to the extent to which they are reflective of a trait themselves. Notably, however, most current theories of mind wandering do not (or at least not explicitly) incorporate such state–trait considerations.

One and, to our best knowledge, currently the only approach in this regard stems from Seli et al. (2016a). These researchers probed participants from time to time, while performing a continuous metronome response task, whether their thoughts had been task-related or task-unrelated in this very moment to assess mind-wandering states. Additionally, they applied a questionnaire asking participants how frequently they usually tend to mind wander to assess mind wandering at a trait level and found the questionnaire scores to be only moderately correlated with the momentary TUT assessments ($r = .24$ to $r = .35$). Importantly, whereas these findings demonstrate that the two assessment methods do not converge, they remain silent regarding to which extent the observed variability in mind-wandering states observed during the metronome-response task can be attributed to person-immanent and/or situation-immanent factors. As mind-wandering states were assessed in the same laboratory session in which the mind-wandering questionnaire was applied situational factors may have contributed to the observed correlation. Additionally, correlation sizes also depend on the (un-)reliabilities of the correlated measures which were not taken into account in this study.

Taken together, it is an open question to which extent the momentary assessment of mind wandering states are reflective of (i) a general predisposition to mind wander and (ii) situation-driven deviations from this general predisposition. Thought probes assess whether a particular mental state (mind wandering) is present versus absent at a particular time within a particular person but do not speak to why this state is observed in this very moment. The reasons may lie to various degrees within the person, within the situation (or within a situation $\times$ person interaction), or may be due to measurement error (i.e., the unreliability of the measures). To illustrate, while reading a novel, a person may be likely to report being off-task in response to a probe because she tends to mind wander a lot in many situations, because she just read

something about a red scarf that reminded her of person she recently started dating, or simply because she got the question wrong (measurement error).

To control for the latter, researchers usually aggregate across responses to several probes presented during one particular task by calculating mean TUT rates (Smallwood & Schooler, 2006). In doing so, researchers reduce measurement error but may also aggregate across systematic (time-on-task) effects (but see Schubert et al., 2019; Steindorf & Rummel, 2020, for an alternative multilevel approach). Some researchers go one step further and assess mean TUT rates during different tasks and then use a latent-factor approach to extract a single common mind-wandering factor (Kane & McVay, 2012; McVay & Kane, 2009; Meier, 2019; Mrazek et al., 2012; Robison et al., 2020; Robison & Unsworth, 2015; Unsworth et al., 2012). The idea behind this approach is to control for measurement-error-induced variance components within the manifest TUT rates, thereby achieving an indicator of mind wandering that is more reliable than the manifest scores and also less task-specific. In personality research, traits have been conceptualized as average aggregated behavior that is consistent across situations (Fleeson, 2001). Accordingly, one may argue that a latent factor reflecting the shared variance of TUT rates assessed with the same probing procedures during different tasks qualifies as a trait indicator of mind wandering. However, according to latent state–trait theory this is not necessarily the case because traits can also be method- or task-specific, that is, some traits may manifest themselves only when assessed with a certain task (Steyer et al., 1992). Accordingly, only the relative consistency of mind-wandering states assessed in different situations would qualify as indication of a mind-wandering trait whereas any inconsistencies across situations would be considered state residuals. We will discuss this point further in the Discussion section.

Nevertheless, proponents of the single-latent-factor approach have been, at least implicitly, treating latent mind-wandering factors in a rather trait-like fashion. That is, latent mind-wandering factors have been correlated with other established constructs of cognitive performance to test theories regarding the role of mind wandering within the nomological network. For example, it has been shown that variability of the latent mind-wandering factor is negatively related to (latent) working-memory and attentional-control variables (Kane et al., 2016; McVay & Kane, 2009; Robison & Unsworth, 2018), to reasoning (Mrazek et al., 2012), and that individual differences in mind wandering mediate the relationship between WMC and reading comprehension (McVay & Kane, 2015).

Importantly, however, not all variance components that are not covered by the mind-wandering variable within the single-latent-factor approach must necessarily reflect random measurement error. In fact, mind-wandering has been shown to fluctuate systematically with the circadian cycle (Smith et al., 2018) as well as with variations in emotional (Smallwood et al., 2009; Stawarczyk et al., 2013), physiological states (Rummel & Nied, 2017; Sayette et al., 2010) or variations of tasks demands (Rummel & Boywitt, 2014). Critically, when applying the single-latent-factor approach, such situation-specific systematic variance components would either be treated as measurement error or, in cases in which situation-specific factors remain largely stable during the assessment occasion (i.e., when all mind-wandering indicators collected in a study are assessed at a single measurement occasion), become an elementary part of the latent factor. Even in study designs within which a latent mind wandering factor is modelled as the shared variance between TUT reports collected during different tasks administered at different days or weeks (e.g., Kane et al., 2016), state-residual and measurement-error-related variance components cannot be statistically separated. Consequently, within the single-latent-factor framework it is not

possible to isolate trait and state-residual components of the observed mind-wandering variability.

In sum, as it currently stands, it is unclear to which degree the most frequently used mind-wandering assessment method provides measures reflective of trait-like predispositions to mind wander. For these reasons, we considered it important to quantify the trait and state-residual components of mean TUT rates, which can be done using the latent state–trait approach from Steyer and colleagues (Steyer et al., 2015; Steyer et al., 1999).

Latent State –Trait Theory and its Application to Mind Wandering

As said, most psychological constructs are assumed to contain both situation-specific and person-specific components and the empirical separation of the two has been a research endeavor for over 30 years (Hertzog & Nesselroade, 1987). One of the most promising approaches in this regard is latent state–trait (LST) theory (Geiser & Lockhart, 2012; Steyer et al., 2015; Steyer et al., 1999). This approach distinguishes between a task-consistent component (i.e. a latent true score) and task-specific components. It construes the task-consistent component as a latent state that consists of a trans-situational consistent component and a situation-specific component. Hence, the LST approach allows distinguishing between variance components which are consistent across measurement occasions (i.e., traits) and variance components which are specific to measurement occasions (i.e. state residuals) that both contribute to the task-consistent latent factor. The LST approach also provides psychometric methods allowing for a clear and unambiguous separation of trait and state-residual effects by using structural equation modeling techniques. The approach suggested by Steyer et al. (1999) requires a specific data structure, that is, the construct of interest has to be assessed with at least two different indicators that are administered in different situations (i.e., at least at two different measurement occasions). From

such data, it is then possible to decompose the variances of observed states and compute the following coefficients:

- *Trait consistency* indicates to which degree observed individual differences are determined by a trait that is consistent across measurement occasions and tasks.
- *Occasion specificity* indicates to which degree observed individual differences are determined by the measurement occasions and/or person $\times$ occasion interactions.
- *Task specificity (sometimes also called method specificity)* indicates for each indicator, to which degree individual differences observed *within* a task are consistent across measurement occasions.
- *Reliability* indicates to which degree observed individual differences are due to reliable sources of variances (rather than measurement error) and therefore equals the sum of trait consistency, occasion-specificity, and task-specificity coefficients.

The LST approach has been successfully applied to identify trait-consistent and occasion-specific (i.e., residual state) variance components in a number of different research domains, such as personality (Schmitt et al., 2005), subjective well-being (Eid & Diener, 2004), clinical anxiety (Endler & Kocovski, 2001), cognitive performance (Danner et al., 2011), neurophysiology (Hagemann et al., 2002), and cognitive modeling (Schubert et al., 2016). An application to the mind-wandering domain, however, is still pending.

To fill this gap, we used a LST model variant measuring not only trait-consistent and occasion-specific but also task-specific effects (LaGrange & Cole, 2008; Steyer et al., 1992). Because there is some indication that mind-wandering tendencies may be task-specific—for example mind wandering assessed during cognitively demanding tasks has been shown to be regularly negatively correlated with WMC, whereas mind wandering during less demanding

tasks has been shown to be often uncorrelated with WMC (Robison et al., 2020; Rummel & Boywitt, 2014, but see Meier, 2019)—we found it necessary to differentiate between task-general and task-specific mind-wandering in addition to investigating how consistent they are across different measurement occasions.

The Present Study

For the present study, we implemented thought probes into two different ongoing tasks (i.e., a two-back and a reading task) and had the same group of participants perform these tasks at two measurement occasions, which were separated by a six-months period. As several different versions of the thought probing method can be found in the literature (Weinstein, 2018), we decided to combine (and slightly modify) two recent variants that have been used very successfully. First, we always asked participants to select from a list of seven options where their thoughts had been in the very moment before the probe occurred (McVay & Kane, 2009, 2012, 2015; Rummel & Boywitt, 2014). Recent research strongly suggests that this content probing method is superior to other probing methods regarding its construct validity (Kane et al., in press). Second, we asked participants to indicate whether they had been mind wandering intentionally or unintentionally (Seli et al., 2016b) or had been intentionally or unintentionally focused on the task. The latter differentiation of task-related thoughts (TRTs) has not yet been introduced to the literature but was inspired by the idea that a flow-like task absorption may systematically affect attention, so that it results in an on-task focus that is experienced as a relatively effortless concentration on the task (cf. Marty-Dugas & Smilek, 2019; Nakamura & Csikszentmihalyi, 2002). Additionally, we assessed WMC at both measurement occasions with two complex span tasks and reasoning abilities with a matrices and a number-series task at one occasion to replicate previously observed correlations of these constructs with mind wandering

(McVay & Kane, 2009; Mrazek et al., 2012; Robison et al., 2020). In doing so, we intended to test the latent trait mind-wandering factor's construct validity but also to achieve trait-consistency benchmarks from the WMC measures as they are known to reflect trait variance to large degrees (Ilkowska & Engle, 2010).

For exploratory reasons, we also assessed facets of three personality variables (i.e., fantasy from the openness scale; depression from the neuroticism scale; self-discipline from the conscientiousness scale) that have been shown to correlate with mind wandering in previous studies (Kane et al., 2017; Ralph et al., 2017; Robison et al., 2017). Due to capacity limits, we refrained from applying the complete personality questionnaire but selected those facets from a widely used personality inventory (Borkenau & Ostendorf, 2007), which we considered most relevant for mind wandering.

Method

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study (Simmons et al., 2012). When implementing experimental tasks for the study of latent trait and state-residual components of mind wandering, we followed the recommendations for the use of experimental tasks in individual differences research suggested by Goodhew and Edwards (2019) whenever it was feasible.

Participants and Design

Data collection was organized with the software *hroot* (Bock et al., 2014), an open-source software for managing participant pools. The study was conducted in accordance with national ethical guidelines and the Declaration of Helsinki (World Medical Association, 2013). Following recommendations by MacCallum et al. (1996), we determined the sample size based on the hypothesis of close fit ($H_0: \varepsilon \leq .05$, $H_1: \varepsilon \geq .10$) for the latent state-trait model ($df = 39$), an alpha

error of $\alpha = .05$, and a power of $1 - \beta = .80$. The resulting minimum sample size was $N = 114$.

We recruited more participants to increase the stability of parameter estimates as well as to account for expected drop-outs between the first and the second measurement occasion.

Data collection was conducted in laboratory group sessions with up to five participants per session. Each participant provided informed consent before being invited to two assessment occasions with a lag of approximately six months between occasions. A total of $N = 193$ students from different schools of higher education in the area (majoring in diverse subjects) attended the first assessment. Of these participants, $N = 150$ also attended the second assessment. In total, nine participants provided missing data. One participant did not finish the reading task at Assessment Occasion 1 and another one did not finish the reading task at Occasion 2. Due to technical errors, performance in the Raven task of two participants and performance in the number-series task for another participant was not recorded. In one session (four participants), the experimenter forgot to hand out post-experiment questionnaires. The valid data of these nine participants were included whenever possible. The full sample of Assessment Occasion 1, $N = 193$, (Occasion 2, $N = 150$) had a mean age of $M_{\text{age}} = 22$; $SD = 3$ ($M_{\text{age}} = 22$; $SD = 3$) and 78% (79%) of the participants were female.

Assessment Tools, Scoring, and Procedure

Tasks were applied at both occasions in the same order as they are described below. Task order was held constant for both measurement occasions as individual mind-wandering scores were the variable of central interest in the present study. For this kind of individual difference research, a constant task order is indicated as it avoids adding task-order-related random measurement error to task scores (see Goodhew & Edwards, 2019, Recommendation 6). Reasoning ability and personality facets were assessed at the first occasion only.

Mind wandering assessment. For the mind-wandering assessment, we embedded thought probes in ongoing two-back and reading tasks.

For the two-back task (Kirchner, 1958), single letters were consecutively presented on the screen. Participants were instructed to press the green-labeled C-key when the currently presented letter matched the one presented two trials earlier (target trials). For all other letters (non-target trials), they were supposed to press the red-labeled B-key. Twenty different letters (B C D F G H J K L M N P Q R S T V W Y Z) were selected as stimuli and used repeatedly without replacement. Stimuli were presented in random order for 500 ms each in the center of the screen followed by a 3-s response window. The task was divided into eight sub-blocks consisting of 13 non-target and 8 target trials each. The first three trials of each sub-block were always non-target trials. Subsequent trials were randomly determined to be target or non-target trials. Each sub-block of the two-back task ended with a thought probe, so that there were eight thought probes in total. The false-alarm rate on non-target trials was subtracted from the correct-response rate on target trials to achieve a target/ non-target discrimination performance measure (*PR*).

For the reading task, participants were asked to read several chapters of *War and Peace* by Leo Tolstoi or of the *Journey to the East* by Hermann Hesse for 30 minutes each. At the first assessment occasion, half of the participants read one story and the other half the other one (randomly determined). At the second occasion, participants received the story they had not yet read. Here, it would not have been appropriate to keep the assignment of stories to occasion constant for all participants, because, in doing so, we would have confounded text-specific with state-residual effects (cf. Goodhew & Edwards, 2019). The stories were always presented page-wise on the computer screen and participants could turn pages in their own pace by pressing the space bar or Enter key. Reading was interrupted by eight thought probes after 4.75, 7.5, 10.5,

14.25, 16.25, 20.5, 24.5, 27.75 minutes of reading. After reading, participants were presented with 16 true/false questions concerning the respective story. The proportion of correct answers to these questions was used as the reading comprehension performance measure.

Thought probe instructions provided definitions and examples of TUTs and encouraged participants to respond to the thought probes honestly. Thought probes in both the two-back and the reading task were presented in white font on a green background. Participants were first asked to indicate what they had been thinking about just before the screen turned green with the response options (1) my current task, (2) my performance in the task, (3) everyday things, (4) my current feelings, (5) my personal worries, (6) I was daydreaming, or (7) about other things not related to the current task (McVay & Kane, 2009). As a mind-wandering measure, the relative frequency with which responses (3) to (7) were selected was calculated (overall TUT rate). Second, participants were asked to indicate the intentionality of their thoughts by selecting one of four options (1) I had intentionally focused my thoughts on the current task, (2) my thoughts were occupied by the current task without my intention, (3) my thoughts had drifted away from the current task without my intention, or (4) I had intentionally allowed my thoughts to drift away from the current task. The frequency rates with which each of the four categories was selected was calculated to quantify the intentionality and non-intentionality of TUTs and TRTs.

WMC assessment. Two automated complex span tasks were used to assess WMC (Redick et al., 2012). For the Operation-Span (OSpan) task, participants were presented with math problems followed by a number. Participants had to decide whether this number was the solution to the preceding math problem or not. After each math problem, a letter was presented for 800 ms, which participants had to remember for a final memory test. Each OSpan trial comprised a set of three to seven letters for the final memory test. For the memory tests,

participants had to identify the previously presented letters in a 4×3 matrix that contained all possible letters (i.e., F, H, J, K, L, N, P, Q, R, S, T, and Y) by clicking on them in correct serial order. Participants were asked to click a “blank” button whenever they had forgotten a letter in a series. There was no time limit for the final memory test. The OSpan task comprised a total of 15 trials (i.e., three of each set size). Imperceptible for participants, the task was further divided into three sub-blocks. Each set size occurred once in each sub-block but the set size was randomly determined within each sub-block.

The Reading-Span (RSpan) task was identical to the OSpan task, except that participants had to judge whether a given sentence was semantically meaningful or not rather than solving math equations between letter presentations on each trial.

As span-score performance measures, we used the sum of letters recalled in the correct position, independent of whether the whole item set or only parts of it were correctly recalled as recommended by Conway et al. (2005).

Reasoning assessment. A matrix reasoning test, a number-series task, and college-admission grades (CAG) were used to assess reasoning abilities. These tasks were only applied at the first assessment occasion.

For the matrix reasoning test, participants were presented with 18 spatial reasoning problems one after another with increasing difficulty levels. The problems were drawn from the Advanced Progressive Raven Matrices set II (Raven, 1962). Participants were instructed to solve as many problems as possible within 8 min. Each problem consisted of a 3×3 matrix. Each cell, except the lower right one, contained a geometric figure. The arrangement of figures within the matrix followed a certain pattern. Participants had to select the figure completing the pattern out

of an array of eight possible figures. The proportion of correctly completed figures was used as the performance measure in this task.

For the number-series task, participants were presented with a series of numbers and were required to determine what the next number in the series should be (Thurstone, 1962). Each series followed a certain rule which participants were required to figure out in order to determine the next number. Participants had to select their answer from five possible numbers that were presented together at the end of each trial. The proportion of correctly selected numbers was used as the performance measure.

Participants were asked to indicate their CAGs. In Germany, CAGs are calculated from both individual high-school grades and standardized final exams and have been shown to be strongly correlated with intelligence test scores (Roth et al., 2015). CAGs could theoretically range from 1.00 (best to-be-achieved grade) to 4.49 (worst to-be-achieved grade). CAGs of 4.50 or lower do not allow for college admission.

Personality facets. At the first assessment occasion, we also applied a short personality questionnaire. Three personality facets from the Neo-FFI personality inventory (Borkenau & Ostendorf, 2007), which we expected to explain variance in mind-wandering states, were selected for this purpose. These were the facets “Fantasy” (e.g., I have a vivid imagination), “Depression” (e.g., I do not like myself) and “Self-Discipline” (e.g., I regularly finish the work I started). Each facet was measured with eight items and items had to be answered on 5-point scales ranging from “strong disagreement” to “strong agreement.” Means were calculated for the personality assessment.

Data Analyses

Structural equation modeling. All indicator variables were z-standardized before being analyzed. Structural equation models for the repeatedly measured WMC and thought-probe data were based on LST theory (Steyer et al., 1999). In this framework, latent trait factors represent the consistent component of the respective indicator variables, which are not specific to either the assessment occasion or to the assessment method (i.e., the specific task used for construct assessment, in our case). Latent occasion-specific factors account for the deviations of occasion-specific states from the latent trait variables (i.e., state residuals). We also included task-specific factors for both indicator variables of the respective construct to account for the unique variance of the respective task across occasions. Following Steyer et al. (1999), the following model restrictions were imposed: trait and occasion-specific variables were not allowed to correlate with task-specific variables and task-specific variables were not allowed to correlate with each other. To render the model identifiable, we had to suppress the correlation of one of the task-specific factors per construct with the other latent trait factors. For example, to compute the correlation between two-back-specific TUTs and WMC, we had to set the correlation between reading-task-specific TUTs and WMC to zero and vice versa. As the correlations of task-specific factors with other constructs were generally close to zero, however, we ultimately set them all to zero, to treat them all equally and to maximize degrees of freedom. We also calculated LST coefficients for each of the observed variables Y_{ij} assessed with task i at measurement occasion j (Steyer et al., 1999). The trait-consistency coefficient reflects the proportion of variance of the manifest variable Y_{ij} that can be accounted for by individual differences in the latent trait T and was calculated as $\sigma^2(T)/\sigma^2(Y_{ij})$. The occasion-specificity (state residual) coefficient reflects situational and person-times-situation effects SR_i and was calculated as $\sigma^2(SR_i)/\sigma^2(Y_{ij})$. The task-specificity coefficient reflects the proportion of variance that can be accounted for by a specific

task M_j and was calculated as $\sigma^2(M_j)/\sigma^2(Y_{ij})$.¹ The reliability coefficient reflects the proportion of variance explained by the model and was calculated as $[\sigma^2(T) + \sigma^2(SR_i) + \sigma^2(M_j)]/\sigma^2(Y_{ij})$. Please refer to Steyer et al. (2012) for more information regarding the calculation of parameters within different latent state–trait frameworks (see also Geiser et al., 2013).

The software Mplus 7.31 (Muthen & Muthen, 2012) was used for the LST analyses. The robust maximum likelihood (MLR) estimator accounted for any non-normality in the item ratings and Full Information Maximum Likelihood (FIML) was used to accommodate missing data. To evaluate model fit, we used the comparative fit index (CFI, with values $\geq .90$ indicating a good fit), the Tucker-Lewis Index (TLI, with values $\geq .90$ indicating a good fit), and the root mean square error of approximation (RMSEA, with values $\leq .05$ indicating a good fit).

Results

Data and analysis codes for all analyses are provided at the open science framework https://osf.io/fdt26/?view_only=6dd6f5f83d7f40f886f8ef424f57d516.

Descriptive Statistics and Preliminary Analyses

Means and standard deviations for all measures are displayed in Table 1; correlations between thought reports and task performance are displayed in Table 2. As evident from Table 2, overall TUT rates—which were assessed while performing the two ongoing tasks—were negatively correlated with task performance in the respective task. This is a typical finding when TUTs are assessed during tasks that impose some cognitive demands on the individuals (McVay & Kane, 2009; Mrazek et al., 2012; Rummel & Boywitt, 2014; Soemer & Schiefele, 2020). When breaking down the thought reports into intentional and unintentional TUTs and TRTs, we observed that the two types of TUTs were uncorrelated in both tasks, suggesting that their

¹ The simplified formulas used here are reflective of the fact that path coefficients were set to 1 for the present analyses (see Figure 1).

occurrence was relatively independent of each other. Nevertheless, both types of TUTs were negatively correlated with performance in the respective task. Intentional and unintentional TRTs were negatively correlated, suggesting that these variables are mutually dependent (i.e., people who experienced more intentional TRT episodes tended to experience fewer unintentional TRT instances and vice versa). Interestingly, in the reading task, only the unintentional but not the intentional TRTs were positively correlated with performance, suggesting that the differentiation between unintentional and intentional TRTs may be meaningful. We will come back to this point in the Discussion section.

Latent State–Trait Analysis of Thought Reports and Working Memory

All variables included in the latent state–trait analyses showed a skewness of $-2 < \gamma < 2$ and a kurtosis of $-4 < \omega < 4$. Thus, according to conventions from Kline (1998) there was little indication for non-normality of the variables included in these models. The only exception were the intentional TUT rates, for which we therefore re-ran all analyses using a robust maximum likelihood (ML) estimator in *Mplus* (i.e., MLR: maximum likelihood with robust standard errors that also take clustering of cases into account). As model fit and results were unaffected by ML methods, for consistency reasons, we report results achieved with standard ML estimation for all variables.

Analyses of overall TUTs. A LST analysis was conducted to determine the consistency across occasions and tasks of TUTs (and TRTs) assessed with online thought probes. To test for criterion-related validity, we also included latent reasoning and WMC factors. Like TUTs and TRTs, WMC was assessed at both occasions with two tasks (OSpan and RSpan task). Consequently, we were able to model WMC analogously to the thought-report data. That is, we included a latent WMC trait in addition to occasion-specific and task-specific factors.

For the combined model with latent trait TUT and trait WMC factors, latent occasion-specific TUT and WMC factors, latent task-specific TUT and WMC factors, as well as a single latent reasoning factor, path coefficients were set to one, while residual variance were estimated freely. This model achieved an excellent fit, $\chi^2(39) = 53.12$, CFI = .98, TLI = .97, RMSEA = 0.04, 90% CI = [0.00, 0.07]. However, TUT state residuals were either very small or negative and were thus set to zero for the calculation of latent state–trait indices, which did not impact model fit, $\chi^2(41) = 53.52$, CFI = .98, TLI = .97, RMSEA = 0.04, 90% CI = [0.00, 0.07]. The final model is illustrated in Figure 1 (see Appendix A for correlations and reliabilities of all manifest variables). Table 3 shows the estimated trait consistencies, occasion-specific variances, task-specific variances, and reliability coefficients for TUTs and WMC. WMC measures showed acceptable reliabilities, ranging from 68 to 70 percent of explained variance. As expected, WMC trait consistencies were relatively high, ranging from .56 to .63. WMC was relatively consistent across measurement occasions, with coefficients of occasion-specificity < .10, and across tasks, with coefficients of task-specificity < .15. Reported overall TUTs showed poorer reliabilities than the WMC measures, ranging from .49 to .58. Overall TUTs showed still moderate trait consistencies, ranging from .29 to .35. Overall TUTs were consistent across situations (empirically, the state residuals could be fixed to zero without impairing model fit) but task-specific to some extent, with coefficients ranging from .19 to .24.

As evident from Figure 1, the WMC trait was significantly correlated with the TUT trait, $r = -.23$, $SE = .10$, 90% CI = [-.41, -.07], $p = .025$. Reasoning was correlated with the WMC trait, $r = .37$, $SE = .10$, 90% CI = [.21, .54], $p < .001$, as well as with the TUT trait, $r = -.38$, $SE = .11$, 90% CI = [-.57, -.20], $p = .001$. The two-back specific and the reading specific TUT factors were both uncorrelated with the WMC trait, $r = .06$, $SE = .17$, 90% CI = [-.21, .34], $p = .702$ and $r = -$

.07, $SE = .17$, 90% CI = $[-.35, .21]$, $p = .698$, respectively, as well as reasoning, $r = .01$, $SE = .10$, 90% CI = $[-.29, .32]$, $p = .948$ and $r = -.01$, $SE = .19$, 90% CI = $[-.33, -.30]$, $p = .099$, respectively. As these correlations were all close to zero, we did not consider them further. Taken together, these results suggest that TUTs are relatively consistent across measurement occasions but also task-specific to some extent. The extracted task-general mind-wandering trait factor correlated negatively with WMC and reasoning in the expected direction.

Exploratory analyses of the relationship between mind wandering and personality facets further showed that the TUT trait factor was not correlated with either the openness for fantasy subscale, $r = -.00$, $SE = .10$, 90% CI = $[-.17, .16]$, $p = .965$, or the depression subscale, $r = .06$, $SE = .10$, 90% CI = $[-.10, .22]$, $p = .528$, but with the self-discipline subscale, $r = -.20$, $SE = .10$, 90% CI = $[-.37, -.04]$, $p = .045$.

Analyses of unintentional and intentional TUTs and TRTs. In a next step, we re-ran the latent state–trait analyses using the unintentional and intentional TUT and TRT rates as indicators. As these variables were naturally based on fewer observations than the overall TUT rates, reliabilities of these indicators were generally lower (ranging from .32 to .59).

Despite the lower reliabilities, the unintentional-TUT model fitted the data well, $\chi^2(41) = 49.65$, CFI = .98, TLI = .98, RMSEA = .03, 90% CI = $[\.00, .06]$, and results for the unintentional TUTs were quite similar to those achieved with the overall TUTs. That is, trait consistencies ranged from .29 to .31 and task-specificity indices were lower ranging from .10 to .23. The unintentional-TUT trait factor was significantly correlated with the WMC trait factor, $r = -.22$, $SE = .11$, 90% CI = $[-.40, -.05]$, $p = .035$, but not with reasoning, $r = -.16$, $SE = .12$, 90% CI = $[-.36, .03]$, $p = .172$. Again, neither of the task-specific TUT factors correlated significantly with WMC or reasoning, $|r/s| < .17$, $ps \geq .561$.

The model fit of the intentional-TUT model was good, $\chi^2(41) = 53.23$, CFI = .98, TLI = .97, RMSEA = .04, 90% CI = [.00, .07]. Intentional-TUT trait consistencies were, with .15, rather low but task-specificity indices ranged from .33 to .44. Descriptively, the intentional-TUT trait was negatively correlated with WMC, $r = -.24$, $SE = .15$, 90% CI = [-.48, .01], $p = .107$, and reasoning, $r = -.31$, $SE = .17$, 90% CI = [-.58, -.04], $p = .064$. These correlations were not significant, probably because a large proportion of participants did not experience any intentional TUTs (i.e., 49% at Occasion 1 and 43% at Occasion 2). Notably, the relatively low intentional TUT rates may also explain why intentional and unintentional TUT rates were uncorrelated in the present study. The two-back- and reading-specific factors were also not significantly correlated with either WMC, $r = -.23$, $SE = .14$, 90% CI = [-.46, -.01], $p = .086$ and $r = .27$, $SE = .17$, 90% CI = [.00, .53], $p = .098$, or reasoning, $r = .06$, $SE = .18$, 90% CI = [-.19, .31], $p = .830$ and $r = -.07$, $SE = .18$, 90% CI = [-.36, .23], $p = .701$, respectively.

The unintentional-TRT model achieved a good fit, $\chi^2(41) = 45.21$, CFI = .99, TLI = .99, RMSEA = .02, 90% CI = [.00, .06]. Trait consistencies ranged from .18 to .19 and task specificities from .17 to .36. The unintentional-TRT trait factor was positively correlated with both WMC, $r = .35$, $SE = .13$, 90% CI = [.14, .56], $p = .006$, and reasoning, $r = .40$, $SE = .14$, 90% CI = [.16, .63], $p = .004$. The two task specific factors were not correlated with WMC, $|r|s < .16$, $ps \geq .499$. Interestingly, the two-back-specific unintentional-TRT factor was negatively correlated with reasoning, $r = -.59$, $SE = .30$, 90% CI = [-.99, -.10], $p = .047$, whereas the reading-specific unintentional-TRT factor was positively correlated with reasoning, $r = .37$, $SE = .15$, 90% CI = [.14, .53], $p = .012$. When the latter correlation was allowed for, the correlation between reasoning and the unintentional-TUT trait factor disappeared, $r = .16$, $SE = .17$, 90% CI = [-.11, .43], $p = .342$.

The intentional-TRT model achieved a slightly worse but still acceptable fit, $\chi^2(41) = 63.13$, CFI = .96, TLI = .94, RMSEA = .053, 90% CI = [.02, .08]. Trait consistencies ranged from .14 to .16 and task-specificity indices from .17 to .24. The intentional-TRT trait factor was not correlated with either WMC or reasoning, both $|r|s < .06$, $ps \geq .206$. None of the two task-specific intentional-TRT factors was correlated with WMC, both $|r|s < .32$, $ps \geq .131$. However, the two-back-specific intentional-TRT factor was marginally positively correlated with reasoning, $r = .40$, $SE = .21$, 90% CI = [.05, .75], $p = .058$, whereas the reading-specific intentional-TRT factor was marginally negatively correlated with reasoning, $r = -.45$, $SE = .24$, 90% CI = [-.84, -.06], $p = .059$.

Taken together, the newly introduced differentiation between unintentional and intentional TRTs might indeed reflect different qualitative experiences with an on-task attentional focus. People with good reasoning abilities, who generally focus more on their ongoing task, seem to experience the maintenance of this strong on-task focus as more reliant on attentional control than their on-task focus during reading.

Discussion

The present study was designed to examine the consistency of mind wandering measured as TUTs via thought probes during laboratory tasks. TUT rates observed during ongoing two-back and reading tasks were negatively correlated with the performance in the respective tasks. This is a typical finding in the literature (e.g., McVay & Kane, 2012; Robison et al., 2020; Rummel & Boywitt, 2014), which renders support to the validity of TUT reports as it shows that TUT rates correspond with a behavioral marker in a meaningful manner. The LST analyses showed that the latent TUT-rate variance components shared between the two indicator tasks (i.e., the remaining variance after error variance and task-specific variance components are

controlled for) were quite consistent across measurement occasions since the occasion-specific variance components were zero. The consistency coefficients of TUTs were moderate (around .30) and considerably lower than those of the WMC measures (which were around .60). In addition, the reliability estimates of WMC measures were also considerably higher (with reliability coefficients between .68 and .86) than those of the TUTs (between .49 and .58). This finding may not be surprising given that TUT measures relied on data from only eight self-reports whereas the WMC measures relied on 15 trials of an objective performance measure. The LST analysis showed that TUT rates assessed in the laboratory are somewhat reflective of a mind-wandering trait and that they also contain considerable amounts of measurement error variance but hardly any state-residual variance. It thus seems appropriate to employ a single-latent-factor approach as suggested by McVay and Kane (2009). Further good news for mind-wandering researchers are that it is generally not necessary to assess TUT rates repeatedly at different measurement occasions to control for potential state-residual effects on the mind-wandering measure as such effects seem to be negligible.

Furthermore, in line with previous studies using a single-latent-factor approach, the mind-wandering trait factor extracted in our study was negatively correlated with WMC and reasoning (McVay & Kane, 2009; Mrazek et al., 2012; Robison et al., 2020) as well as with self-discipline (Ralph et al., 2017). The depression and fantasy personality facets did not correlate with the mind-wandering trait, but the findings regarding the correlation between mind wandering and these personality variables have been mixed (Kane et al., 2017; Ralph et al., 2017; Robison et al., 2017). In sum, there was some evidence for the construct validity of the trait variable that correlated with other constructs within the nomological network in a meaningful manner. Importantly, the present study does not speak to the reasons why

correlations between mind wandering, WMC, and reasoning are regularly observed. It may well be that these correlations are due to the fact that people with a high predisposition to mind wander are also particularly likely to mind wander during working-memory and reasoning tasks, which may, in turn, hamper their performances in these tasks. As the complex span tasks used in the present study were experimenter-paced, it seems likely that frequent TUT occurrences interfered with performance in these tasks. For the self-paced reasoning task, similarly strong TUT influences on performance seem less likely but may still be possible. Another theoretical idea, well in line with the present findings, is that individual differences in attention control cause variation in WMC as well as in mind wandering – and maybe also in reasoning abilities to some extent (Kane & McVay, 2012). If so, this third variable could have been responsible for the correlational patterns we observed. As we did not assess attention control in the present study, however, we can neither confirm or disconfirm this third variable explanation.

At first thought, it may seem surprising that mind-wandering state residuals were so low in the present study. A methodological limitation of the present study to consider in this respect is that we only realized two measurement occasions separated by only six months. It is thus possible that we would have observed stronger indications of state residuals in TUT rates with more assessment occasions and/or longer time-intervals between occasions (Cole et al., 2005). However, given that state residuals were very close to zero in the present study, we find it unlikely that state-residual effects on mind-wandering will play a major role for the interpretation of TUT rates across additional measurement occasions.

Mind wandering researchers aim to understand when and why mind wandering will occur. Klinger (1971, 2013) argues that individuals situationally commit themselves to certain goals which then become *current concerns* for them, meaning that goal-related thoughts compete

with currently ongoing tasks for attention. The current concerns view implies that mind-wandering phenomena should vary from situation to situation to the extent to which goals change over time. However, the current concerns view is mostly concerned with explaining why certain TUTs occur at a certain time rather than how frequently TUTs will occur for a particular individual. For the present analyses, following common procedures, we aggregated across TUT contents (i.e., different TUT categories participants could choose between) to achieve a reliable TUT-frequency measure. Thus, although individual differences in the frequency with which TUTs occurred have been quite consistent across situations in our study, TUT contents may likely have varied between situations. Future research is necessary to extend the present findings to stability and change in mind wandering contents.

Another important point to consider in this context is that we restricted ourselves to the investigation of one particular mind-wandering phenomenon—namely TUTs occurring during laboratory tasks. To the extent to which TUTs observed in the laboratory are manifestations of sustained attention failures (Kane & McVay, 2012; Kane et al., 2016) it seems plausible that they are, just like other cognitive ability measures, of a trait-like nature. Notably, the present study does not directly speak to the question of how consistent mind-wandering phenomena other than TUTs or even TUTs assessed outside a laboratory setting will be. Regarding the latter, many factors (such as environmental noise, light, the clarity of current task goals, and the like) are held constant across different measurement occasions in the well-controlled laboratory setting. It thus seems likely that state residuals will be larger in more naturalistic settings, for instance, in ambulatory assessment studies. However, we know from experimental studies that situational factors such as current motivational, affective, and physiological states do affect (mean) TUT rates (Robison & Unsworth, 2018; Rummel & Nied, 2017; Smallwood et al., 2009).

Consequently, it is not trivial that situational factors have a very limited impact on the variability of mind-wandering behavior observed in the laboratory.

Interestingly, in the present study, there was also evidence for task-specific mind-wandering components, that is, individual differences in TUT rates were, to some extent, unique to the respective task but, within this task, consistent across occasions (Geiser & Lockhart, 2012; LaGrange & Cole, 2008). So how should this task-specific uniqueness of mind wandering be interpreted?

In many LST theory applications, the task-specific factors are reflective of systematic variance induced by a particular assessment method (e.g., self- vs. other ratings, Questionnaire A vs. B; Geiser & Lockhart, 2012). In these cases, task-specific factors cover for nuisance effects and the methods to assess the construct of interest are typically selected to be as homogeneous as possible to minimize these effects (Geiser & Lockhart, 2012). In the present case, however, the assessment method was almost identical in both tasks, that is, we used thought probes with very similar wordings and embedded them in two ongoing tasks. At the same time, the tasks in which the thought probes were embedded were chosen to be quite disparate (i.e., one was a cognitive updating task, the other was a reading task) to put the latent-trait assumption at critical test. Consequently, in the present study, the task-specific effects are not mere nuisance effects but of theoretical value as they reflect task-unique but situation-consistent variance in mind wandering. This finding indicates that, although mind-wandering reports are relatively consistent across laboratory situations; they depend on the current task. In other words, some people seem to experience TUTs particularly in cognitively taxing tasks whereas other people seem to experience TUTs particularly while reading. Notably, these differences were not just due to occasion-specific influences as they were consistent over a six-month period. As differentiating

between consistent trait and state-residual variance components was our primary interest in the present study, we kept the running order of the two-back and the reading task constant for the two measurement occasions. Thus, technically, the observed task-specific effects could also be reflective of time-on-task effects. We find this unlikely, however, because, from our experience, time-on-task effects on mind wandering are typically much stronger within tasks than between tasks. Moreover, mean TUT rates were relatively similar in both tasks. Thus, the reasons for these task-unique individual differences in mind wandering may rather lay in personal preferences known to influence mind wandering, like individual differences in the enjoyment of cognitively demanding activities (Vannucci & Chiorri, 2018), or in the subjective interest in to-be-read texts (Unsworth & McMillan, 2013). Future research is certainly necessary to better understand the causes underlying the task-specific uniqueness effects on mind wandering.

The merit of the present study, however, lies in the fact that it clearly demonstrates that some parts of the variance that is typically attributed to measurement error in mind-wandering studies using the single-latent-factor approach is systematic (i.e., consistent) and theoretically meaningful, as it reflects task-specific effects. It is important to point out that we do not want to imply that the single-latent-factor approach is generally flawed. On the contrary, in many situations, a latent mind-wandering factor extracted from a set of more or less divergent tasks will be a good enough indicator to answer the research question of interest. Rather, we want to stress that there are additional consistent but task-specific individual differences in mind wandering, which should be taken into account in future theorizing and investigations. One practical implication of our results is therefore that researchers investigating individual differences in mind wandering with thought probes should consider testing whether their

findings translate to other tasks or assess and compare mind wandering during different tasks right away.

In the present study, we also aimed to differentiate between intentional and unintentional mind-wandering (Seli et al., 2016b). The present data show that consistent task-specific mind wandering seems to play a crucial role for this differentiation, too. For intentional mind-wandering, task-specific coefficients were even higher than trait-consistency coefficients, implying that intentional mind wandering is particularly task-specific. As the engagement in intentional mind wandering is assumed to lie under personal control (Seli et al., 2016b), it seems likely that these mind-wandering manifestations are more strongly influenced by personal preferences for a particular task and, in turn, by the motivation to do well in the particular task (Seli et al., 2015). The often observed negative correlation between (intentional) mind wandering and motivation (Robison et al., 2020; Robison & Unsworth, 2018; Seli et al., 2015) may thus be a result of a task-specific trait expression. That is, when a particular task is boring for a person, this person may be less motivated to perform the task and more prone to show a consistent mind-wandering behavior to relieve herself from boredom (cf. Schooler et al., 2014).

Unlike previous studies, we not only differentiated between intentional and unintentional mind wandering but we also asked participants to evaluate whether they had unintentionally or intentionally been focusing on the task when they were currently not mind wandering. The rates of intentional and unintentional TRTs were substantially negatively correlated, suggesting that they are not as independent of each other as the intentional and unintentional TUT measures. Nevertheless, both TRT measures showed trait consistencies that were comparable to the one of the intentional mind wandering measure. More interestingly, task-specific TRTs showed a distinct pattern. For the cognitive task, intentional on-task focusing was more task-specific than

unintentional on-task focusing but, for the reading task, unintentional on-task focusing was more task-specific than intentional on-task focusing. This pattern may explain why high interest in a topic naturally reduces mind wandering during reading (Soemer & Schiefele, 2019; Unsworth & McMillan, 2013), namely because individuals get absorbed by the to-be-read text even without engaging in much effort to focus on it. Thus, the differentiation between intentional and unintentional on-task focusing might be particularly relevant for future investigations using tasks that are likely to generate some kind of flow experience (Nakamura & Csikszentmihalyi, 2002). In a related vein, recent research showed that stronger flow experiences are associated with a higher likelihood of an unconstrained on-task focus (Brosowsky et al., under review, Experiment 2).

Conclusion

Mind wandering is most frequently assessed with thought probes that are embedded in ongoing tasks. Researchers have used the resulting mind-wandering indicators as trait-like indicators in classic latent-factor approaches, but it has not yet been tested to which extent latent mind-wandering factors are consistent across assessment occasions. The present results clearly show that TUT rates assessed with online thought probes in laboratory settings can be considered an indicator of a consistent mind-wandering trait, which is not strongly affected by situational factors. The significant amount of consistent task-specific variance we observed in our data further implies that currently ongoing activities influence when and how individual differences in mind wandering manifest themselves. In sum, the present results suggest that the variability of mind-wandering states observed while performing laboratory tasks is hardly reflective of situational factors but mostly of individual mind-wandering trait differences. However, mind wandering trait expressions seem to be dependent on the task at hand, so that certain people tend

to mind wandering particularly during certain task but less so during other tasks in a rather consistent manner.

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Table 1. Mean scores of all measures.

Measure	<i>M</i>	<i>SD</i>	<i>N</i>
Raven total score	11.06	2.75	191
Numbers total score	10.39	2.42	192
University entrance grade	1.72	.63	193
OSpan total score	61.20/ 63.42	9.96/ 11.31	193/ 149
RSpan total score	56.15/ 55.70	11.33/ 14.06	193/ 149
2-back PR score	.84/ .85	.16/ .19	193/ 150
Reading accuracy	.69/ .70	.15/ .16	192/ 148
Overall TUTs 2-back	.29/ .36	.23/ .27	193/ 150
Unintentional TUTs 2-back	.27/ .31	.22/ .24	193/ 150
Intentional TUTs 2-back	.04/ .06	.10/ .15	193/ 150
Unintentional TRTs 2-back	.22/ .21	.22/ .22	193/ 150
Intentional TRTs 2-back	.47/ .42	.22/ .22	193/ 150
Overall TUTs reading	.31/ .27	.25/ .22	192/ 149
Unintentional TUTs read	.25/ .23	.22/ .19	192/ 149
Intentional TUTs read	.08/ .06	.13/ .13	192/ 149
Unintentional TRTs read	.38/ .41	.29/ .30	192/ 149
Intentional TRTs read	.29/ .30	.25/ .26	192/ 149

Note. Results from Assessment Occasion 1 (2) are displayed first (second). TUTs = task-unrelated thoughts; TRTs = task-related thoughts; OSpan = operation span task; RSpan = reading span task; PR = 2-back target hit-rate minus target false-alarm-rate. Variations in *N* are due to software failures and participants' non-compliance with instructions producing missing data in some tasks.

Table 2. Correlations between task performance and thought reports.

	1.	2.	3.	4.	5.	6.
1. Task performance	--	-.38*/ -.35*	-.30*/ -.18*	-.39*/ -.41*	.11/ .22*	.29*/ .19*
2. Overall TUTs	-.35*/ -.31*	--	.71*/ .72*	.41*/ .46*	-.11/ -.19*	-.60*/ -.67*
3. Unintentional TUTs	-.28*/ -.24*	.76*/ .65*	--	.07/ .02	-.18*/ -.30*	-.63*/ -.60*
4. Intentional TUTs	-.18*/ -.29*	.43*/ .61*	.02/ .06	--	-.13/ -.18*	-.32*/ -.37*
5. Unintentional TRTs	.29*/ .35*	-.49*/ -.47*	-.48*/ -.43*	-.33*/ -.36*	--	-.56*/ -.43*
6. Intentional TRTs	.02/ -.08	-.34*/ -.26*	-.34*/ -.27*	-.17*/ -.15	-.54*/ -.64*	--

Note. Results for the 2-back task are displayed above and results of the reading task are displayed below the diagonal. Results from Assessment Occasion 1 are displayed first and from Assessment Occasion 2 second in each cell. TUTs = task-unrelated thoughts; TRTs = task-related thoughts. $*p < .05$

Table 3. Trait consistencies, occasion specificities, task specificity, and reliabilities from latent state–trait analyses of working memory and thought reports.

	Trait Consistency	Occasion Specificity	Task Specificity	Reliability
OSpan (O1)	.56	.02	.11	.68
OSpan (O2)	.61	.09	.12	.83
RSpan (O1)	.60	.02	.13	.74
RSpan (O2)	.63	.10	.13	.86
Overall TUT 2-back (O1)	.32	.00	.24	.56
Overall TUT 2-back (O2)	.33	.00	.24	.57
Overall TUT Reading (O1)	.35	.00	.23	.58
Overall TUT Reading (O2)	.29	.00	.19	.49
Unintentional TUT 2-back (O1)	.29	.00	.10	.39
Unintentional TUT 2-back (O2)	.31	.00	.11	.41
Unintentional TUT Reading (O1)	.31	.00	.23	.53
Unintentional TUT Reading (O2)	.29	.00	.21	.49
Intentional TUT 2-back (O1)	.15	.00	.44	.59

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Intentional TUT 2-back (O2)	.15	.00	.44	.59
Intentional TUT Reading (O1)	.15	.00	.34	.49
Intentional TUT Reading (O2)	.15	.00	.33	.48
Unintentional TRT 2-back (O1)	.18	.00	.17	.35
Unintentional TRT 2-back (O2)	.19	.00	.18	.37
Unintentional TRT Reading (O1)	.19	.00	.35	.54
Unintentional TRT Reading (O2)	.19	.00	.36	.55
Intentional TRT 2-back (O1)	.15	.00	.23	.38
Intentional TRT 2-back (O2)	.15	.00	.24	.40
Intentional TRT Reading (O1)	.16	.00	.19	.35
Intentional TRT Reading (O2)	.14	.00	.17	.32

Note. OSpan = operation-span; RSpan = reading span; TUT = task-unrelated thoughts; TRT = task-related thoughts; O1 = first assessment occasion; O2 = second assessment occasion.

Figure 1. Latent state–trait model of mind wandering and working-memory capacity and correlations with reasoning

Note. CAG = college admission grade; O1 = Occasion 1; O2 = Occasion 2; Ospan = operation span task; Rspan = reading span task; 2back = two-back task; Read = Reading task; WMC = working-memory capacity; TUT = task-unrelated thoughts; Reason = reasoning. 90% confidence intervals for parameter estimates are provided in brackets.

Appendix A. Correlation table for all measures used in the latent state–trait analyses.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Raven	0.68																													
2. Numbers	0.39	0.70																												
3. CAG	-0.34	-0.14	—																											
4. Fantasy	0.14	0.02	0.08	0.79																										
5. Depression	-0.10	-0.13	0.11	0.11	0.86																									
6. Self-Discipline	-0.06	0.00	-0.24	-0.32	-0.33	0.83																								
7. Ospan_O1	0.15	0.04	-0.18	0.02	-0.10	0.07	0.78																							
8. Ospan_O2	0.17	0.16	-0.25	-0.02	-0.09	0.03	0.71	0.87																						
9. Rspan_O1	0.22	0.15	-0.25	0.01	-0.10	0.02	0.59	0.65	0.77																					
10. Rspan_O2	0.25	0.18	-0.28	-0.01	-0.14	-0.02	0.61	0.73	0.77	0.89																				
11. 2back_TUT_O1	-0.13	-0.28	0.09	0.08	0.18	-0.22	-0.06	-0.13	-0.08	-0.13	0.53																			
12. 2back_TUT_O2	-0.03	-0.12	0.03	0.12	0.12	-0.13	-0.09	-0.12	-0.08	-0.10	0.54	0.70																		
13. Read_TUT_O1	-0.18	-0.11	0.13	-0.10	0.09	-0.08	-0.09	-0.10	-0.19	-0.14	0.34	0.42	0.64																	
14. Read_TUT_O2	-0.13	0.01	0.05	0.00	-0.08	-0.04	-0.09	-0.12	-0.19	-0.03	0.13	0.24	0.49	0.58																
15. 2back_intTRT_O1	-0.03	0.20	-0.03	-0.11	-0.08	0.13	-0.01	0.16	0.05	0.16	-0.60	-0.29	-0.13	0.05	0.74															
16. 2back_intTRT_O2	-0.05	0.09	0.03	-0.07	-0.15	0.17	0.02	0.07	0.02	0.02	-0.38	-0.67	-0.33	-0.15	0.37	0.76														
17. 2back_uniTRT_O1	0.04	0.03	0.01	-0.03	-0.10	0.02	0.08	0.00	0.06	-0.01	-0.11	-0.14	-0.07	-0.05	-0.56	-0.07	0.68													
18. 2back_uniTRT_O2	-0.02	-0.06	-0.01	0.06	0.13	-0.08	-0.13	-0.13	-0.10	-0.12	0.40	0.72	0.39	0.24	-0.23	-0.60	-0.13	0.76												
19. 2back_uniTUT_O1	0.03	-0.24	-0.03	0.12	0.19	-0.15	-0.05	-0.09	-0.02	-0.10	0.71	0.36	0.19	0.00	-0.63	-0.27	-0.18	0.38	0.55											
20. 2back_uniTUT_O2	0.05	0.01	-0.05	-0.12	0.02	0.02	0.17	0.12	0.15	0.16	-0.18	-0.19	-0.13	-0.13	-0.08	-0.43	0.34	-0.30	-0.19	0.61										
21. 2back_intTUT_O1	-0.06	-0.13	0.14	0.12	0.03	-0.09	-0.04	-0.23	-0.21	-0.21	0.41	0.37	0.12	-0.02	-0.32	-0.34	-0.13	0.16	0.07	-0.11	0.56									
22. 2back_intTUT_O2	0.05	-0.08	0.03	0.22	0.07	-0.23	-0.08	-0.11	-0.10	-0.10	0.39	0.46	0.20	0.11	-0.24	-0.37	-0.17	0.02	0.21	-0.18	0.58	0.72								
23. Read_intTRT_O1	-0.13	-0.02	0.04	0.07	0.03	0.05	0.02	-0.09	0.02	0.02	-0.10	-0.11	-0.34	0.02	0.19	0.29	-0.12	-0.14	-0.10	-0.20	-0.09	-0.05	0.71							
24. Read_intTRT_O2	-0.15	-0.07	0.19	-0.05	0.14	0.07	-0.08	-0.23	-0.12	-0.20	0.09	0.06	0.04	-0.26	-0.06	0.11	0.01	-0.04	0.05	-0.13	0.05	0.02	0.31	0.73						
25. Read_uniTRT_O1	0.19	0.09	-0.12	0.02	-0.10	0.04	0.04	0.12	0.12	0.09	-0.20	-0.20	-0.49	-0.33	-0.03	0.04	0.19	-0.14	-0.13	0.23	-0.04	-0.19	-0.54	-0.28	0.71					
26. Read_uniTRT_O2	0.24	0.12	-0.27	0.08	-0.09	0.01	0.13	0.28	0.24	0.20	-0.26	-0.23	-0.47	-0.47	0.11	0.03	0.03	-0.17	-0.15	0.25	-0.05	-0.14	-0.24	-0.64	0.55	0.80				
27. Read_uniTUT_O1	-0.05	-0.04	0.08	-0.11	0.10	-0.09	-0.07	-0.13	-0.12	-0.17	0.32	0.35	0.76	0.31	-0.19	-0.37	-0.06	0.34	0.28	-0.01	0.07	0.19	-0.34	7.5e-4	-0.48	-0.34	0.56			
28. Read_uniTUT_O2	-0.09	-0.02	0.12	-0.06	-0.05	-0.06	-0.11	-0.16	-0.15	-0.06	0.20	0.22	0.44	0.65	-0.13	-0.18	0.02	0.31	0.16	-0.14	-0.01	0.06	-0.06	-0.27	-0.27	-0.43	0.48	0.47		
29. Read_intTUT_O1	-0.09	-0.10	0.06	0.01	-0.01	-0.03	-0.01	0.09	-0.10	0.02	0.07	0.10	0.44	0.20	0.01	-0.06	-0.08	0.05	0.01	-0.12	0.13	0.21	-0.17	0.03	-0.33	-0.25	0.02	-0.02	0.67	
30. Read_intTUT_O2	-0.10	-0.09	0.05	0.01	-0.01	-0.07	0.01	0.06	-0.08	0.04	0.11	0.09	0.35	0.61	0.07	-0.03	-0.10	0.02	^{-4.3e-4}	-0.11	0.02	0.19	-0.01	-0.15	-0.28	-0.36	0.07	0.06	0.49	0.65

Note. Reliability measures are displayed in the diagonal. For task-performance and personality measures, Cronbach's Alpha coefficients are reported. For TUT and TRT measures, split-half reliabilities (odd/even split) after Spearman-Brown correction are reported. CAG = college admission grade; O1 = Occasion 1; O2 = Occasion 2; Ospan = operation span task; Rspan = reading span task; 2back = two-back task; Read = Reading task; TUT = task-unrelated thoughts; TRT = task-related thoughts; int = intentional; uni = unintentional