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For Whom the Mind Wanders, and When, Varies Across Laboratory and Daily-Life Settings

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Abstract

Undergraduates (*N* = 274) participated in a weeklong daily-life experience-sampling study of mind wandering after being assessed in the lab for executive-control abilities (working memory capacity; attention-restraint ability; attention-constraint ability; and propensity for task-unrelated thoughts, or TUTs) and personality traits. Eight times a day, electronic devices prompted subjects to report on their current thoughts and context. Working memory capacity and attention abilities predicted subjects' TUT rates in the lab, but predicted the frequency of daily-life mind wandering only as a function of subjects' momentary attempts to concentrate. This pattern replicates prior daily-life findings but conflicts with laboratory findings. Results for personality factors also revealed different associations in the lab and daily life: Only neuroticism predicted TUT rate in the lab, but only openness predicted mind-wandering rate in daily life (both predicted the content of daily-life mind wandering). Cognitive and personality factors also predicted dimensions of everyday thought other than mind wandering, such as subjective judgments of controllability of thought. Mind wandering in people's daily environments and TUTs during controlled and artificial laboratory tasks have different correlates (and perhaps causes). Thus, mind-wandering theories based solely on lab phenomena may be incomplete.

Keywords

mind wandering, executive control, experience sampling, personality, open data

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> Before experimenting, isn't it appropriate to know as exactly as possible *on what* one is going to experiment? (Sartre, 1936/2012, p. 127)

Mind wandering is a subjective, typically spontaneous experience, yet psychologists and neuroscientists conduct most mind-wandering research under directed, controlled laboratory conditions. Subjects undertake a task that is periodically interrupted by thought probes asking them to report whether their immediately preceding thoughts were on or off task. This empirical strategy helps illuminate how mind wandering affects performance, or individual differences, in theoretically important laboratory tasks (e.g., McVay & Kane, 2012a, 2012b). But is it suitable for exploring the nature of mind wandering as it typically unfolds in human experience? Whereas the laboratory seems like a neutral and controlled context to researchers, it is a uniquely strange place to subjects and may ironically create idiosyncratic irregularities in their behavior and experiences (Rubin, 1989). This study expands on prior findings to show that the laboratory biases researchers' perspective on individual differences in mind wandering.

In a 2007 study of "feral cognition," Kane et al. used daily-life experience-sampling methods (ESM) to determine whether cognitive abilities predicted undergraduates' subjective experiences in the moment. They found

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that variation in working memory capacity (WMC; measured by three tasks) did not correlate with overall mind-wandering rates, but had an interactive effect with environmental demands. That is, only when students reported trying hard to concentrate, or when their activity felt cognitively demanding, did those with higher WMC mind-wander less than those with lower WMC. Kane et al. therefore argued that executive mechanisms regulate everyday thought and distraction only in demanding contexts. WMC did not moderate other contextual influences on mind wandering; for example, subjects with higher versus lower WMC did not differ in mind wandering as a function of how much they liked their activities, how boring or stressful their activities were, or how happy they felt.

Subsequent evidence that executive-control failures contribute to mind wandering has come from laboratory findings that lower-WMC subjects report more task-unrelated thoughts (TUTs) than do higher-WMC subjects (e.g., Kane et al., 2016; McVay & Kane, 2012b; Robison, Gath, & Unsworth, 2017; Unsworth & McMillan, 2014). Also, during relatively simple executive-control tasks (e.g., go/no-go and Stroop tasks), poor performers report more TUTs than do better performers (Kane et al., 2016; McVay & Kane, 2012b; Robison et al., 2017; Unsworth, 2015; Unsworth & McMillan, 2014). WMC also predicts TUTs best, and perhaps only, in relatively demanding tasks (e.g., Levinson, Smallwood, & Davidson, 2012; McVay & Kane, 2012a; Rummel & Boywitt, 2014). So far, so good—laboratory and daily-life findings agree. However, two contradictions have arisen: (a) WMC does not always predict TUTs in demanding tasks (e.g., Krawietz, Tamplin, & Radvansky, 2012), and (b) in laboratory experiments requiring subjects to rate their concentration after each probe, as in Kane et al. (2007), Smeekens and Kane (2016) found that WMC did not moderate the association between concentration and mind wandering.

Thus, WMC's relation to mind wandering appears to be complex and may differ between laboratory and everyday settings, assuming that the daily-life results were reliable. The study by Kane et al. (2007) influenced theorizing about executive contributions to mind wandering, so it requires replication and extension. Because ESM studies are challenging and expensive, however, they elicit few replication attempts (but see Marcusson-Clavertz, Cardeña, & Terhune, 2016[1]). In the present study, we expanded on the original study by Kane et al. by using a larger sample size, measuring WMC more broadly, and assessing conscious experiences beyond mind wandering (e.g., thought controllability). Moreover, given theoretical claims regarding WMC's executive-attentional basis, we expanded our assessment to include attention-restraint ability (via inhibitory-control tasks), attention-constraint ability (via flanker-interference tasks), and laboratory TUT propensity (via task-embedded thought probes), to test whether other executive-control constructs also interact with prevailing cognitive demands in predicting mind wandering.

Although executive-control abilities predict mind wandering, and executive failures may precipitate TUTs, mind-wandering theories disagree about the relative contributions of executive control and other trait and contextual variables (e.g., McMillan, Kaufman, & Singer, 2013; McVay & Kane, 2010; Mooneyham & Schooler, 2013; Smallwood & Andrews-Hanna, 2013). Personality traits are likely contributors to mind-wandering variation, as they influence a host of experiential constructs (e.g., Mehl, Gosling, & Pennebaker, 2006; Ozer & Benet-Martínez, 2006). Surprisingly, though, few thought-sampling studies have investigated personality. Instead, researchers have primarily correlated personality scales with retrospective daydreaming questionnaires (McMillan et al., 2013), which are vulnerable to memory and reporting biases. Among the Big Five factors of personality, only neuroticism (Jackson, Weinstein, & Balota, 2013; Robison et al., 2017), conscientiousness (Jackson & Balota, 2012; Jackson et al., 2013), and openness to experience (Smeekens & Kane, 2016) have been assessed as predictors of TUT rates measured using probes in the lab.

These few studies suggest that the frequency of laboratory TUTs correlates positively with neuroticism (Jackson et al., 2013; Robison et al., 2017), correlates negatively with conscientiousness (Jackson & Balota, 2012; but see Jackson et al., 2013), but does not correlate with openness (Smeekens & Kane, 2016). The findings for neuroticism and conscientiousness fit well with theory and seem generalizable to everyday life (at least, in the case of conscientiousness, to activities requiring motivation). The null association between TUTs and openness, however, seems counterintuitive because openness is partially defined as reflecting a rich fantasy life (McCrae & Sutin, 2009). Indeed, openness correlates with responses on retrospective questionnaires assessing "positive-constructive" daydreaming (McMillan et al., 2013). Perhaps these discrepant results indicate that high-openness people engage in frequent everyday mind wandering when circumstances allow, but can concentrate when necessary, such as during artificial laboratory tasks.

These selective personality correlations, and the divergence between lab and daily-life findings concerning the effects of concentration on WMC's association with mind wandering, suggest potentially important differences in mind-wandering experiences across environments, which would be consistent with the "context regulation" perspective offered by Smallwood and Andrews-Hanna (2013). In this view, because mind wandering's costs and benefits vary by context, so will its regulation; researchers should therefore examine mind wandering across a range of laboratory contexts.

Our study went still further, uniquely contrasting how cognitive and personality constructs are related to mind-wandering propensity in the laboratory and outside the lab, in daily-life settings.

Method[2]

Subjects

Undergraduates at the University of North Carolina at Greensboro, a comprehensive state university (and Minority Serving Institution for African American students), were invited to participate in an experience-sampling assessment after completing the second and third sessions of a laboratory study (Kane et al., 2016). Our data-collection stopping rule was to test subjects until at least 400 had completed three laboratory sessions and at least 200 of these had provided usable data for the present study. Five hundred forty-five subjects completed the first lab session, 492 completed two sessions, and 472 completed three; 276 subjects enrolled in the ESM study reported here. Our target sample size of 200 was based on Monte Carlo simulations (Muthén & Muthén, 2002) that estimated power to detect significant Level 1 and Level 2 main effects and cross-level interactions (with five latent-variable predictors at Level 2). We simulated power for several sample sizes (100, 200, and 300) and for small, medium, and large effects. Our proposed sample size, which we exceeded by 37%, was sufficiently powered (> .85) to detect medium effects.

We collected usable experience-sampling data from 274 subjects (188 female, 81 male, 5 with unreported gender), ages 18 to 35 years (M = 18.74, SD = 1.79; n = 273) after dropping 2 subjects' data (see Experience-Sampling Data Analyses and Screening). The self-reported racial distribution of the sample (n = 271) was 44% African American, 42% White, 3% Asian, 0% Native American or Alaskan Native, 0% Native Hawaiian or Pacific Islander, 6% multiracial, and 6% other; in response to a separate question, 8% of the sample (n = 272) reported being Latino or Hispanic.

Laboratory cognitive measures

In this section, we briefly describe the laboratory tasks and their scoring. More extended descriptions are provided in Kane et al. (2016).

WMC. In six tasks, subjects briefly maintained items in memory while engaging in additional mental processes. Four complex span tasks presented short sequences of items for immediate serial recall; each memory item was preceded by an unrelated processing task requiring a "yes" or "no" response. Operation Span required subjects to recall series of three to seven letters interleaved with compound equations to be verified as correct or incorrect; Reading Span required subjects to recall series of two to six words interleaved with sentences to be verified as meaningful or nonsensical; Symmetry Span required subjects to recall two to five red cells presented within 4 × 4 matrices interleaved with black-and-white grid patterns to be verified as vertically symmetrical or asymmetrical; Rotation Span required subjects to recall the orientations of a series of two to five large and small arrows (radiating from fixation) interleaved with rotated letters to be verified as normal or mirror-reversed. The other two WMC tasks were Running Span and Updating Counters. Running Span required subjects to recall the last three to seven letters from a sequence. The number of letters to be recalled was cued on each trial, and the total length of each sequence was unpredictably the same as the number of letters to be recalled or one or two letters longer. Updating Counters required subjects to encode the digit presented in each of three to five horizontally arranged boxes on each trial. After an updating phase in which two to six digit values could be unpredictably updated with values from −7 to +7, subjects recalled the final value for each box as it was cued in random order. For all six tasks, higher scores indicated correct recall of more items.

Attention restraint. In five restraint tasks, subjects needed to override a dominant response in favor of a novel one. Two of these tasks were antisaccade tasks, in which a cue flashed on the left or right, and subjects had to orient their attention to the opposite side to identify a brief, masked target presented there; the targets in the Antisaccade Letters task were the letters "B," "P," and "R," and the targets in the Antisaccade Arrows task were arrows that pointed up, down, left, or right. The dependent measure for both antisaccade tasks was error rate. The Sustained Attention to Response Task (SART) was a go/no-go task requiring subjects to press a key when animal names were presented (89% of 675 trials) and to withhold response when vegetable names were presented (11% of trials); the dependent measures for the SART were d' and intraindividual standard deviation of response time (RT). In the Number Stroop task, a row of two to four digits was presented on each trial, and subjects reported via key press the number of digits while ignoring their identity; incongruent arrays (e.g., "44," "3333") were presented on 20% of the trials. The dependent measure was RT for incongruent trials. The Spatial Stroop task required subjects to report via key press the position of a direction word ("UP," "DOWN," "RIGHT," or "LEFT") relative to an asterisk; the word and the asterisk were presented together, to the left or right of fixation or above or below fixation. On incongruent trials (33% of the trials), both the absolute and the relative locations of the word were incongruent with the word's meaning (e.g., "DOWN" presented above the asterisk and both presented above fixation), and on congruent trials (33% of the trials), both the absolute and the relative locations of the word were congruent with the word's meaning (e.g., "DOWN" presented below the asterisk and both presented below fixation). The dependent measure was the residual of incongruent-trial accuracy regressed on congruent-trial accuracy.

Attention constraint. In five flanker tasks, a target for identification was presented amid visual distractors that were target compatible, target incompatible, or neutral. In the Arrow Flanker task, the targets were right- or left-pointing arrows that were flanked horizontally by four right-pointing, left-pointing, or upward-pointing (neutral) arrows, and in the Letter Flanker task, the targets were normal- or backward-facing *F*s horizontally flanked by six normal- or backward-facing *F*s, on compatible and incompatible trials, or by six normal- or backward-facing *E*s and tilted *T*s (90° and 270° tilt), on neutral trials. For both of these tasks, the dependent variables were the residual of RT on incompatible trials regressed on RT on neutral trials and on compatible trials (see Kane et al., 2016, for more details on the various residual scores for the flanker tasks). In the Conditional Accuracy Flanker task, a target *H* or *S* was flanked horizontally by four *H*s or *S*s or, on neutral trials, by *B*s; the first trial block imposed a 600-ms response deadline for each trial, and the second imposed a 500-ms deadline (deadline feedback was provided in both blocks). The dependent measures were the residual of accuracy on incompatible trials regressed on accuracy on neutral trials and on compatible trials. In the Masked Flanker task, a target letter was flanked above, below, to the left, and to the right by other letters or by colons (neutral) and the entire display was masked after 50 or 70 ms; the dependent variables were the residual of accuracy on incompatible trials regressed on accuracy on neutral trials and on compatible trials. In the Circle Flanker task, a target *X* or *N* was flanked by two matching letters (*H, K, M, V, Y*, or *Z*) or colons (neutral), along the circumference of an imaginary circle made up by eight possible target locations; the dependent measure was the residual of incompatible-trial RT regressed on neutral-trial RT.

TUTs. Thought probes appeared unpredictably during five tasks (45 probes in the SART, 20 in the Number Stroop task, 20 in the Arrow Flanker task, 12 in the Letter Flanker task, and 15 in an otherwise-unanalyzed 2-back task). At each probe, subjects indicated which of the eight presented options most closely matched the content of their immediately preceding thoughts. Choices 3 through 8 reflected TUTs ("everyday things," "current state of being," "personal worries," "daydreams," "external environment," "other"), and the mind-wandering dependent measure for each task was the proportion of probes in response to which subjects chose one of these options.

Nonanalyzed measures. As part of the larger project, laboratory subjects also completed schizotypy questionnaires and divergent-thinking tasks (see Kane et al., 2016). Associations between these measures and daily-life experiences will be reported elsewhere.

Scores for cognitive constructs. We derived individual subjects' scores for WMC, attention restraint, attention constraint, and TUT rate by saving factor scores from a confirmatory factor analysis on all laboratory measures (including the schizotypy questionnaires) using the complete laboratory subject sample (see Kane et al., 2016). As reported in Kane et al., all indicators loaded significantly onto their respective factors, and TUT rate showed good internal reliability within tasks (αs = .78–.93) and also demonstrated reliability by correlating across tasks (*r*s = .32–.68). In all subsequent analyses reported here, we used the four cognitive factor scores of the subjects who completed the ESM component of the study. Higher WMC scores reflected better performance, whereas higher restraint and constraint scores reflected more performance failures, and higher TUT-rate scores reflected more off-task thought.

Personality measures

During the initial information session for the ESM component of the study, subjects completed a computerized version of the NEO Five-Factor Inventory-3 (McCrae & Costa, 2010), a 60-item inventory for assessing the personality traits of openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (12 items per factor). Each item (e.g., "I often feel tense and jittery," "I think it's interesting to learn and develop new hobbies") used a 5-point Likert scale, labeled *strongly disagree, disagree, neutral, agree*, and *strongly agree*. (Subjects then completed two additional self-report scales that are not analyzed here.) Personality data were missing for 3 subjects, so the final sample size for all personality-related analyses was 271.

ESM component

Palm personal digital assistants (Palm Zire; Palm, Sunnyvale, CA) running ESP software (Barrett & Barrett, n.d.) presented all questionnaires for the ESM component of the study and collected responses via a stylus interface. Each questionnaire was cued by a beep. For 7 days (plus part of the day that included the training session), subjects were randomly signaled during each of eight 90-min blocks from noon to midnight. After

Table 1. Items on the Experience-Sampling Questionnaire

1. At the time of the beep, my mind had wandered to something other than what I was doing
[Items 2 through 6 were presented if the subject was mind wandering.]
2. My mind wandering was: tuning out (aware) | zoning out (unaware) [zoning out > tuning out]
3. My mind wandered to daydreaming or fantasizing [daydreaming]
4. My mind wandered to worries or problems [worrying]
5. My mind wandered to stuff I need to/plan to do [things to do]
6. My mind wandered to things I see/hear around me [surroundings]
7. At the beep, I was trying to concentrate on what I was doing [concentration]
8. Right now my thoughts are pleasant [pleasant thoughts]
9. Right now my thoughts are strange or unusual [strange thoughts]
10. Right now my thoughts are clear [clear thoughts]
11. Right now I can hardly control my thoughts [unable to control thoughts]
12. Right now I have no thoughts or emotions [no thoughts]
13. Right now my thoughts are racing [racing thoughts]
14. Right now my thoughts are suspicious [suspicious thoughts]
15. Right now I feel someone or something is controlling my thoughts or actions [controlled thoughts]
16. I feel happy right now [happy]
17. I feel confused right now [confused]
18. I feel irritable right now [irritable]
19. I feel safe right now [safe]
20. I feel anxious right now [anxious]
21. I feel tired right now [tired]
22. I feel sad right now [sad]
23. Right now my sight or hearing seems strange or unusual [strange perception]
24. I like what I'm doing right now [preferred activity]
25. What I'm doing right now takes a lot of effort [effortful activity]
26. What I'm doing right now is boring [boring activity]
27. I am successful at this activity right now [successful activity]
28. I am alone right now [not alone]
[Items 29 and 30 were presented if the subject was alone.]
29. I am alone right now because people do not want to be with me
30. Right now I would prefer to be with people
[Items 31 through 33 were presented if the subject was with other people.]
31. I feel close to this person (these people)
32. I can express myself clearly right now to this person (these people)
33. Right now I prefer to be alone
34. My current situation is stressful [stressful situation]
35. My current situation is positive [positive situation]

Note: Items 1 and 28 required a "yes" (coded as 1) or "no" (coded as 2) response; for Item 2, subjects selected either "tuning out," scored as 1, or "zoning out," scored as 2. All other items were answered on a scale from 1 to 7 (1 = *not at all*, 4 = *moderately*, 7 = *very much*). As indicated in the table, Items 2 through 6 were skipped if the response to Item 1 was "no," and which of Items 29 through 33 were presented depended on the response to Item 28. Each item is followed, in brackets, by the label used to refer to it in the subsequent tables. Responses to Items 29 through 33 were not analyzed for the current study.

the beep, subjects had up to 5 min to begin responding and up to 5 min to complete the questionnaire.

Each questionnaire (see Table 1 for items) first asked subjects whether they were mind wandering at the time of the beep ("yes" = 1; "no" = 2); if they had been mind wandering, subjects then rated the qualities of their off-task thoughts along five dimensions. These questions were asked first because they addressed potentially fleeting conscious states. Regardless of subjects' mind-wandering status, the questionnaire then asked several questions about their efforts to concentrate and the subjective qualities of their thoughts (again, these questions were asked before other context questions to minimize forgetting). Finally, subjects answered nearly 20 questions about their current activity and emotional context. Most items on the questionnaire were rated on a 7-point Likert scale (see Table 1).

At the ESM information session, subjects provided informed consent, and the experimenter explained the ESM questionnaire (including what we meant by mind wandering, with examples; the full instruction script is available at https://osf.io/gdyu4/), instructed subjects on how to use the personal digital assistants, and described the study requirements (including three brief lab visits to download data and report technical problems). We took pains to instruct subjects to use each beep as a cue to take immediate stock of their thoughts so that they could accurately answer the questions. For example, early in the instruction script, we said: "As you know, your thoughts can drift and change very quickly, so it's very important that when you hear the beep, you immediately take stock of what you were actually thinking about." Later in the script, we said,

> So, just to review, we'll be asking you throughout the week to respond, at the beep, to questions about what you were thinking and doing *just before the beep interrupted you* [emphasis in the original]. Because your thoughts can change quickly, please use the beep as a signal to pay attention to, and remember, what exactly you were thinking about just before the PalmPilot beeped.

Subjects then completed the NEO Five Factor Inventory-3. We gave them written instructions and laboratory contact information to take with them, and experience-sampling blocks began immediately following the information session. Subjects earned $50 for completing the study and were entered into a gift-card lottery if they attended all download appointments and completed at least 70% of the experience-sampling questionnaires.

Experience-sampling data analyses and screening

Experience-sampling data have a hierarchical structure, with questionnaire responses (Level 1) nested within subjects (Level 2). Therefore, our primary analyses, conducted with Mplus 7.0 (Muthén & Muthén, 2012), used multilevel modeling with robust standard errors (MLR estimator). Level 1 predictors (e.g., concentration ratings at the beeps) were group-mean centered. Level 2 predictors (e.g., WMC factor score) were grand-mean centered for cognitive constructs and standardized for personality factors. Cross-level interactions tested whether within-person associations between Level 1 variables (e.g., the relation between concentrating and mind wandering) were moderated by between-person, Level 2 variables (e.g., WMC). We analyzed mind wandering as a categorical outcome, coded as 1 (mind wandering) or 2 (on task). All reported coefficients from the multilevel analyses are unstandardized, and thus their magnitudes are not comparable.

Survey researchers acknowledge that subjects sometimes respond carelessly or randomly, and so a common strategy is to embed catch items into self-report questionnaires to identify problematic data and subjects (e.g., Maniaci & Rogge, 2014). In daily-life ESM studies, however, researchers seek to minimize the burden on subjects and rarely include noncritical items in their questionnaires. To screen our data for potentially problematic responding (see Sperry & Kwapil, in press), we calculated the variance for Items 7 through 27 in every completed survey; all of these items were presented as a Likert scale from 1 to 7, and they appeared on every questionnaire. Low variance across these items likely reflected carelessly or inattentively selecting (nearly) the same numerical response for each item, particularly because several items implied opposite responses and so should have produced divergent ratings (e.g., having pleasant vs. suspicious thoughts; feeling sad vs. happy; feeling safe vs. anxious; liking one's activity vs. finding it boring). We then dropped all individual questionnaires with variance scores more than 1.96 *SD* below the mean, thereby treating 223 completed questionnaires (2.1%) as missing data. Furthermore, all data from 2 subjects were removed because 56% and 39% of their questionnaires, respectively, were dropped for low variance. This left us with 274 subjects in the data set. (We decided to conduct these questionnaire-variance analyses after observing our raw Level 1 data; however, this decision preceded our conducting the Level 1 and Level 2 analyses.)

Results

For our primary analyses that were constrained by prior published findings, we set a conventional .05 alpha level: These replication analyses assessed (a) WMC as a cross-level moderator of the effect of concentration on daily-life mind wandering (Kane et al., 2007), (b) WMC as a cross-level moderator of the effect of effort demands on daily-life mind wandering (Kane et al., 2007), and (c) laboratory TUT rate as a predictor of overall mind-wandering rate during the week in daily life (McVay, Kane, & Kwapil, 2009). Our a priori analyses involving personality assessed (a) conscientiousness as a negative predictor of overall mind-wandering rate in daily life and neuroticism and openness as positive predictors of overall mind-wandering rate in daily life and (b) openness as a positive predictor of fantasy and daydreaming content of daily-life mind wandering, neuroticism as a positive predictor of worry content, and conscientiousness as a positive predictor of goal-related content. Because we report many analyses in addition to these, we adopted an alpha of .005 for those additional analyses.

Table 2. Correlations Among the Cognitive and Personality Predictor Variables From the Laboratory

Variable	1	2	3	4	5	6	7	8
1. Lab TUT rate	—							
2. Working memory capacity	−.20**	—						
3. Attention-restraint failures	.47**	−.72**	—					
4. Attention-constraint failures	.49**	−.51**	.75**	—				
5. Openness	−.03	.18**	−.09	−.15	—			
6. Conscientiousness	−.13	−.01	−.01	.02	.00	—		
7. Extraversion	.04	−.07	.02	.04	.14	.27**	—	
8. Agreeableness	−.05	.04	−.11	−.08	.07	.20**	.27**	—
9. Neuroticism	.18**	−.04	.18**	.13	.06	−.35**	−.32**	−.21**

Note: N = 274 for correlations involving only cognitive variables and 271 for correlations involving a personality variable. TUT = task-unrelated thought.
**p < .005.

On average, subjects completed 38.4 (SD = 11.6, range = 12–71) usable experience-sampling questionnaires. Completion rate did not correlate with the cognitive measures of WMC, $r(272) = .06$, $p > .250$; attention restraint, $r(272) = -.09$, $p = .140$; or attention constraint, $r(272) = -.07$, $p > .250$, but it did correlate with laboratory TUT rate, $r(272) = -.20$, $p = .001$: Subjects with higher lab TUT rates completed fewer questionnaires. Completion rate did not correlate (by our conservative .005 alpha level) with personality factors—openness: $r(269) = -.08$, $p = .196$; conscientiousness: $r(269) = .16$, $p = .008$; extraversion: $r(269) = -.13$, $p = .029$; agreeableness: $r(269) = .02$, $p > .250$; neuroticism: $r(269) = -.03$, $p > .250$ (although effect sizes for conscientiousness and extraversion were arguably as expected).

Associations among the cognitive and personality predictor variables

Table 2 presents the correlations among our predictor variables. The results were consistent with the latent-variable findings from the full laboratory sample (Kane et al., 2016) and with findings of prior studies (McVay & Kane, 2012b; Unsworth & McMillan, 2014) in that laboratory TUT rate was modestly negatively correlated with WMC and more strongly positively correlated with failures of attention restraint and constraint. TUT rate was also positively correlated with neuroticism, as found previously by Robison et al. (2017) but uncorrelated with openness, as found previously by Smeekens and Kane (2016). No other personality factors significantly predicted lab TUT rate. Note that the inconsistently demonstrated correlation between conscientiousness and TUT rate (Jackson & Balota, 2012, vs. Jackson et al., 2013) was not significant by our conservative threshold, but would have been by a more liberal and typical one, $r(269) = -.13$, $p = .040$.

Overall rate and content of daily-life mind wandering

The overall rate of mind wandering reported on the experience-sampling questionnaires over the course of the week was, on average, 32% (SD = 17%, range = 2–97%), matching our prior findings that undergraduates' thoughts are off task 30% of the time (Kane et al., 2007; McVay et al., 2009; see also Franklin et al., 2013; Marcusson-Clavertz et al., 2016; Song & Wang, 2012). These results reinforce the idea that mind wandering is generally a common occurrence that nonetheless varies greatly in frequency among young adults, perhaps because of cognitive and personality differences. When subjects reported mind-wandering episodes, they indicated they were "tuned out" (i.e., mind wandering with some awareness) 60.4% of the time and "zoned out" (i.e., mind wandering without awareness) 39.6% of the time. Their mean ratings for mind-wandering content (on a scale from 1 to 7) were 3.79 (SE = 0.08) for daydreams and fantasy, 3.20 (SE = 0.07) for worries and problems, 4.39 (SE = 0.07) for things they needed to do, and 3.63 (SE = 0.07) for visual and auditory surroundings. Off-task thoughts thus tended to happen with awareness and, with respect to content, to focus on everyday plans and goals.

Contextual predictors of daily-life mind wandering in the moment

When tested individually, many of the contextual variables significantly predicted mind wandering in the moment (see Table 3): Subjects tended to be more mentally on task when they tried harder to concentrate, when they engaged in preferred activities that they were performing well, and when they were happier and their situations were generally more positive.

Table 3. Modeling Results for Contextual Predictors of On-Task Thought (Versus Mind Wandering), With Each Predictor Tested Individually and All Predictors Modeled Together

	Tested individually			Modeled together		
Predictor	*b*	*z*	*p*	*b*	*z*	*p*
Concentration	**0.44 [0.39, 0.48]**	**18.06**	**< .001**	**0.45 [0.40, 0.50]**	**18.08**	**< .001**
Happy	**0.09 [0.06, 0.12]**	**5.55**	**< .001**	−0.01 [−0.05, 0.03]	−0.62	> .250
Confused	**−0.08 [−0.11, −0.05]**	**−4.65**	**< .001**	−0.05 [−0.09, −0.00]	−2.15	.031
Irritable	**−0.05 [−0.08, −0.02]**	**−3.05**	**.002**	0.03 [−0.01, 0.07]	1.57	.116
Safe	0.05 [0.01, 0.09]	2.33	.020	−0.03 [−0.07, 0.02]	−1.15	.249
Anxious	**−0.08 [−0.12, −0.05]**	**−5.33**	**< .001**	**−0.08 [−0.11, −0.04]**	**−4.16**	**< .001**
Tired	**−0.06 [−0.09, −0.04]**	**−4.84**	**< .001**	−0.04 [−0.06, −0.01]	−2.38	.017
Sad	**−0.08 [−0.12, −0.05]**	**−4.95**	**< .001**	−0.01 [−0.06, 0.04]	−0.36	> .250
Strange perception	**−0.08 [−0.13, −0.03]**	**−3.07**	**.002**	−0.02 [−0.08, 0.04]	−0.73	> .250
Preferred activity	**0.12 [0.10, 0.15]**	**8.76**	**< .001**	0.04 [0.01, 0.08]	2.46	.014
Effortful activity	0.03 [−0.00, 0.06]	1.90	.058	−0.04 [−0.07, −0.01]	−2.66	.008
Boring activity	**−0.12 [−0.15, −0.10]**	**−9.13**	**< .001**	**−0.07 [−0.11, −0.04]**	**−4.51**	**< .001**
Successful activity	**0.05 [0.02, 0.08]**	**3.26**	**.001**	−0.03 [−0.07, 0.00]	−1.82	.069
Not alone	0.03 [−0.08, 0.13]	0.50	> .250	0.09 [−0.02, 0.20]	1.64	.101
Stressful situation	−0.04 [−0.07, −0.01]	−2.82	.005	−0.00 [−0.04, 0.04]	−0.05	> .250
Positive situation	**0.10 [0.07, 0.13]**	**6.31**	**< .001**	0.02 [−0.02, 0.06]	1.06	> .250

Note: For the outcome variable, a higher score indicated more on-task thought and a lower score indicated more mind wandering. Values inside brackets are 95% confidence intervals. Significant effects ($p < .005$) are highlighted in boldface.

Subjects tended to mind wander more when they were experiencing more negative affect (feeling anxious, sad, irritable, and confused), when they felt more tired, and when their activities were more boring. The probability of mind wandering was statistically unaffected by whether subjects were alone or with other people, by how safe they felt in their context, or by how effortful their current activity was or how stressful their current situation was. When all of the contextual variables were entered into a single model, however, only three met our conservative significance criterion for predicting unique variance in mind wandering: Subjects were more on task when they tried harder to concentrate, and they were more off task when they felt more anxious and when their activity was more boring.

Executive-control ability, daily-life mind-wandering rate, and context

Before exploring individual differences in daily-life mind wandering, we considered the reliability of our assessment, particularly because whether thinking was on or off task was substantially influenced by the prevailing context. In fact, mind-wandering rates were statistically reliable. We estimated reliability for the first, mind-wandering, experience-sampling questionnaire item in a many-facet Rasch model framework (Eckes, 2011) using FACETS 3.71.4 (Linacre, 2014). This class of mixed Rasch models can estimate reliability for a single item assessed repeatedly, even when the item is categorical and subjects differ in number of responses. Rasch reliability—the true lower bound of reliability (Linacre, 1997)—for this mind-wandering item was .77, which indicated that it had a good ability to discriminate among people's propensities to mind wander in daily life.

McVay et al. (2009) found that laboratory TUT rate predicted the rate of daily-life mind wandering overall, whereas Kane et al. (2007) found that WMC predicted the rate of daily-life mind wandering only as a function of the cognitive demands of the context (i.e., lower-WMC subjects mind-wandered more than higher-WMC subjects when they tried harder to concentrate and their activities were more challenging or effortful than usual). In the current study, laboratory TUT rate did not significantly ($\alpha = .05$) predict mind-wandering rate in daily life, $b = -0.18$, 95% confidence interval (CI) = [−0.37, −0.02], $z = -1.81$, $p = .070$, although this nearly significant effect was in the same direction as in McVay et al. (2009); more TUTs in the lab predicted more mind wandering (less on-task thinking) in daily life. Given that our sample was larger ($N = 274$ vs. 72) and we observed only a marginal effect, we must conclude that any relation between laboratory and overall daily-life mind-wandering propensities is not robust. None of the other cognitive constructs predicted overall mind-wandering rate in daily life, even though they significantly predicted TUT rate in the lab (WMC: $b = .01$, 95% CI = [−0.17, 0.19], z = 0.14, $p > .250$; attention restraint: b = −0.07, 95% CI = [−0.21, 0.08], z = −0.87, $p > .250$; attention constraint: b = −0.27, 95% CI = [−0.60, 0.06], z = −1.62, p = .106).

We did find, however, that WMC significantly moderated the association between self-reported concentration efforts and mind wandering (see Table 4, which reports cross-level interactions for each of the cognitive-ability factors with each of the experience-sampling contextual variables). This result contrasts with the laboratory findings from Smeekens and Kane (2016), but, as Figure 1 illustrates, the cross-level interaction reported by Kane et al. (2007) in their daily-life study was replicated. As subjects reported trying harder than usual to concentrate, those with higher WMC were more mentally on task than were those with lower WMC; moreover, as subjects reported trying less than usual to concentrate, those with higher WMC mind-wandered *more* than did those with lower WMC. Viewed another way, the steeper slope for higher-WMC subjects suggests that their conscious experiences were more responsive to their concentration efforts than were those of lower-WMC subjects; in other words, higher-WMC subjects exerted better control over their thoughts.

Table 4 also indicates that WMC did not moderate the association between the subjective effort required by students' activities and their mind wandering; thus, our study did not replicate the finding (from Kane et al., 2007) that lower-WMC subjects mind-wandered more than did higher-WMC subjects as their activities became more effortful. Note also that this lack of an association between WMC and mind wandering under conditions of high effort (see also Marcusson-Clavertz et al., 2016) seems to conflict with lab findings that WMC predicts TUTs only during relatively demanding tasks (e.g., Levinson et al., 2012; McVay & Kane, 2012a).

Although the cross-level interaction involving effort was not replicated, the cross-level interaction involving concentration was significant not only for WMC, but also for attention-restraint and laboratory TUT rates (α = .005). Table 4 and Figure 1 indicate that subjects with fewer attention-restraint failures and fewer laboratory TUTs also were more effectively on task as they reported trying harder than usual to concentrate on their ongoing activity than were subjects with more attention-restraint failures and more laboratory TUTs. Similarly, the higher-ability subjects tended to mind-wander more than the lower-ability subjects on occasions when they tried to concentrate less than usual. It is all the more impressive that this cross-level interaction pattern was replicated across our cognitive individual difference variables given that laboratory TUT rate correlated only modestly with WMC. These constructs were not simply redundant, but they should share some executive-control-related variance.

Indeed, we tested the hypothesis that general executive-control processes drove the associations between cognitive abilities and the self-regulation of daily-life mind wandering, in two ways. The first was analogous to simultaneous multiple regression, which assesses whether predictors account for variance in an outcome above and beyond the variance accounted for by the other predictors in the model. Specifically, we entered all three significant cognitive predictors into the model for the cross-level interaction between concentration and mind wandering, to see whether any executive-control construct moderated the interaction independently of the others. They did not (WMC: b = 0.12, 95% CI = [−0.04, 0.28], z = 1.50, p = .133; attention restraint: b = −0.03, 95% CI = [−0.15, 0.10], z = −0.46, $p > .250$; laboratory TUT rate: b = −0.10, 95% CI = [−0.21, 0.01], z = −1.77, p = .077); these conclusions also held when the constraint factor was added to the model.

Second, we used structural equation modeling to model the predictor variables as reflecting both general (shared) executive-control variance and domain-specific variance. Specifically, we saved factor scores from a bifactor structural model from Kane et al. (2016), which represented the variance shared by all WMC, restraint, constraint, and TUT measures as a general executive-control factor. It also modeled the variance common to the WMC tasks but not shared with the other tasks as a WMC-residual (specific) factor, and the variance common to the TUT measures but not shared with the other tasks as a TUT-residual (specific) factor. In this analysis, the general executive-control factor moderated the effect of concentration on daily-life mind wandering, b = −0.14, 95% CI = [−0.22, −0.07], z = −3.82, $p < .001$, whereas the WMC-residual factor and the TUT-residual factor did not, b = 0.05, 95% CI = [−0.05, 0.14], z = 0.98, $p > .250$, and b = −0.10, 95% CI = [−0.21, 0.01], z = −1.83, p = .068, respectively. Both analyses reinforce the conclusion that the executive-control variance shared among WMC, attention restraint, and laboratory TUT propensity drove their interactions with concentration efforts in predicting daily-life mind wandering.

As in Kane et al. (2007), the cognitive-ability constructs did not moderate the influences of other contextual predictors of mind wandering, such as how boring subjects' activities were and how anxious subjects felt (see Table 4). That is, lower-WMC subjects did not simply report more mind wandering than higher-WMC subjects when they were relatively bored, or relatively anxious, or doing relatively undesirable activities. These findings indicate, again, that the effects of cognitive ability on mind wandering are limited to contexts in which subjects attempt to bring their executive-control

Table 4. Modeling Results for Cross-Level Interactions of Level 1 Cognitive Predictors of On-Task Thought (Versus Mind Wandering) With Level 2 Cognitive Constructs From the Laboratory (Each Tested Individually)

	Working memory capacity			Attention-restraint failures			Attention-constraint failures			Lab TUT rate		
Predictor	*b*	*z*	*p*	*b*	*z*	*p*	*b*	*z*	*p*	*b*	*z*	*p*
Concentration	**0.17 [0.07, 0.27]**	**3.39**	**.001**	**−0.14 [−0.21, −0.07]**	**−3.77**	**< .001**	−0.20 [−0.36, −0.05]	−2.59	.010	**−0.14 [−0.24, −0.05]**	**−3.00**	**.003**
Happy	−0.00 [−0.07, 0.06]	−0.12	> .250	0.00 [−0.05, 0.05]	0.06	> .250	−0.02 [−0.12, 0.09]	−0.35	> .250	0.05 [−0.02, 0.11]	1.45	.148
Confused	0.01 [−0.05, 0.08]	0.37	> .250	0.00 [−0.05, 0.05]	0.12	> .250	0.05 [−0.05, 0.15]	0.97	> .250	−0.04 [−0.10, 0.02]	−1.25	.212
Irritable	0.04 [−0.02, 0.09]	1.28	.202	−0.00 [−0.05, 0.04]	−0.16	> .250	0.07 [−0.02, 0.17]	1.53	.126	−0.03 [−0.09, 0.03]	−1.12	> .250
Safe	−0.06 [−0.13, 0.01]	−1.62	.106	0.04 [−0.02, 0.10]	1.36	.173	−0.01 [−0.14, 0.12]	−0.15	> .250	0.01 [−0.06, 0.08]	0.23	> .250
Anxious	0.03 [−0.03, 0.09]	1.05	> .250	−0.01 [−0.06, 0.03]	−0.51	> .250	0.01 [−0.08, 0.11]	0.24	> .250	−0.05 [−0.12, 0.01]	−1.67	.095
Tired	0.00 [−0.05, 0.05]	0.08	> .250	0.02 [−0.02, 0.05]	0.76	> .250	0.03 [−0.06, 0.11]	0.66	> .250	−0.01 [−0.05, 0.04]	−0.27	> .250
Sad	−0.01 [−0.08, 0.06]	−0.33	> .250	0.04 [−0.02, 0.09]	1.25	.210	0.11 [0.00, 0.23]	1.95	.051	−0.02 [−0.09, 0.05]	−0.60	> .250
Strange perception	−0.05 [−0.14, 0.04]	−1.16	.244	0.06 [−0.02, 0.14]	1.44	.149	0.24 [0.07, 0.41]	2.74	.006	0.03 [−0.08, 0.13]	0.50	> .250
Preferred activity	−0.01 [−0.07, 0.05]	−0.33	> .250	−0.02 [−0.07, 0.02]	−1.11	> .250	−0.03 [−0.13, 0.06]	−0.71	> .250	−0.04 [−0.09, 0.02]	−1.34	.179
Effortful activity	0.03 [−0.04, 0.09]	0.88	> .250	−0.02 [−0.07, 0.03]	−0.70	> .250	0.06 [−0.04, 0.16]	1.14	> .250	0.02 [−0.04, 0.08]	0.69	> .250
Boring activity	0.02 [−0.03, 0.06]	0.67	> .250	−0.00 [−0.04, 0.03]	−0.07	> .250	−0.02 [−0.10, 0.06]	−0.53	> .250	0.00 [−0.04, 0.05]	0.15	> .250
Successful activity	−0.03 [−0.08, 0.03]	−0.87	> .250	−0.03 [−0.07, 0.01]	−1.43	.153	−0.04 [−0.13, 0.05]	−0.87	> .250	−0.04 [−0.11, 0.02]	−1.33	.183
Not alone	−0.10 [−0.31, 0.12]	−0.89	> .250	−0.01 [−0.18, 0.17]	−0.07	> .250	−0.21 [−0.57, 0.16]	−1.12	> .250	0.08 [−0.11, 0.27]	0.81	> .250
Stressful situation	0.01 [−0.04, 0.07]	0.42	> .250	0.01 [−0.04, 0.06]	0.44	> .250	0.08 [−0.02, 0.18]	1.66	.097	−0.00 [−0.06, 0.06]	−0.04	> .250
Positive situation	0.03 [−0.04, 0.10]	0.93	> .250	−0.05 [−0.09, 0.00]	−1.89	.059	−0.08 [−0.17, 0.02]	−1.58	.113	0.02 [−0.04, 0.08]	0.74	> .250

Note: For the outcome variable, a higher score indicated more on-task thought and a lower score indicated more mind wandering. Values inside brackets are 95% confidence intervals. Significant effects ($p < .05$ for the analyses listed in the first paragraph of the Results section, $p < .005$ for all other analyses) are highlighted in boldface. TUT = task-unrelated thought.

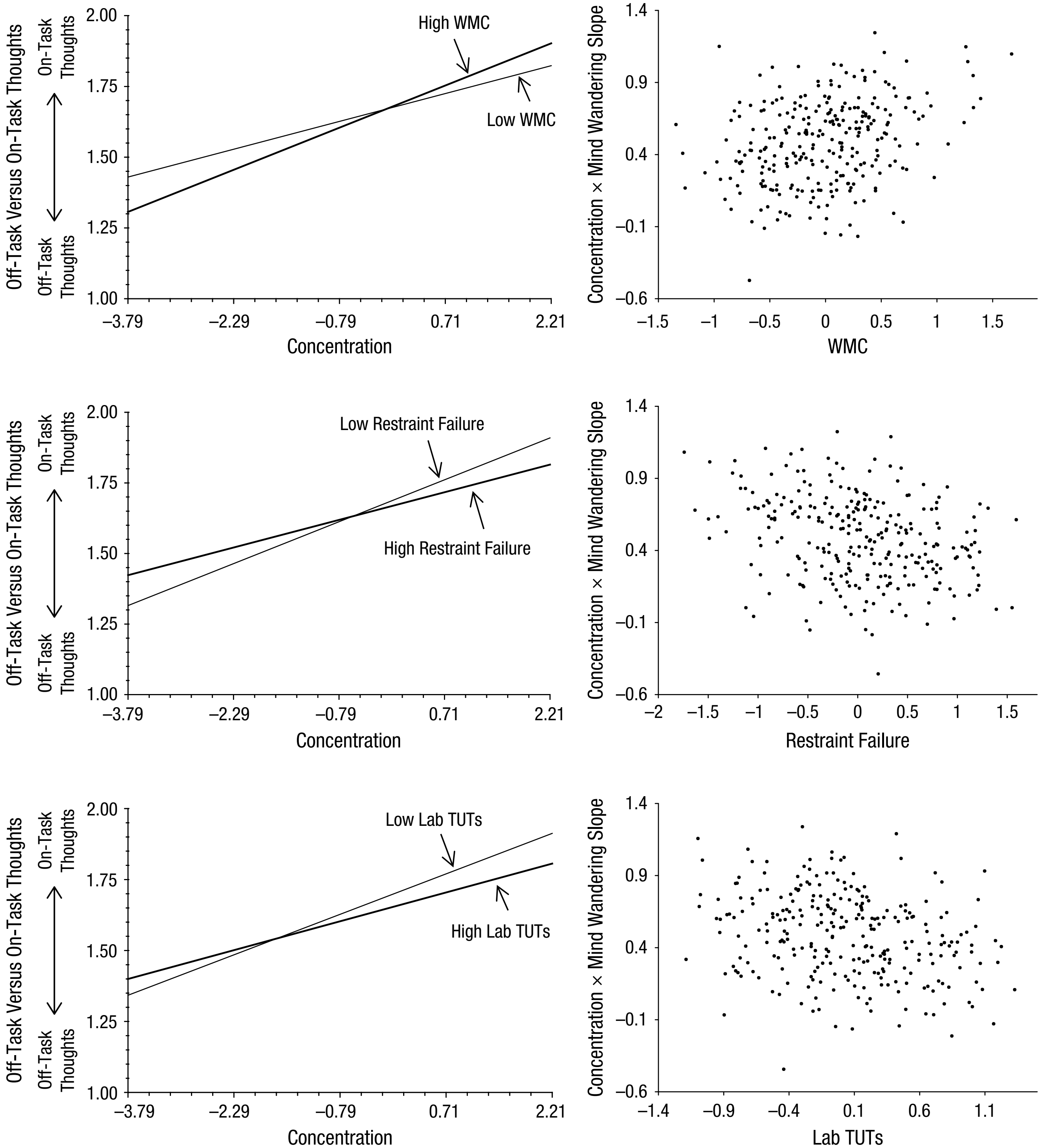

Fig. 1. The relation between daily-life mind wandering and self-reported concentration among subjects with higher versus lower working memory capacity (WMC; top row), attention-restraint failure rates (middle row), and laboratory rates of task-unrelated thoughts (TUTs; bottom row). In the left column, the graphed lines depict the means of the within-person slopes for subjects in the top and bottom quartiles of these three executive-control abilities, and the values on the *x*-axis represent the group-centered ratings for daily-life concentration; the mind-wandering dependent variable was scored as either 1 (for off-task thoughts) or 2 (for on-task thoughts). In the graphs in the right column, each dot represents the results for an individual subject; values on the *x*-axis represent grand-mean-centered scores for WMC, rate of attention restraint failure, and laboratory TUT rate, and values on the *y*-axis represent the slope of the effect of concentration rating on the probability of on-task thought (vs. mind wandering) in daily life (steeper positive slopes indicate stronger positive associations between momentary concentration and on-task thinking).

Table 5. Modeling Results for On-Task Thought (Versus Mind Wandering) in the Moment as a Predictor of Thought Qualities

Predictor	*b*	*z*	*p*
Pleasant thoughts	**0.18 [0.11, 0.26]**	**4.81**	**< .001**
Strange thoughts	**−0.22 [−0.29, −0.16]**	**−6.77**	**< .001**
Clear thoughts	**0.38 [0.30, 0.45]**	**9.93**	**< .001**
Unable to control thoughts	**−0.23 [−0.31, −0.16]**	**−6.14**	**< .001**
No thoughts	0.03 [−0.05, 0.10]	0.70	> .250
Racing thoughts	**−0.21 [−0.29, −0.13]**	**−5.12**	**< .001**
Suspicious thoughts	**−0.11 [−0.17, −0.06]**	**−4.08**	**< .001**
Controlled thoughts	−0.07 [−0.12, −0.02]	−2.62	.009

Note: Positive coefficients indicate experiences that were more likely when subjects were on task, and negative coefficients indicate experiences that were more likely when subjects were mind wandering. Values inside brackets are 95% confidence intervals. Significant effects ($p < .005$) are highlighted in boldface.

abilities to bear on regulating thought via concentration, and are not merely the result of common folk theories about when people should or should not experience mind wandering in everyday life. Moreover, WMC does not moderate the association between concentration and mind wandering in the laboratory (Smeekens & Kane, 2016), as it did in the present study and in Kane et al. (2007), and so WMC's moderation of the relation between concentration and daily-life mind wandering does not appear to reflect a WMC-related bias or belief about TUTs and concentration.

Executive-control ability and qualities of daily-life thought

Whether or not subjects were currently mind wandering, they always answered eight questions about the subjective controllability and content of their thoughts. Table 5 indicates that, overall, on-task thoughts were significantly more pleasant and clear than off-task thoughts, and significantly less strange, suspicious, racing, and uncontrollable. Mind-wandering experiences, then, were relatively negative in our sample, which is consistent with findings reported by Killingsworth and Gilbert (2010; see also Kane et al., 2007; McVay et al., 2009).

On those occasions when subjects reported mind wandering, the content of their off-task thought was not generally associated with the executive-attention constructs we measured (see Table 6). Thus, subjects of higher cognitive ability were no more or less likely to zone out without awareness, to daydream, to worry, to think about their unfulfilled goals and plans, or to be distracted by their immediate environment than were subjects of lower ability. (We thus failed to replicate an exploratory finding, from McVay et al., 2009, that subjects with higher lab TUT rates reported more worrying in their daily-life mind wandering than did those with lower lab TUT rates.)

In contrast, several cognitive constructs predicted other subjective qualities of thought—most notably the perceived self-regulation of thought—regardless of whether subjects were on or off task in the moment (see Table 6). Attention-restraint failure and lab TUT rate significantly predicted subjective ratings of the controllability of thoughts in the moment; these effects were nearly significant also for WMC and attention-constraint failures (*p*s = .007 and .008, respectively), and are consistent with the steeper slopes between concentration attempts and mind wandering (on- vs. off-task thinking) for higher-ability subjects than for lower-ability subjects (depicted in Fig. 1). Subjects with higher laboratory TUT rates also endorsed more strongly the statement that their current thoughts were racing, and subjects with more attention-restraint failures were more likely to report that their thoughts felt controlled by someone or something else. Regarding qualities of thought content, subjects with more restraint failures in the lab reported stranger thoughts in everyday life.

Personality traits, mind-wandering rate, and mind-wandering content

As a preliminary validity check for our personality questionnaire measures, we assessed whether they correlated with the experience-sampling daily-life indicators that one would theoretically expect them to (see Table S1 in the Supplemental Material). Indeed, subjects higher in openness to experience reported engaging in less boring activities in the moment. Subjects higher in neuroticism reported feeling less happy and feeling more confused, irritable, anxious, tired, and sad, and they described their activities and contexts as more

Table 6. Modeling Results for Cognitive Constructs From the Laboratory (Each Tested Individually) as Predictors of Daily-Life Thought Qualities

	Working memory capacity			Attention-restraint failures			Attention-constraint failures			Lab TUT rate		
Outcome	*b*	*z*	*p*	*b*	*z*	*p*	*b*	*z*	*p*	*b*	*z*	*p*
Mind-wandering qualities												
Zoning out > tuning out	−0.14 [−0.35, 0.08]	−1.23	.219	0.19 [0.01, 0.37]	2.04	.042	0.31 [−0.05, 0.68]	1.69	.092	0.23 [−0.01, 0.46]	1.89	.058
Daydreaming	−0.22 [−0.53, 0.09]	−1.41	.159	0.21 [−0.04, 0.45]	1.63	.103	0.07 [−0.44, 0.57]	0.26	> .250	0.36 [0.09, 0.62]	2.63	.009
Worrying	−0.17 [−0.44, 0.10]	−1.25	.212	0.22 [0.03, 0.41]	2.31	.021	0.44 [0.05, 0.84]	2.21	.027	0.20 [−0.05, 0.44]	1.55	.121
Things to do	−0.22 [−0.44, 0.00]	−1.93	.053	0.13 [−0.05, 0.31]	1.41	.159	0.43 [0.03, 0.84]	2.08	.037	0.17 [−0.08, 0.42]	1.34	.182
Surroundings	0.08 [−0.17, 0.33]	0.61	> .250	0.02 [−0.17, 0.21]	0.20	> .250	−0.11 [−0.56, 0.34]	−0.48	> .250	0.01 [−0.24, 0.25]	0.06	> .250
Other thought qualities												
Pleasant thoughts	−0.02 [−0.22, 0.17]	−0.24	> .250	−0.04 [−0.20, 0.11]	−0.52	> .250	0.02 [−0.30, 0.34]	0.14	> .250	−0.11 [−0.31, 0.10]	−0.99	> .250
Strange thoughts	−0.08 [−0.26, 0.09]	−0.92	> .250	**0.16 [0.05, 0.26]**	**2.88**	**.004**	0.17 [−0.03, 0.38]	1.65	.099	0.17 [0.04, 0.31]	2.48	.013
Clear thoughts	−0.03 [−0.26, 0.20]	−0.27	> .250	−0.18 [−0.35, −0.01]	−2.06	.039	−0.20 [−0.56, 0.17]	−1.06	> .250	−0.24 [−0.45, −0.02]	−2.13	.033
Unable to control thoughts	−0.32 [−0.55, −0.09]	−2.68	.007	**0.34 [0.18, 0.50]**	**4.09**	**< .001**	0.47 [0.12, 0.81]	2.65	.008	**0.42 [0.17, 0.67]**	**3.30**	**.001**
No thoughts	−0.29 [−0.50, −0.08]	−2.69	.007	0.21 [0.06, 0.35]	2.73	.006	0.35 [−0.00, 0.71]	1.95	.051	0.26 [0.03, 0.48]	2.24	.025
Racing thoughts	−0.07 [−0.33, 0.19]	−0.55	> .250	0.17 [−0.01, 0.34]	1.90	.058	0.27 [−0.11, 0.65]	1.38	.169	**0.42 [0.18, 0.65]**	**3.42**	**.001**
Suspicious thoughts	−0.07 [−0.25, 0.11]	−0.77	> .250	0.12 [0.00, 0.25]	1.99	.047	0.13 [−0.12, 0.37]	0.99	> .250	0.20 [0.06, 0.35]	2.72	.007
Controlled thoughts	−0.09 [−0.23, 0.06]	−1.14	> .250	**0.15 [0.05, 0.24]**	**2.97**	**.003**	0.18 [−0.00, 0.36]	1.93	.054	0.11 [−0.02, 0.25]	1.68	.093

Note: Values inside brackets are 95% confidence intervals. Significant effects ($p < .005$) are highlighted in boldface. TUT = task-unrelated thoughts.

Table 7. Modeling Results for the Five-Factor Personality Traits as Predictors of On-Task Thought (Versus Mind Wandering) and of Mind-Wandering Content

Outcome and predictor	*b*	*z*	*p*
Mind-wandering rate			
Openness	**−0.13 [−0.24, −0.03]**	**−2.49**	**.013**
Conscientiousness	0.06 [−0.04, 0.16]	1.21	.225
Extraversion	0.01 [−0.10, 0.12]	0.18	> .250
Agreeableness	−0.03 [−0.13, 0.07]	−0.55	> .250
Neuroticism	−0.02 [−0.15, 0.11]	−0.30	> .250
Daydreaming content			
Openness	**0.18 [0.04, 0.32]**	**2.47**	**.014**
Conscientiousness	−0.00 [−0.15, 0.14]	−0.03	> .250
Extraversion	−0.04 [−0.19, 0.11]	−0.53	> .250
Agreeableness	−0.16 [−0.31, −0.01]	−2.08	.037
Neuroticism	0.16 [−0.03, 0.35]	1.63	.102
Worrying content			
Openness	−0.12 [−0.25, 0.01]	−1.86	.063
Conscientiousness	−0.03 [−0.17, 0.11]	−0.42	> .250
Extraversion	0.09 [−0.05, 0.23]	1.26	.209
Agreeableness	0.05 [−0.09, 0.19]	0.67	> .250
Neuroticism	**0.33 [0.19, 0.47]**	**4.58**	**< .001**
Things-to-do content			
Openness	−0.07 [−0.20, 0.07]	−0.98	> .250
Conscientiousness	0.04 [−0.10, 0.18]	0.54	> .250
Extraversion	0.19 [0.03, 0.35]	2.32	.020
Agreeableness	−0.01 [−0.15, 0.13]	−0.13	> .250
Neuroticism	0.02 [−0.11, 0.16]	0.32	> .250
Surroundings content			
Openness	0.09 [−0.05, 0.24]	1.22	.222
Conscientiousness	−0.03 [−0.17, 0.10]	−0.50	> .250
Extraversion	−0.03 [−0.18, 0.12]	−0.42	> .250
Agreeableness	−0.12 [−0.24, 0.01]	−1.85	.064
Neuroticism	−0.09 [−0.26, 0.09]	−0.99	> .250

Note: For this analysis, all predictors were standardized and modeled simultaneously. A higher score for mind wandering indicated more on-task thought, and a lower score indicated more mind wandering. Values inside brackets are 95% confidence intervals. Significant effects ($p < .05$ for the analyses listed in the first paragraph of the Results section, $p < .005$ for all other analyses) are highlighted in boldface.

boring, more stressful, less liked, and less positive. Subjects higher in conscientiousness reported being more successful in their current activity, subjects higher in agreeableness reported feeling more happy and described their situation as more positive, and subjects higher in extraversion felt more happy (but also more confused) in the moment.

Returning to our primary questions, when we tested the personality factors simultaneously, we found that only openness to experience significantly ($\alpha = .05$) predicted overall daily-life mind-wandering rate (Table 7); higher openness was associated with more mind wandering. Recall that openness was unassociated with laboratory TUT rate, both in the present study and in Smeekens and Kane (2016). Moreover, although neuroticism correlated positively with lab TUT rate (see also Jackson et al., 2013; Robison et al., 2017), neither neuroticism nor conscientiousness (see Jackson & Balota, 2012) predicted everyday mind wandering, even in analyses in which each of these personality constructs was the only predictor in the model (neuroticism: $z < 1$, $p > .250$; conscientiousness: $z = 1.36$, $p = .175$).

As predicted (see Table 7), on occasions when subjects reported mind wandering, those who were higher in openness endorsed more fantastical-daydream content than did those lower in openness, whereas those higher in neuroticism endorsed more worry-based content than did those lower in neuroticism. (Our expectation that high conscientiousness would predict more thinking about unfulfilled tasks and goals during mind wandering was not confirmed, even when conscientiousness was the only predictor modeled, $z = 1.21$, $p = .226$.) Personality did not otherwise predict the content of subjects' mind wandering (Table 7). In addition, the fact that off-task thoughts were generally reported as less pleasant and clear, and more out of control, strange, racing, and suspicious, than on-task thoughts (see prior discussion of Table 5) did not change significantly with personality (see Table S2 in the Supplemental Material). So, for example, subjects high in openness did not differentially experience mind wandering as especially more pleasant than on-task thought, despite their more frequently engaging in fantasy; nor did subjects high in neuroticism experience mind wandering as especially less pleasant than on-task thought, despite their more frequently engaging in worry.

Personality and contextual predictors of mind wandering and subjective qualities of thought

In contrast to the executive-ability constructs, none of the personality factors moderated the influence of in-the-moment concentration on mind wandering; they also did not moderate any other theoretically coherent contextual influence (e.g., momentary happiness, irritability, anxiety, sadness, activity effort, and stress) on mind wandering (see Table S3 in the Supplemental Material). So, for example, openness predicted daily-life mind wandering regardless of how relaxed (i.e., non-anxious) subjects felt at the time. Similarly, neuroticism failed to predict mind wandering regardless of how irritable or anxious subjects felt. Conscientiousness did not predict mind wandering even when people reported engaging in effortful activities.

Our final analyses tested for influences of personality on other subjective qualities of thought in the moment (collapsed across occasions of on-task and off-task thinking, as in the parallel analyses involving cognitive predictors). All of the significant effects ($\alpha = .005$) were driven by neuroticism, agreeableness, and extraversion (Table 8). Subjects who were higher in neuroticism reported less pleasant and clear thoughts, and more racing thoughts, than did those lower in neuroticism. More highly agreeable subjects reported more pleasant thoughts and less strange, suspicious, and externally controlled thoughts than did less agreeable subjects. Subjects who were higher in extraversion reported more racing, strange, and suspicious thoughts than did those lower in extraversion.

Discussion

We found not only robust individual differences in how daily-life mind wandering (Kane et al., 2007) is related to cognitive abilities and personality factors, but also suggestive discrepancies between laboratory and daily-life results. Effects that were modest but replicated prior results in one domain were not observed in the other. To understand individual differences in mind wandering, then, context matters (Smallwood & Andrews-Hanna, 2013).

Individual differences in executive control in the lab versus life

Whereas prototypical executive-control constructs—WMC, attention restraint, and attention constraint—correlated with mind wandering in the lab, they did not correlate with daily-life mind wandering; indeed, even laboratory TUT rate did not significantly predict daily-life mind wandering (the effect was only marginally significant, though in the expected direction). Executive abilities, instead, predicted mind wandering only as a function of subjects' concentration attempts, a pattern replicating and extending the findings of Kane et al. (2007): When subjects tried harder to concentrate, those with better executive abilities mind-wandered less than those with worse abilities; when not trying to concentrate, subjects with better executive abilities mind-wandered *more* than those with worse abilities. Such contingencies on concentration were not observed in three laboratory experiments examining WMC's association with mind wandering (Smeekens & Kane, 2016). Moreover, prior laboratory findings that WMC negatively predicted mind wandering in challenging but not easy tasks (e.g., McVay & Kane, 2012a; Rummel & Boywitt, 2014) was absent in our analyses of daily-life mind wandering: Subjective effort demanded by activities did not moderate the associations between executive control and mind wandering. This finding contradicts results reported by Kane et al. (2007) but replicates those reported by Marcusson-Clavertz et al. (2016).

Thus, executive abilities that substantially influence laboratory mind wandering play more circumscribed roles in everyday life, and the variables that affect the association between executive control and mind wandering in the lab may not be the variables that affect the association between executive control and mind wandering in daily life. In the lab, task difficulty drives executive contributions to reducing TUTs. In everyday life, executive processes serve people's attempts to concentrate on ongoing activities, regardless of (subjective) difficulty.

Table 8. Modeling Results for the Five-Factor Personality Traits as Predictors of Daily-Life Thought Qualities

Outcome and predictor	*b*	*z*	*p*
Pleasant thoughts			
Openness	−0.00 [−0.10, 0.10]	−0.05	> .250
Conscientiousness	0.13 [0.02, 0.24]	2.38	.017
Extraversion	0.12 [0.01, 0.24]	2.08	.037
Agreeableness	**0.16 [0.05, 0.27]**	**2.95**	**.003**
Neuroticism	**−0.17 [−0.27, −0.06]**	**−3.18**	**.001**
Strange thoughts			
Openness	−0.03 [−0.10, 0.05]	−0.73	> .250
Conscientiousness	−0.09 [−0.17, −0.02]	−2.32	.020
Extraversion	**0.12 [0.05, 0.19]**	**3.18**	**.001**
Agreeableness	**−0.13 [−0.22, −0.05]**	**−3.03**	**.002**
Neuroticism	0.08 [0.01, 0.15]	2.10	.036
Clear thoughts			
Openness	−0.00 [−0.11, 0.11]	−0.03	> .250
Conscientiousness	0.19 [0.06, 0.33]	2.83	.005
Extraversion	−0.04 [−0.16, 0.08]	−0.68	> .250
Agreeableness	0.01 [−0.12, 0.13]	0.13	> .250
Neuroticism	**−0.21 [−0.33, −0.09]**	**−3.47**	**.001**
Unable to control thoughts			
Openness	−0.02 [−0.13, 0.09]	−0.38	> .250
Conscientiousness	−0.10 [−0.24, 0.04]	−1.44	.149
Extraversion	0.11 [−0.02, 0.24]	1.62	.105
Agreeableness	−0.05 [−0.20, 0.09]	−0.69	> .250
Neuroticism	0.17 [0.04, 0.29]	2.63	.009
No thoughts			
Openness	−0.12 [−0.23, −0.01]	−2.07	.038
Conscientiousness	−0.06 [−0.17, 0.05]	−1.04	> .250
Extraversion	−0.03 [−0.16, 0.11]	−0.42	> .250
Agreeableness	−0.07 [−0.19, 0.06]	−0.99	> .250
Neuroticism	0.01 [−0.11, 0.13]	0.13	> .250
Racing thoughts			
Openness	−0.02 [−0.15, 0.12]	−0.25	> .250
Conscientiousness	−0.10 [−0.26, 0.06]	−1.25	.210
Extraversion	**0.23 [0.09, 0.37]**	**3.27**	**.001**
Agreeableness	−0.05 [−0.19, 0.09]	−0.66	> .250
Neuroticism	**0.27 [0.11, 0.42]**	**3.41**	**.001**
Suspicious thoughts			
Openness	−0.07 [−0.15, 0.01]	−1.74	.082
Conscientiousness	−0.09 [−0.17, −0.01]	−2.31	.021
Extraversion	**0.11 [0.04, 0.19]**	**3.09**	**.002**
Agreeableness	**−0.12 [−0.20, −0.04]**	**−3.00**	**.003**
Neuroticism	0.09 [0.01, 0.16]	2.25	.025
Controlled thoughts			
Openness	−0.04 [−0.11, 0.04]	−0.99	> .250
Conscientiousness	−0.01 [−0.08, 0.06]	−0.19	> .250
Extraversion	0.08 [0.01, 0.15]	2.13	.034
Agreeableness	**−0.13 [−0.21, −0.05]**	**−3.29**	**.001**
Neuroticism	0.07 [−0.02, 0.16]	1.47	.143

Note: For this analysis, all predictors were standardized and modeled simultaneously. Values inside brackets are 95% confidence intervals. Significant effects ($p < .005$) are highlighted in boldface.

The lab-life discrepancy regarding "difficulty" may reflect the fact that subjective feelings of effort assessed ecologically do not map directly to determinants of performance that are manipulated in laboratories. Perhaps experiments effect subtle cognitive changes that are either not present or not subjectively detectable in everyday contexts, but that objectively influence mind wandering by selectively engaging or disengaging critical executive mechanisms (see McVay & Kane, 2012a). After all, many subjectively challenging tasks do not elicit WMC-related variation in performance because they do not tap into executive processes of attention restraint or constraint (e.g., Kane, Poole, Tuholski, & Engle, 2006; Smeekens & Kane, 2016). Laboratory findings may thus indicate what is *possible* about the association between executive control and mind wandering, but their implications may be negligible for most everyday conscious experiences.

Our results for the effects of concentration in daily life may not be replicated in the laboratory because of an inherently restricted range of activities: Compared with action video games, animated political discussions, or attempts to woo a crush, for example, lab tasks may not be engaging, important, and challenging enough to elicit maximal concentration efforts from many subjects. Similarly, compared with watching TV, showering, or mowing a lawn, lab tasks may not be effortless and routine enough to elicit minimal concentration. Recreating the diversity of not just the difficulty but also the motivated engagement that is characteristic of activities of daily life may be unrealistic even within the most creatively designed and task-inclusive lab settings, especially because adults sometimes choose their daily-life contexts.

Individual differences in personality in the lab versus life

Similar lab-life dissociations are evident for the personality variables. As did Jackson et al. (2013) and Robison et al. (2017), we found that neuroticism positively predicted laboratory TUT rate, and as did Smeekens and Kane (2016), we found that openness did not predict laboratory TUT rate. In daily life, however, we found the reverse: Openness positively predicted mind-wandering rate, but neuroticism was not a significant predictor of mind-wandering rate. Why?

If openness reflects tendencies toward playful and creative fantasy—which would be consistent with the association we found between openness and daydreaming thought content—then more open subjects should engage in more mind wandering than less open subjects when everyday life provides opportunity (McMillan et al., 2013). But assuming that their penchant for daydreaming is not pathological, more open subjects should not have any more difficulty than less open subjects in focusing attention when they must, as in the lab. This idea jibes with previous reports that openness is correlated with retrospective-questionnaire assessments of positive-constructive daydreaming (e.g., "I find my daydreams are worthwhile and interesting to me," "I imagine solving all my problems in my daydreams") but not everyday distractibility (e.g., "At times it is hard for me to keep my mind from wandering," "My imagination goes around and around in the same circle"; Zhiyan & Singer, 1996–1997).

Why should neuroticism predict laboratory but not daily-life mind wandering? Highly neurotic adults may find the laboratory particularly anxiety arousing because of its novelty and its association with evaluation; the lab may thus elicit negative self-reflections about competence and ability, or threat of the experimenter's judgment. These evaluative cues may be especially effective TUT triggers for subjects with relatively low emotional stability. We had expected neuroticism to predict daily-life mind-wandering rate, thinking that highly neurotic subjects might worry or ruminate excessively, even when trying to focus attention on their activities (Perkins, Arnone, Smallwood, & Mobbs, 2015). Our findings, however, corroborate arguments that what distinguishes positive and negative outcomes of repetitive thinking in anxiety and depression is not its quantity, but rather its affective valence, its context, and its generality (i.e., level of construal; Watkins, 2008), perhaps, in part, because people avoid negative or threatening environments in daily life. Thus, neuroticism may not so much increase propensity for mind wandering overall—or even in response to negative affect—but may instead increase particularly negative content of mind wandering when it occurs. Indeed, neuroticism specifically predicted worried mind wandering in daily life.

Individual differences in subjective thought qualities in daily life

The present study went beyond examining mind-wandering content, to also investigate thought qualities transcending task relatedness. Executive abilities tended to predict subjective controllability of thought; poorer executive-task performance was associated with less controllable (and, to some extent, more racing and externally controlled) thoughts. Personality also correlated with thought qualities in predictable ways; for example, more agreeable subjects reported more pleasant thoughts, and more extraverted subjects reported more racing thoughts. Subjects higher in neuroticism reported more racing thoughts and less clear thinking, despite not experiencing more mind wandering.

Conclusion

These cognitive and personality findings suggest that scientists interested in the causes, contents, and consequences of spontaneous thought might benefit from expanding their investigations beyond overt mind-wandering episodes to additional qualities of subjective cognitive experience. Moreover, researchers must remember that laboratories are not neutral environments that affect everyone—and everyone's conscious experiences—equally. Although divergences between laboratory and daily-life predictors of mind wandering might not affect theories about the contributions of TUTs to performance on particular laboratory tasks (e.g., McVay & Kane, 2009, 2012a), they suggest that general mind-wandering theories based largely or completely on laboratory findings do not capture all of mind wandering's causes or correlates as it actually occurs in everyday experience.

Action Editor

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Author Contributions

M. J. Kane, P. J. Silvia, and T. R. Kwapil developed the concept for the experience-sampling study. All the authors contributed to the study's design. Testing, data collection, and data management were performed by G. M. Gross, C. A. Chun, B. A. Smeekens, and M. E. Meier; M. J. Kane and T. R. Kwapil performed the data analysis with input from P. J. Silvia; M. J. Kane drafted the manuscript; and M. E. Meier, P. J. Silvia, and T. R. Kwapil provided critical revisions. All the authors approved the final version of the manuscript for submission.

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Open Practices

Data used for all analyses, as well as sample analysis scripts and output, have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/gdyu4/. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617706086. This article has received the badge for Open Data. More information about the Open Practices badges can be found at https://www.psychologicalscience.org/publications/badges.

Notes

1. Marcusson-Clavertz et al. found that one WMC measure predicted daily-life mind wandering only for subjects with "guilty" daydreaming styles. WMC did not interact with cognitive demand (the "concentration required by activity," p. 455) to predict mind wandering, so this study did not replicate the findings of Kane et al. (2007).
2. Note that we report how we determined our sample size and all data exclusions, manipulations, and measures in the study (Simmons, Nelson, & Simonsohn, 2012).

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