Working memory capacity does not always support future-oriented mind wandering.

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Abstract:

To evaluate the claim that mind-wandering demands executive resources, and more specifically that people with better executive control will have the resources to engage in more future-oriented thought than will those with poorer executive control, we reanalyzed thought-report data from 2 independently conducted studies (J. C. McVay & M. J. Kane, 2012, Why does working memory capacity predict variation in reading comprehension? On the influence of mind wandering and executive attention, Journal of Experimental Psychology: General, Vol. 141, pp. 302–320; N. Unsworth & B. D. McMillan, in press, Mind-wandering and reading comprehension: Examining the roles of working memory capacity, interest, motivation, and topic experience, Journal of Experimental Psychology: Learning, Memory, and Cognition) on working memory capacity (WMC), mind-wandering, and reading comprehension. Both of these individual-differences studies assessed large samples of university subjects' WMC abilities via multiple tasks and probed their immediate thought content while reading; in reporting any task-unrelated thoughts (TUTs), subjects indicated whether those thoughts were about the future or the past, if applicable. In contrast to previously published findings indicating that higher WMC subjects mind-wandered about the future more than did lower WMC subjects (B. Baird, J. Smallwood, & J. W. Schooler, 2011, Back to the future: Autobiographical planning and the functionality of mind-wandering, Consciousness and Cognition, Vol. 20, pp. 1604–1611), we found only weak to modest negative correlations between WMC and future-oriented TUTs. If anything, our findings suggest that higher WMC subjects' TUTs were somewhat less often future-oriented than were lower WMC subjects'. Either WMC is not truly associated with mind-wandering about the future, or we have identified some important boundary conditions around that association.

Keywords: executive control | individual differences | mind-wandering | working memory capacity | future | psychology

Article:

The potential association between working memory capacity (WMC) and the propensity for mind-wandering was first suggested by research indicating that individual differences in WMC predict performance on a variety of nonmemory tasks requiring executive control. That is, people with lower WMC show greater difficulty than people with higher WMC in withholding prepotent or habitual responses when they are goal-inappropriate—as in Stroop and antisaccade tasks—and in preventing salient environmental distractors from deflecting attention from goal-relevant stimuli—as in flanker-interference and dichotic-listening tasks (for reviews, see Engle & Kane, 2004; Heitz, Unsworth, & Engle, 2005; Kane, Conway, Hambrick, & Engle, 2007). On the logic that people's control over their actions and their external attentional focus should also be linked to their control over the internal stream of thought, WMC might also be expected to covary with mind-wandering experiences.

Kane, Brown et al. (2007) first tested this idea by asking whether laboratory-assessed WMC (via complex memory span tasks; see Conway et al., 2005) predicted self-reported mind-wandering experiences in daily life. Their experience-sampling study used personal digital assistants to randomly cue subjects, over 7 days, to categorise their immediately preceding thoughts, activities, and moods. Lower WMC subjects reported significantly more task-unrelated thoughts (TUTs) than did higher WMC subjects in cognitively demanding contexts (i.e., that were reported to require concentration or to be effortful or challenging), but not in low-demand contexts; WMC was also unrelated to the variation in mind-wandering that was driven by mood or motivation variables (such as boredom, stress, or competence). Conceptually related daily diary research (Unsworth, McMillan, Brewer, & Spillers, 2012) asked undergraduates to maintain a week-long record of their attention failures, and found that mind-wandering during class and while completing homework were among the most frequent failures that students reported. Of most importance here, students' WMC scores (assessed over multiple complex span tasks) correlated negatively with these mind-wandering rates. Thus, WMC generally seems linked to the executive control over task-irrelevant thinking during difficult everyday activities, that is, during those tasks that compel some conscious focus for successful performance.

Research assessing TUTs during challenging laboratory tasks has similarly indicated that WMC is negatively correlated with mind-wandering frequency (for a review, see Kane & McVay, in press). In repetitive, long-duration go/no-go tasks, which build up a strong “go” bias over most trials and thus require executive control over rare, no-go trials, lower WMC subjects commit more errors and report more TUTs than do higher WMC subjects; moreover, the WMC–performance correlations in these tasks are partially mediated by individual differences in TUT rate, suggesting that WMC variation predicts performance in executive control tasks in part because it predicts off-task thinking (McVay & Kane, 2009, 2012a). Similar patterns emerge from reading studies. McVay and Kane (2012b) tested subjects' comprehension of multiple and varied text types, reflecting either long or short passages of fiction or nonfiction, while probing for mind-wandering during two of the reading tasks and two executive control tasks (go/no-go and numerical Stroop). They found that TUT frequency was consistent across task types, indicating a stable individual difference (see also Grodsky & Giambra, 1990–1991). Moreover, WMC again correlated negatively with mind-wandering, and TUTs again partially mediated the

WMC–performance (comprehension) association. This meditational pathway, of WMC → TUTs → reading comprehension, was replicated by Unsworth and McMillan (in press). Their subjects completed multiple WMC measures and a single reading comprehension task (expository nonfiction) that was interrupted by occasional thought probes. Not only did TUT rate partially mediate the WMC–comprehension correlation, but self-report indicators of motivation and task interest also exerted influences on mind-wandering and comprehension that were independent of WMC, consistent with the motivation-related daily life findings from Kane, Brown et al. (2007; see also Heitz, Schrock, Payne, & Engle, 2008).

The association between WMC and mind-wandering in the laboratory becomes more complex, however, when considering a wider range of task demands. That is, WMC is not always negatively correlated with TUT frequency: It appears to be uncorrelated with mind-wandering during less executively demanding tasks. When McVay and Kane (2012a) modified their go/no-go task into a "no-go/go," or traditional vigilance task, in which most trials required no response and thus no restraint over prepotent responding, both the WMC–TUT correlation and the WMC–performance correlation disappeared (see also Baird et al., 2011). Similarly, Levinson, Smallwood, and Davidson (2012) presented subjects with a visual search task for targets appearing amid similar-looking distractors (e.g., an X among Ks, Ws, and Zs). Performance in such search tasks typically shows no association to WMC (Kane, Poole, Tuholski, & Engle, 2006; Poole & Kane, 2009; Sobel, Gerrie, Poole, & Kane, 2007), and here WMC failed to correlate with TUT reports. According to McVay and Kane (2012a; see also McVay & Kane, 2010a, 2010b), these finding suggest that the executive control processes associated with WMC either are or are not brought to bear to control both thoughts and behaviour. In tasks that require no executive regulation of performance, WMC will predict neither performance nor off-task thinking; it is only when executive processes are elicited and engaged that higher WMC subjects will show an advantage over lower WMC subjects in control of behaviour and thought. McVay and Kane (2010a, 2010b) relied on individual-differences findings such as these, as well other results from the broader mind-wandering literature, in their theoretical proposal that TUTs are automatically cued and sustained in a resource-free manner unless subjects are able, and motivated, to block or suppress them via executive control processes.

However, an alternative explanation of WMC's association with mind-wandering, and of mind-wandering experiences more generally, has been put forward by Smallwood and colleagues (e.g., Smallwood, 2010, in press; Smallwood, Brown, et al., 2011; Smallwood & Schooler, 2006). They argue that mind-wandering is resource-demanding, but often beneficial. That is, although TUTs may sometimes impair performance on ongoing tasks, they also may broadly support creativity, problem solving, and planning for the future (see also Baars, 2010; Baird et al., in press; Klinger, 1999; Mason, Bar, & Macrae, 2007). Higher resource subjects, therefore, should mind-wander more frequently than lower resource subjects when they can afford to do so (i.e., when they have life concerns to consider and their ongoing tasks do not excessively tax executive control). In fact, two lines of behavioural evidence seem to support this executive resource view. First, Levinson et al. (2012) found that, in a "pop-out" search task, in which subjects searched for targets with different visual features from distractors (e.g., a large X among small os), and in a breath-monitoring task, in which subjects pressed a key with each exhalation, WMC and TUT rates were positively correlated, with higher WMC subjects mind-wandering more than lower WMC subjects.

A second source of behavioural support for Smallwood's claims—and the issue at the heart of the present investigation—comes from considering the temporal focus of subjects' thoughts. Mind-wandering is most often (but not exclusively) future-oriented, commonly reflecting people's ongoing and unresolved concerns, plans, and goals (e.g., Klinger, 1971, 1999; Mason et al., 2007; Singer, 1966; Smallwood, Nind, & O'Connor, 2009). Moreover, and critically, future-oriented thoughts have been argued to be more resource-demanding than others. The idea here is that future-oriented thinking involves novel manipulations, simulations, and combinations of information stored in memory, and so is more computationally complex than simple memory retrieval (Schacter, Addis, & Buckner, 2008; Tulving, 1985). Indeed, Smallwood et al. (2009) found that future-oriented thinking varied with tasks' resource demands: Future-oriented TUT reports were much more frequent during easy tasks (~40% of all thought reports; e.g., simple vigilance/choice–reaction time [RT] tasks involving digits) than they were during demanding tasks (~20% of reports; e.g., working memory tasks involving the online maintenance and updating of digits), and future-oriented TUTs were more frequent than past-oriented TUTs (again, at about double the frequency) only during the easy, nondemanding tasks (see also Smallwood, Schooler, et al., 2011).

Most relevant to present concerns regarding WMC variation, Baird et al. (2011) tested subjects for WMC and had them complete a simple choice-RT task while being periodically probed for an open-ended verbal report of their immediately preceding thoughts. Although WMC did not predict overall TUT rates (as coded by independent raters), it was positively correlated with the proportion of off-task thoughts coded as future-oriented. Thus, when they were mind-wandering, higher WMC subjects more frequently described thoughts about the future than did lower WMC subjects (WMC was negatively correlated with frequency of present-oriented TUT descriptions and uncorrelated with past-oriented TUTs).

The present study investigated this latter source of evidence for the claim that mind-wandering demands executive resources, that is, that people with better executive control will engage in more future-oriented (but not past-oriented) thought than will those with poorer control. Specifically, we analyse here, for the first time, the thought content of mind-wandering episodes from two previously published, and independently conducted, studies on the associations among WMC, TUTs, and reading comprehension abilities (McVay & Kane, 2012b; Unsworth & McMillan, in press; recall that both studies found that the positive association between WMC and comprehension was mediated by TUTs' negative association with WMC and comprehension). Both studies assessed university subjects' WMC via three complex memory span tasks (as opposed to a single task in Baird et al., 2011, and Levinson et al., 2012) and probed subjects' current thought content with forced multiple-choice probes embedded within reading-for-comprehension tasks (McVay and Kane also probed thoughts in nonreading tasks). Those thought probes asked subjects to categorise their immediately preceding thoughts, via key press, as either on-task or not, with multiple off-task thought choices: evaluative thoughts about one's comprehension/performance, thoughts about one's current state (e.g., emotional, physical, intellectual), thoughts about the future, thoughts about the past, or other thoughts. Here, then, we asked subjects to categorise the temporal orientation of their own thoughts—when applicable—rather than forcing them to classify all TUTs as either future- or past-oriented (as in Smallwood et al., 2009; Smallwood, Schooler, et al., 2011), and without relying on external raters to code the temporal focus of potentially ambiguous open-ended thought reports (as in Baird et al., 2011), the ratings of which might be influenced by subjects' verbal expressive abilities, which are also likely correlated to WMC (e.g., Daneman & Merikle, 1996; Unsworth, Spillers, & Brewer, 2011). The final strengths of the current approach are that (a) McVay and Kane assessed subjects' TUTs (and temporal orientation thereof) across multiple tasks on different occasions, allowing for powerful latent variable analyses of the multivariate data; (b) we draw our findings from two separate studies (McVay–Kane; Unsworth–McMillan) composed of subjects from two different university populations; and (c) the sample sizes in each correlational study were between 150 and 250. To preview, our findings do not support the claim that higher WMC subjects mind-wander more about the future than do lower WMC subjects.

Method

Below, we present the methodological details from McVay and Kane (2012b) and Unsworth and McMillan (in press) that are necessary to evaluate the current reanalyses. For further information, particularly regarding additional measures that subjects completed, the reader may consult the original publications.

Subjects

McVay and Kane (2012b) tested 242 undergraduates from the University of North Carolina at Greensboro (UNCG) across all three 90-min sessions (mean total completion time = 31 days, SD = 19); 258 subjects completed Session 1 and 248 completed Session 2; subjects were tested in groups of one to six. Unsworth and McMillan (in press) individually tested 150 undergraduates from the University of Oregon (UO), each in a single 120-min session.

WMC Tasks and Scoring

Both McVay and Kane (2012b) and Unsworth and McMillan (in press) assessed WMC with the same automated complex span tasks (for details, see Unsworth, Heitz, Schrock, & Engle, 2005; Unsworth, Redick, Heitz, Broadway, & Engle, 2009): operation span, reading span, and symmetry span. In all three tasks, subjects attempted to maintain in memory a list of unrelated items that were each interpolated with an unrelated processing task with an individualized response deadline (M + 2.5 SDs) calculated across 15 processing-task-only practice items. In operation span, subjects memorised lists of three to seven letters interpolated with compound mathematical equations to verify as true or false via key press. Immediately on completion of each set of three to seven equation–letter pairs, subjects recalled the letters of the set in serial order by mouse-clicking them onscreen (where they appeared among all 12 letters used in the task). Subjects completed three sets at each set size. Reading span similarly tested immediate serial memory for letters, in sets of three to seven, but here the letters were presented amid sentences to verify as either sensible or nonsensical. In symmetry span, memory items were single red squares within a 4 × 4 matrix, with two to five appearing per set, each presented in alternation with a visuospatial processing task of verifying the vertical symmetry of a black-and-white grid pattern. Subjects recalled the red squares from each trial in serial order by mouse-clicking on the squares of a single blank 4 × 4 matrix.

At UNCG, subjects completed operation span (final n = 253) as the first task in Session 1, symmetry span (final n = 243) as the first task in Session 2, and reading span (final n = 238) as the first task in Session 3. At UO, all 150 subjects completed operation span, symmetry span, and reading span, in that order, as the first three tasks of the session. Scores for each task reflected the total number of memory items recalled in their correct serial position (theoretical maximum = 75, 75, and 42 for operation span, reading span, and symmetry span, respectively); subjects with <85% processing-task accuracy within a task were given no score for that task. For some of the present analyses, subjects were assigned a WMC composite score, calculated by converting each subject's task score into a z-score, and then averaging across the available z-scores. For UNCG subjects, the individual task z-scores were based on the means and standard deviations from a database of more than 2,000 UNCG students; for UO students, the z-scores were based on the present sample of 150 students.

Thought Probes

Both McVay and Kane (2012b) and Unsworth and McMillan (in press) probed subjects' thoughts with identical onscreen prompts. At unpredictable intervals during the ongoing task (see below for task details), a screen appeared asking the question, “What were you just thinking about?” followed by six numbered options arrayed vertically: (1) The text; (2) How well I'm understanding the text; (3) A memory from the past; (4) Something in the future; (5) Current state of being; (6) Other. The experimenter explained these response options to subjects before the task began (with Options 1 and 2 worded differently for the attention tasks in the McVay and Kane study). Subjects indicated their thought content at each probe by pressing the corresponding number key on the keyboard. In both the McVay–Kane and Unsworth–McMillan studies, Options 3–6 were coded as TUTs; here, we separately analyse only Options 3 and 4, reflecting past- and future-oriented TUTs, respectively.

Tasks Presenting Thought Probes

McVay and Kane (2012b) study

Thought probes interrupted four different tasks, two reading comprehension tasks and two computerized attention tasks. Final sample sizes varied by task (indicated in parentheses below), depending on sessions completed, experimenter error, or equipment failures; a programming error led to data loss from a substantial number of subjects from the second reading task (the journal article).

Reading tasks

As the last (50-min) task in Session 2, subjects read the first five chapters of Tolstoy's War and Peace (approximately 8,000 words) onscreen, with a self-paced, paragraph-by-paragraph presentation (final $n = 247$); thought probes appeared at 20 unpredictable intervals. As the second (15-min) task in Session 3, subjects read a journal article about media bias from Current Directions in Psychological Science, on paper, while seated before a computer screen (final $n = 166$); every 2–4 min, the computer screen would change colour to cue the subject to respond to one of the six onscreen thought probes.

Attention tasks

As the third task in Session 1, subjects completed a numerical Stroop task (final $n = 243$) that presented rows of two to four identical digits whose identities either matched their tallies (e.g., 22, 333, 4444; 75% of trials) or conflicted with their tallies (e.g., 222, 3333, 44; 25% of trials); subjects quickly pressed a key to report the tally of each row. In the second half of the 480-trial task, 36 thought probes followed immediately after 60% of the conflict trials. As the second task in Session 2, subjects completed a go/no-go task (final $n = 225$) with word stimuli and 89% go trials (of 540 total trials); subjects pressed the spacebar for any animal names (go trials) and withheld responding to any food names (no-go trials). Thirty-six thought probes followed 60% of the rare no-go trials.

Unsworth and McMillan (in press) study

After completing the WMC tasks, subjects read approximately half of the first chapter (17 paragraphs) of an introductory political science text, with self-paced, paragraph-by-paragraph presentation onscreen. Thought probes appeared at six unpredictable intervals.

Results

For all nondirectional null hypothesis significance tests, we set alpha to .05. For latent variable models of the McVay and Kane (2012b) data, we used the following fit statistics (and rules of thumb for adequate model fit; see Hu & Bentler, 1999; Kline, 2005): χ^2/df (<2), comparative fit index (CFI; > 0.90), root mean square error of approximation (RMSEA; < .08), standardized root mean square residual (SRMR; < .10). Some subjects from McVay and Kane had missing data from one or more measures; they were retained for analysis using data from their completed tasks using the Mplus full information maximum likelihood missing data function (Muthén & Muthén, 2007).

How Frequent Is Future- Versus Past-Oriented Mind-Wandering?

For both the McVay–Kane and Unsworth–McMillan data sets, we computed critical thought-type proportions in two ways: (1) against each subject's total pool of on- and off-task thought reports, and (2) against the subset of each subject's thought reports that were TUTs (i.e., thought-report Options 3–6). The former reflects subjects' overall propensity to engage in off-task thoughts about the future (or past) during an ongoing task, whereas the latter reflects subjects' relative propensity to be (or conditional probability of) engaging in thoughts about the future (or past) on the occasions when they were mind-wandering. Although these measures have different meanings and potential implications, they have been used interchangeably as critical dependent measures across studies of the temporal orientation of mind-wandering: Experimental demonstrations that tasks' cognitive demands influence rates of future-oriented mind-wandering have focused on the proportion of all thought reports that reflect future- versus past-oriented TUTs (Smallwood et al., 2009; Smallwood, Schooler, et al., 2011), whereas individual-differences analyses of WMC variation and temporally focused mind-wandering have assessed the proportion of subjects' TUT reports that were future- versus past-oriented TUTs (Baird et al., 2011).

As shown in Table 1, for both types of proportion measures, subjects showed a weak bias toward future-oriented TUTs versus past-oriented TUTs, with that bias appearing to be somewhat stronger in the McVay and Kane (2012b) study. For the McVay–Kane data, contrasts between rates of future- versus past-oriented TUTs (for both proportion measures) were significant for the War and Peace, journal article, and numerical Stroop tasks ($ts = -3.65$ to -8.00, $ps < .001$), suggesting more frequent future- than past-oriented thinking. For the go/no-go task, however, neither the proportion of all thought reports, $t(209) = -1.34$, $p = .18$, nor the proportion of TUT reports, $t(203) = -0.42$, $p = .67$, indicated any difference in frequency between future- versus past-oriented TUTs; the same was true for the Unsworth and McMillan (in press) data, in which neither the proportion of all thought reports, $t(149) = -0.543$, $p = .58$, nor the proportion of TUT reports, $t(149) = 0.008$, $p = .99$, showed future- versus past-oriented TUT differences. These findings are arguably consistent with experimental demonstrations that future-oriented TUTs are approximately twice as frequent as past-oriented TUTs only when subjects engage in tasks making minimal cognitive demands (Smallwood et al., 2009; Smallwood, Schooler, et al., 2011); in more demanding tasks, however, perhaps like those represented in the McVay–Kane and Unsworth–McMillan studies, subjects' bias toward future thought is diminished or absent, suggesting that future-oriented TUTs require more resources than do past-oriented TUTs. Again, although these findings may be interpreted as supporting prior findings, there are a few problems. First, several of the McVay–Kane “demanding” tasks elicited approximately 2:1 ratios of future- versus past-oriented thought, despite the low overall rates for these thought types. Second, there is no independent measure of cognitive demand that can be used, a priori, to predict whether a task will elicit future-dominated thought; one therefore runs the risk of circular reasoning when one finds—or does not find—large discrepancies between future- and past-oriented TUT rates.

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Is WMC Variation Specifically Associated With Future-Oriented TUTs?

The McVay and Kane (2012b) data set, which includes multiple measures of each construct, allows for latent variable analyses in addition to considering bivariate correlations. The Unsworth and McMillan (in press) data set, in contrast, with only one measure for each thought type, allows only for simple correlational analyses. (Although Unsworth and McMillan used latent variable analyses in their original article, they focused on overall TUT rate and thus divided their six thought probes from the reading task into two parcels of three probes each; for present purposes, these parcels simply have too few observations to divide them further by the temporal orientation of TUTs, and so we could not create latent variables for them.) We thus report our individual-differences analyses separately by study.

McVay and Kane (2012b) study

Correlations among individual WMC and TUT measures, with proportions of future- and past-oriented TUTs calculated against all thought reports within each task, are reported in Table 2; the parallel correlations for proportions of TUTs that were future-oriented and past-oriented are reported in Table 3. In general, the measures for each construct (WMC, future-oriented TUTs, past-oriented TUTs) correlated reasonably strongly with each other and more strongly with each other than with other measures, indicating both convergent and discriminant validity. The main exception to this general observation was past-oriented TUTs as a proportion of TUT reports (see Table 3), where many of the intraconstruct correlations were weak. Of importance to our primary question, the individual and composite WMC scores tended toward null to negative correlations with future-oriented TUT rates, and WMC scores showed no indication of correlating more positively with future-oriented TUTs than with past-oriented TUTs (if anything, the opposite pattern appears to hold).

Tables 2 & 3 are omitted from this formatted document.

Figure 1 presents a latent variable, confirmatory factor analysis of the WMC, future TUT, and past TUT constructs, with future- and past-oriented TUT rates calculated against all thought reports (e.g., proportion of all thoughts that were future-oriented TUTs). Cook's D and Mahalanobis distance statistics indicated two multivariate outliers, whose data were dropped. The model provided an adequate fit to the data, $\chi^2(41, N = 249) = 46.149$, $p < .001$; $\chi^2: df = 1.13$; CFI = 0.983; RMSEA = .022, 90% CI [.000, .050]; SRMR = .047. It also demonstrated a significantly positive correlation between future- and past-oriented TUT rates and a significantly negative correlation between WMC and future-oriented TUT rate (for archival purposes we note that, in the model that included the two multivariate outliers, with *n* = 251, the WMC–future TUT correlation was also negative, and nearly significant, at −.18, $p = .06$); consistent with Baird et al. (2011), WMC did not predict past-oriented thinking.

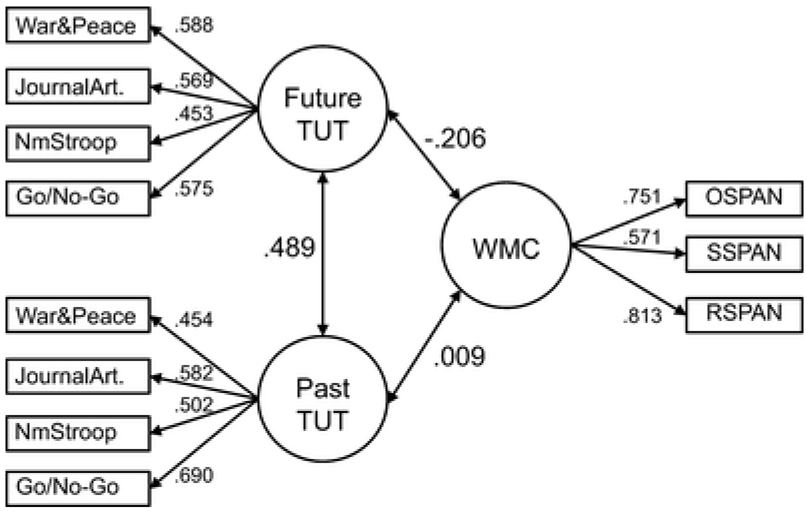

Figure 1. Latent variable model (confirmatory factor analysis) depicting the relations among working memory capacity (WMC) and the proportions of all on- and off-task thought reports that were future-oriented task-unrelated thoughts (TUTs) or past-oriented TUTs (data from McVay & Kane, 2012b); latent factors are depicted as circles. Numbers along double-headed arrows represent the strength of the correlations between latent variables. Rectangles represent observed variables contributing to each factor; numbers along single-headed arrows represent the observed variable's loading onto the latent factor. Future TUT = proportion of thoughts that were future-oriented TUTs; Past TUT = proportion of thoughts that were past-oriented TUTs; War&Peace = future-/past-oriented TUT rate during the War and Peace reading task; JournalArt. = future-/past-oriented TUT rate during the journal article reading task; NmStroop = future-/past-oriented TUT rate during the numerical Stroop task; Go/No-Go = future-/past-oriented TUT rate during the go/no-go task; OSPAN = operation span task of WMC; SSPAN = spatial span task of WMC; RSPAN = reading span task of WMC.

Figure 2 presents the corresponding confirmatory factor analysis for WMC and future TUTs, with future-oriented TUT proportions calculated against only TUT reports (e.g., proportion of all TUT reports that had a future orientation). Seven multivariate outliers, by the same criteria as above, were dropped from analyses (the models would not converge with these outliers included). Even so, a model that also included past TUTs did not provide an adequate fit to the data, $\chi^2(41, N = 244) = 93.18$, $p < .001$; χ^2: *df* = 2.27; CFI = 0.836; RMSEA = .072, 90% CI [.053, .091]; SRMR = .080, apparently because several of the past TUT indicator measures had poor loadings on the factor (*War and Peace* past-oriented TUTs = .235; journal article past-oriented TUTs = .040). The Figure 2 model, in contrast, provided an adequate fit, $\chi^2(13, N = 244) = 13.00$, $p = .45$; χ^2: *df* = 1.00; CFI = 1.00; RMSEA = .001, 90% CI [.000, .063]; SRMR = .041. Despite a reliable assessment of both WMC and future TUT factors, the WMC–future TUT correlation was nonsignificantly negative (*p* = .612); the model indicates a clear failure to find even a weak positive association between WMC and future-oriented mind-wandering.

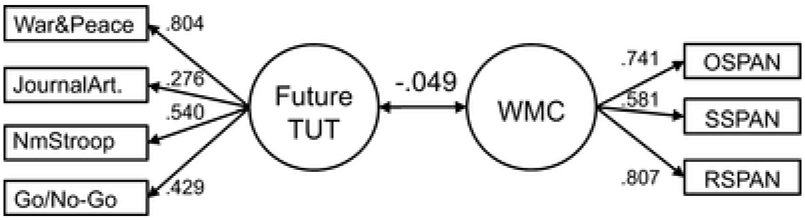

Figure 2. Latent variable model (confirmatory factor analysis) depicting the relation between working memory capacity (WMC) and the proportions of all task-unrelated thoughts (TUTs) that were future-oriented (data from McVay & Kane, 2012b); latent factors are depicted as circles. Numbers along double-headed arrows represent the strength of the correlations between latent variables. Rectangles represent observed variables contributing to each factor; numbers along single-headed arrows represent the observed variable's loading onto the latent factor. Future TUT = proportion of TUTs that were future-oriented; War&Peace = future-oriented TUT rate during the War and Peace reading task; JournalArt. = future-oriented TUT rate during the journal article reading task; NmStroop = future-oriented TUT rate during the numerical Stroop task; Go/No-Go = future-oriented TUT rate during the go/no-go task; OSPAN = operation span task of WMC; SSPAN = spatial span task of WMC; RSPAN = reading span task of WMC.

Unsworth and McMillan (in press) study

Correlations among WMC and TUT measures, with proportions of future- and past-oriented TUTs calculated against all thought reports within each task, and with proportions calculated against only TUT reports, are all reported in Table 4. As in the McVay and Kane (2012b) data, the weak correlations between WMC measures and future-oriented TUTs all trended in the negative direction (note that the strong correlations among the WMC measures, and the modest correlations among the TUT measures, indicate that they were each measured with reasonable reliability). As in the McVay–Kane data set, then, we find that higher WMC subjects did not mind-wander more about the future than did lower WMC subjects.

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Discussion

The present study reanalyzed the thought-report data from two large-scale, independently conducted and published studies on WMC and mind-wandering during reading (and, in one of the two data sets, mind-wandering was assessed during attention-task performance, as well). Our goal was to examine critically whether people with greater executive capacities (i.e., higher WMC subjects) would mind-wander more about future-oriented topics than would people with lesser executive capacities (i.e., lower WMC subjects). Baird et al. (2011) reported such a positive association in their study of 47 subjects who completed a single WMC task and had their thoughts assessed during a vigilance-type choice-RT task. Their findings, that higher WMC subjects reported more TUTs about the future than did lower WMC subjects, have been interpreted as supporting the theoretical view that mind-wandering (and, particular, mind-wandering about the future) is a resource-demanding activity, whether those resources are used to fuel the stream of thought or to protect it from external distractions (e.g., Smallwood, 2010, in press; Smallwood & Schooler, 2006).

Our analyses provide little support for prior conclusions about the temporal orientation and resource costs of mind-wandering. Our (ostensibly) demanding ongoing tasks elicited null to sizeable increases in future-oriented TUTs relative to past-oriented TUTs, depending on the task, and the null comparisons may be considered consistent with published experimental studies showing that future-oriented TUTs dominate the stream of thought only during low-demand activities (Baird et al., 2011; Smallwood et al., 2009; Smallwood, Schooler, et al., 2011); the seemingly demanding tasks that did yield more future- than past-oriented mind-wandering, however, are not easily accounted for by the view that future-oriented thought is especially resource-demanding (although, perhaps, the importance of variables associated with task interest or task-relevant knowledge could profitably be explored further in future work; see Smallwood et al., 2009). Moreover, our studies convincingly failed to support the Baird et al. (2011) individual-differences findings, as WMC consistently showed weakly negative correlations with future-oriented mind-wandering, measured in two different ways (i.e., as a proportion of all thoughts and as a proportion of only TUTs) and measured across multiple tasks. Our data yielded no suggestion that people with higher WMC mind-wander more about the future than do those with lower WMC.

To what should we attribute these discrepant results? One obvious possibility is that the Baird et al. (2011) findings, which were derived from a single study with a small sample, and which were evident only when future TUTs were considered as proportion of TUTs (rather than as a proportion of all thought reports), were simply spurious. Indeed, we share psychologists' increasingly expressed concerns that studies with small sample sizes can lead to false positives, as well as false negatives (e.g., Schimmack, in press; Simmons, Nelson, & Simonsohn, 2011). A second, more subtle possibility, however, is that higher WMC subjects may be more clear, expressive, or complete than lower WMC subjects when they provide written, open-ended thought reports (as in Baird et al.), and so raters may systematically misinterpret either higher or lower WMC subjects' reports when coding their temporal orientation. Our multiple-choice thought reports allowed subjects, themselves, to indicate any temporal orientation to their thinking, if it were applicable, free of any potential confounds of verbal ability or expression. (The overall rates of future-oriented mind-wandering reported by Baird et al. matched those from previous forced-choice probe studies [Smallwood et al., 2009; Smallwood, Schooler, et al., 2011], indicating no reason to believe that either closed- or open-ended thought reports differentially bias the temporal orientation of subjects' thoughts, in general.)

In closing, we note a final and more optimistic possibility that was also acknowledged and anticipated by Baird et al. (2011). Perhaps our studies, combined with Baird et al., indicate boundary conditions around the future thought–WMC association. That is, WMC tends to correlate negatively with overall TUT rates during cognitively demanding activities and tasks (Kane, Brown et al., 2007; McVay & Kane, 2009, 2012a, 2012b; Mrazek et al., 2012; Unsworth & McMillan, in press; Unsworth et al., 2012), but not during less demanding tasks, in which the correlations range from null to positive (Baird et al., 2011; Kane, Brown et al., 2007; Levinson et al., 2012; McVay & Kane, 2012a). In the same way, WMC may positively predict future-oriented mind-wandering during relatively low-demand tasks—as Baird et al. found—but not in relatively high-demand tasks—as in the present work (assuming, again, that we can accurately assess cognitive demand a priori, which may not be a safe assumption). Further research will thus be necessary to determine whether the positive correlation between WMC and future thought demonstrated by Baird et al. will hold up to replication during relatively simple, low-demand tasks (and with multiple varieties of thought probe), indicating that we have identified a significant boundary condition around a potentially important finding, rather than refuted it altogether. In the meantime, researchers should (and will) continue to explore the question of whether executive control processes are exclusively involved in preventing or minimising unwanted mind-wandering experiences, as proposed by McVay and Kane (2010a, 2010b), or whether control mechanisms may sometimes—or even frequently—act to support internally focused streams of thought, as proposed by Smallwood, Schooler, and their colleagues (e.g., Smallwood, 2010, in press; Smallwood & Schooler, 2006).

Footnotes

1 Although McVay and Kane have not denied that mind-wandering can have positive benefits (e.g., McVay & Kane, 2010a), our research has emphasized the potential costs of mind-wandering to the performance of one's ongoing activities.

2 Evidence suggesting the executive resource demands of mind-wandering also come from neuroimaging studies, which appear to indicate that executive control networks are activated, along with so-called default-mode networks, during self-reported TUT experiences (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; but see Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011, for a more complex picture). Granting the validity of the findings, what remains unclear is what role these executive mechanisms are playing during mind-wandering; they may be directly involved in creating or molding the content of TUTs, or they may be serving the control functions of maintaining conscious focus on the internal stream of thought and limiting processing of external stimuli (Smallwood, in press), or they may even be involved in returning the system back to a task-focused mode (McVay & Kane, 2010b).

3 Neither McVay and Kane (2012b) nor Unsworth and McMillan (in press) previously conducted or reported analyses of particular TUT categories, as we do here by investigating

future- versus past-oriented TUTs. Both published studies conducted all analyses on total TUT rates, collapsing over the particular varieties of TUTs that subjects reported.

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