# Validating older adults’ reports of less mind-wandering: An examination of eye movements and dispositional influences

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## Abstract:

The Control Failures × Concerns theory perspective proposes that mind-wandering occurs, in part, because of failures to inhibit distracting thoughts from entering consciousness (McVay & Kane, 2012). Despite older adults (OAs) exhibiting poorer inhibition, they report less mind-wandering than do young adults (YAs). Proposed explanations include (a) that OAs’ thought reports are less valid due to an unawareness of, or reluctance to report, task-unrelated thoughts (TUTs) and (b) that dispositional factors protect OAs from mind-wandering. The primary goal of the current study was to test the validity of thought reports via eye-tracking. A secondary goal was to examine whether OAs’ greater mindfulness (Splevins, Smith, & Simpson, 2009) or more positive mood (Carstensen, Isaacowitz, & Charles, 1999) protects them from TUTs. We found that eye movement patterns predicted OAs’ TUT reports and YAs’ task-related interference (TRI, or thoughts about one’s performance) reports. Additionally, poor comprehension was associated with more TUTs in both age groups and more TRI in YAs. These results support the validity of OAs’ thought reports. Concerning the second aim of the study, OAs’ greater tendency to observe their surroundings (a facet of mindfulness) was related to increased TRI, and OAs’ more positive mood and greater motivation partially mediated age differences in TUTs. OAs’ reduced TUT reports appear to be genuine and potentially related to dispositional factors.

**Keywords:** aging | mind-wandering | mindfulness | mood | eye movements

## Article:

Imagine you are reading a journal article when you suddenly realize that your mind has wandered to something else. Such off-task thoughts are often referred to as mind-wandering or task-unrelated thoughts (TUTs; e.g., Giambra, 1989). Mind-wandering is a common experience, with younger adults (YAs) reporting TUTs 30–50% of the time during everyday tasks (e.g., Kane et al., 2007; Killingsworth & Gilbert, 2010) and 50–70% of the time during laboratory tasks (e.g., Antrobus, Singer, & Greenberg, 1966; Jackson & Balota, 2012; McVay, Meier, Touron, & Kane, 2013). Mind-wandering is even more prevalent for YAs with poorer executive control, at least during challenging tasks (McVay & Kane, 2009; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; Randall, Oswald, & Beier, 2013; Rummel & Boywitt, 2014; Unsworth & McMillan, 2013). This finding has led to the Control Failures × Concerns theory, which posits that people use executive control to suppress distracting thoughts, particularly when their current concerns are cued by the context (McVay & Kane, 2010; see Smallwood & Schooler, 2006, 2013 for an alternative view). McVay and Kane (2010) argue that when executive control fails, off-task thoughts intrude into consciousness, distracting from the ongoing task. Given the findings for YAs, one would predict that older adults (OAs), with their decreased working memory capacity (Hasher & Zacks, 1988; Salthouse, 1991; Schaie, 1994), would engage in more frequent mind-wandering. However, OAs consistently report *fewer* TUTs compared to YAs (Giambra, 1989; Jackson & Balota, 2012; Krawietz, Tamplin, & Radvansky, 2012; McVay et al., 2013; Zavagnin, Borella, & De Beni, 2014).

The present study examines two broad categories of explanation often given for why OAs report fewer TUTs: (a) OAs underreport TUTs in the laboratory due to a reporting bias or lack of awareness (Einstein & McDaniel, 1997; Jackson & Balota, 2012; McVay et al., 2013; Zavagnin et al., 2014) and (b) OAs experience fewer TUTs due to dispositional factors. Specifically, OAs have been proposed to be protected from TUTs through better emotional regulation (Zavagnin et al., 2014) or by processing information more mindfully (Jackson & Balota, 2012). We address the validity of OAs' thought reports by using eye movements as a behavioral correlate of mind-wandering. As a secondary aim, we also consider mediation models for mood and mindfulness as measured via questionnaires.

Mind-wandering is often assessed in the laboratory via self-reports collected during a task where participants are periodically and unpredictably asked about their current thoughts. Thought reports have been used in a number of tasks, including reading comprehension (Foulsham, Farley, & Kingstone, 2013; McVay & Kane, 2012; Reichle, Reineberg, & Schooler, 2010; Smilek, Carriere, & Cheyne, 2010; Uzzaman & Joordens, 2011), go/no-go vigilance tasks (Jackson & Balota, 2012; McVay & Kane, 2009; McVay et al., 2013; Mrazek et al., 2011), and everyday activities (Kane et al., 2007; Killingsworth & Gilbert, 2010; Song & Wang, 2012).

In addition to allowing participants to indicate on-task thoughts and TUTs, some studies allow reporting thoughts about one's performance on the ongoing task, known as "task-related interference" (TRI; McVay & Kane, 2009; McVay et al., 2013; Mrazek et al., 2011; Mrazek, Smallwood, Franklin, et al., 2012; Smallwood, O'Connor, & Heim, 2005). Like TUTs, TRI experiences are associated with increased task errors in the moment, despite being task related (McVay & Kane, 2009; McVay et al., 2013; Mrazek et al., 2011; Mrazek, Smallwood, Franklin, et al., 2012; Smallwood et al., 2005). In contrast to TUTs, OAs engage in more TRI compared to YAs (McVay et al., 2013; Zavagnin et al., 2014). Although OAs report more TRI, they still report more on-task thoughts overall, but the age difference in mind-wandering is significantly reduced when TRI is considered (McVay et al., 2013).

### *Reporting Bias and Eye Movements*

Because mind-wandering studies rely on self-reports, an unresolved issue is whether OAs' reporting accurately indicates their experience. OAs may be reluctant to report TUTs if they believe that off-task thinking reflects poorly on them (Giambra, 1989; Jackson & Balota, 2012; McVay et al., 2013; Zavagnin et al., 2014), or they may have less access to what they were just thinking and, by default, report thinking about the task. Although McVay et al. (2013, pp. 144–145) point to multiple findings validating OAs' thought reports, the present study leveraged eye-tracking to examine validity by testing whether on-task thoughts, TRI, and TUTs differ at a behavioral level in OAs and YAs.

Eye movements during reading differ when individuals are mind-wandering relative to when they are on task (Foulsham et al., 2013; Reichle et al., 2010; Smilek et al., 2010; Uzzaman & Joordens, 2011). However, previous research does not identify a consistent signature for these thought types. Reichle et al. (2010) and Foulsham et al. (2013) found longer gaze durations preceding TUTs. However, Smilek et al. (2010) found no difference in a similar measure (fixation duration) but did find an increase in blink rate preceding TUTs. Reichle et al. (2010) found an increase in off-text gazes preceding TUTs and longer gazes for longer words preceding on-task thoughts but not TUTs. Uzzaman and Joordens (2011)found a decrease in recursive eye movements (within-word regressions) and fewer fixations in general (fewer words fixated and total fixations) preceding TUTs—suggesting that participants generally skip more words when mind-wandering. However, Reichle et al. (2010) found no difference in the number of words fixated preceding TUTs. Thus, it is important to conceptually replicate previous findings to examine which measures most reliably indicate TUTs during reading.

Furthermore, no study has examined eye movements and mind-wandering in OAs, and no eye movement studies have allowed TRI reports. The present study tested a somewhat larger sample of YAs than other eye-tracking studies of mind-wandering and also examined eye movements in OAs to assess the validity of their thought reports. If OAs' eye movements preceding TUTs and on-task reports vary in ways similar to those of YAs, this would provide additional support for the validity of their thought reports. However, if OAs' eye movements preceding TUTs and on-task thought reports are less distinguishable than those of YAs, this may indicate an inability or unwillingness to report TUTs. We will also compare eye movements for on-task thoughts and TUTs to those for TRI.

## Mood

The second major aim of this study is to consider the contribution of dispositional factors to OAs' less frequent reports of mind-wandering. A particular factor that might influence the experience of and age differences in mind-wandering is mood. OAs typically indicate greater positive affect, lower negative affect, and greater life satisfaction compared to YAs (Carstensen, Isaacowitz, & Charles, 1999; Grühn, Kotter-Grühn, & Röcke, 2010). This is particularly relevant because research with YAs demonstrates that negative mood is related to greater mind-wandering (Kane et al., 2007; Killingsworth & Gilbert, 2010; McVay, Kane, & Kwapil, 2009; Mrazek, Smallwood, & Schooler, 2012; Smallwood, Fitzgerald, Miles, & Phillips, 2009). We investigate the possibility that OAs' decreased negative affect and increased positive affect may explain age differences in TUT rates.

**Negative affect**

Smallwood et al. (2009) found that YAs induced into negative mood made more errors and reported greater TUTs and TRI. In experience sampling studies, participants indicate more negative affect (Killingsworth & Gilbert, 2010) and reduced positive affect and greater anxiety (Kane et al., 2007; McVay & Kane, 2009) when reporting TUTs. Likewise, self-reported dysphoria predicts increased TUTs and TRI (Smallwood et al., 2005). The current study examines whether OAs' lower negative affect contributes to their lower TUT frequency.

**Positive affect**

The broaden-and-build theory of positive psychology suggests that positive affect is associated with a broadening of attention beyond the central focus to peripheral information (Fredrickson, 2001). This may result from a decrease in inhibition and wider distribution of cognitive resources (Biss & Hasher, 2011; Rowe, Hirsh, & Anderson, 2007), which should result in increased TUTs. By contrast, any mood-induced increase in cognitive resources (Fredrickson, 2001) might allow OAs to use these resources to suppress TUTs. Consistent with this latter interpretation, on-task thoughts were associated with increased self-reported happiness in YAs (and TUTs associated with less) in experience sampling studies (Kane et al., 2007; McVay & Kane, 2009). We thus examine the possibility that OAs' higher levels of positive affect contribute to their lower frequency of TUTs.

**Mindfulness**

Mindfulness is a multifaceted construct, which involves being nonjudgmentally engaged in, and aware of, the present (Langer, 2000; Prakash, De Leon, Patterson, Schirda, & Janssen, 2014; Teper, Segal, & Inzlicht, 2013). It is not surprising, then, that researchers have linked mindfulness to having fewer TUTs (Mrazek et al., 2013; Mrazek, Smallwood, & Schooler, 2012; Prakash et al., 2014). Engaging in 2 weeks of mindfulness training, 8 min of mindful breathing, or scoring high on dispositional measures of mindfulness (the Mindful Attention Awareness Scale [MAAS]; Brown & Ryan, 2003) were all related to fewer TUTs on laboratory tasks (Mrazek et al., 2013; Mrazek, Smallwood, Franklin, et al., 2012; Mrazek, Smallwood, & Schooler, 2012).

Consistent with the socioemotional selectivity theory (Carstensen, 1992, 1995), which proposes that people become more fully oriented in the present with aging, Splevins, Smith, and Simpson (2009) found that OAs scored higher on two facets of mindfulness (observing and acting with awareness; Baer, Smith, & Allen, 2004) compared with YAs from previous studies. Thus, we tested the possibility that OAs' greater mindfulness accounts for their lower TUT rate compared to YAs.

*Current Aims*

The primary purpose of this study was to examine whether OAs' thought reports are valid. An additional purpose was to consider whether dispositional factors might underlie age differences in TUT rates. To address the first question, we compared eye movements between thought reports in OAs and YAs during a reading task. We use thought reports that distinguish between

TUTs and TRI to also consider how TRI influences eye movements. To address the possibility that dispositional factors influence age differences in TUTs, we examine mood and mindfulness as potential mediators of age differences in TUTs. These latter analyses are intended to provide valuable information to guide future studies of the mechanisms underlying age differences in mind-wandering.

If OAs' thought reports are as valid as those by YAs, then on-task thoughts are expected to produce patterns of eye movements that differ from those during TUTs, with a similar pattern for OAs and YAs. Conversely, we might question the validity of OAs' thought reports if OAs' patterns of eye movements are less differentiated compared to those of YAs. If TRI results in mindless reading akin to TUTs, then we should see a similar pattern of eye movements preceding TUTs and TRI. If, however, TRI involves a less complete decoupling of thoughts from the text, then eye movements preceding TRI may be more similar to those preceding on-task thoughts. If mood or mindfulness contributes to age differences in TUTs and TRI, then age differences in thought reports should be reduced when including these as mediators.

*Method*

## Participants

We tested 36 YAs (ages 18–25) and 40 OAs (ages 60–85). YAs were undergraduates participating for course credit. OAs were recruited via newspapers and paid a modest honorarium. All participants scored greater than 20/50 on a test of near visual acuity, and no participants reported a history of dementia or stroke. Nine OAs and seven YAs were excluded from eye-tracking analyses due to poor tracking but were retained for other analyses. OAs took more medications, scored higher on vocabulary (Ekstrom, French, & Harman, 1976) and lower on processing speed (Salthouse, 1993), and read for pleasure more hours per week relative to YAs (see Table 1).

Table 1. *Participant Demographics*

| | Young | | Old | | | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *p* | *d* |
| Demographics | | | | | | |
| Age | 19.50 | 1.32 | 69.00 | 5.37 | | |
| Education | 13.19 | 1.24 | 15.70 | 2.62 | <.001 | 1.22 |
| Processing speed | 40.97 | 7.17 | 27.34 | 5.98 | <.001 | 2.06 |
| Vocabulary | 42.21 | 11.09 | 58.06 | 20.82 | <.001 | 0.95 |
| Medications | 0.89 | 0.98 | 2.60 | 2.31 | <.001 | 0.96 |
| Reading for pleasure | 1.75 | 1.87 | 9.60 | 6.10 | <.001 | 1.74 |

*Note*. Education = years of education; processing speed = number correct; vocabulary = percentage correct on the Advanced Vocabulary Test (Ekstrom et al., 1976); medications = number of daily medications; reading for pleasure = estimated number of weekly hours spent reading for pleasure.

## Materials and Apparatus

### Eye-tracking equipment

Participants completed the reading task while wearing an Applied Science Laboratories head-mounted eye-tracker (Model H6HS with eye–head integration) recording at a sampling rate of 120 Hz. Participants sat approximately 61 cm away from a 27 × 34 cm liquid crystal display (LCD) monitor with the resolution set to 1,024 × 768. Pupil diameters of zero lasting more than 100 ms were considered blinks and were removed before analyses (excepting blink rate analyses). Areas of interest (AOIs) were drawn around each word, extending roughly 0.5 cm to the bottom, left, and right and 1.0 cm above.

### Reading task

Participants read the first five chapters of Tolstoy's *War and Peace*, presented via E-Prime software. The text comprised 153 screens in gray-on-black 22-point DotumChe font, with as many complete sentences as could fit onto each screen (3–97 words per screen; $M$ = 47.30, $SD$ = 22.14). Participants pressed the space bar to advance screens and could not reread previous screens.

The reading was divided into 20 blocks of seven to eight screens plus one thought probe. Probes were placed randomly within blocks, but two screens with <10 words were never probed. For probed screens, the probes interrupted reading randomly between 3 and 8 s following screen onset. If a participant pressed the space bar before the probe (6% and 9% of trials for OAs and YAs, respectively), they were immediately shown the probe. Following the probe, the text screen reappeared to allow participants to finish reading before advancing.

Thought probes asked "What were you just thinking about?" Response options and their descriptions appeared as follows: (a) the text: focused on reading the actual textual content on screen; (b) reading-related: images or thoughts related to the content of the text, but not directly corresponding to the actual words on the screen; (c) task performance: evaluating how effectively you were understanding or remembering the text; (d) everyday things: thinking about recent or impending life events; (e) current state of being: thinking about conditions such as hunger or sleepiness; (f) personal worries: thinking about concerns, troubles, or fears; (g) daydreams: fantasies disconnected from reality; and (h) other. Participants also read a thorough description of each thought category in the initial instructions. Participants responded using the numbered keys 1–8. If the participant indicated a response other than "the text," they were asked "Before the probe, were you aware that your thoughts were about something other than the task?" Participants then indicated yes or no (pressing 1 or 2, respectively).

#### *Mood*

Current mood was assessed using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS consists of 10 items measuring momentary positive affect and 10 items measuring momentary negative affect using a 5-point Likert scale (1 = *very slightly or not at all*, 5 = *extremely*).

## Mindfulness

The Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) was developed from existing scales, including the Kentucky Inventory of Mindfulness Skills (KIMS) scale (Baer et al., 2004) and MAAS (Brown & Ryan, 2003) used in previous studies of mindfulness and mind-wandering (Mrazek, Smallwood, & Schooler, 2012; Splevins et al., 2009). The 39 FFMQ items each load onto one of five factors: acting with awareness, nonjudging of internal experience, nonreactivity to internal experience, describing, and observing. Participants responded on a 5-point Likert scale (1 = *never or very rarely true*, 5 = *very often or always true*).

## Procedures

Consenting participants completed a demographics questionnaire, processing speed test, vocabulary test, PANAS, and FFMQ. Participants were offered a break prior to the 9-point calibration of the eye-tracker.

Participants were then instructed on the reading task and were informed that a true–false comprehension test would follow it. At no point was the term “mind-wandering” used. Participants were then asked to predict how often they would report thinking about something other than the text (0–100%) and to predict their performance on the comprehension test (50–100%). Tracker recalibration occurred whenever the technician noted that calibration was compromised ($M$ = 2.97 times, $SD$ = 1.94).

Following the reading, participants completed a 14-item comprehension test (Jackson & Balota, 2012). Participants then estimated how often they thought about something other than the text (0–100%) and their performance on the comprehension test (50–100%). Lastly, participants completed a posttask survey regarding their experience (see Table 2).

Table 2. *Performance and Self-Ratings*

| | Young | | Old | | | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *p* | *d* |
| Thought reports and judgments | | | | | | |
| Percentage of TUTs | 32.60 | 20.82 | 11.27 | 15.91 | <.001 | 1.17 |
| Percentage of TRI | 13.68 | 11.52 | 21.38 | 19.91 | .046 | 0.47 |
| Percentage of reading-related | 14.35 | 9.19 | 15.79 | 10.27 | .570 | 0.15 |
| Percentage of TUT prediction | 43.17 | 20.36 | 29.98 | 20.34 | .006 | 0.65 |
| Percentage of TUT postdiction | 54.92 | 23.26 | 28.25 | 20.19 | <.001 | 1.22 |
| Performance and judgments | | | | | | |
| Reading time | 181.39 | 54.13 | 230.69 | 69.91 | .009 | 0.63 |
| Comprehension | 69.25 | 16.54 | 69.29 | 13.65 | .991 | 0.00 |
| Comprehension prediction | 72.86 | 10.24 | 72.68 | 10.53 | .938 | 0.02 |
| Comprehension postdiction | 61.14 | 10.74 | 65.18 | 12.99 | .147 | 0.34 |
| Posttask survey | | | | | | |
| Reading difficulty | 4.39 | 1.27 | 4.85 | 1.82 | .209 | 0.29 |
| Motivation | 3.28 | 1.43 | 5.18 | 1.74 | <.001 | 1.19 |
| Control over thoughts | 4.06 | 1.51 | 4.93 | 1.38 | .011 | 0.60 |
| Fatigue | 5.08 | 1.70 | 5.08 | 1.53 | .982 | 0.00 |
| Tracking fatigue | 5.11 | 1.82 | 3.93 | 2.09 | .011 | 0.60 |
| Tracking discomfort | 4.50 | 1.87 | 3.65 | 2.08 | .067 | 0.43 |
| Consciousness of eye movements | 4.53 | 1.32 | 2.98 | 1.83 | <.001 | 0.97 |
| Tune-outs | | | | | | |
| Proportion for TUTs | 72.96 | 44.51 | 68.54 | 46.70 | .432 | 0.10 |
| Proportion for TRI | 63.91 | 48.27 | 46.15 | 50.00 | .006 | 0.36 |

*Note*. Percentage of TUTs = percentage of thought reports indicating a TUT; percentage of TRI = percentage of thought reports indicating TRI; percentage of reading-related = percentage of thought reports as “reading-related thoughts or images”; percentage of TUT prediction = estimated percentage of time participant will have TUTs on the upcoming reading; percentage of TUT postdiction = estimated percentage of time participant had TUTs on the previous reading; reading time = median reading time per page in seconds; comprehension prediction _ estimated percentage of true–false questions participant will get correct on the comprehension test; comprehension postdiction = estimated percentage of true–false participant got correct on the comprehension test. The following were rated on a scale from 1 = *not at all* to 7 = *very*: reading difficulty = response to “Please rate how difficult you found the reading”; motivation _ response to “Please rate how motivated you were to keep your thoughts on task”; control over thoughts = response to “Please rate how in control you were of your thoughts”; fatigue = response to “Please rate how fatiguing you found the reading”; tracking fatigue = response to “Please rate how fatiguing you found wearing the eye-tracking headgear”; tracking discomfort = response to “Please rate how uncomfortable you found wearing the eye-tracking headgear”; consciousness of eye movements = response to “Please rate how conscious you were about your eye movements while reading”; proportion tune-outs for TUTs = proportion of TUT responses followed by a “yes” response to the question “Before the probe, were you aware that your thoughts were about something other than the task?”; proportion tune-outs for TRI = proportion of TRI responses followed by a “yes” response to the question “Before the probe, were you aware that your thoughts were about something other than the task?”

*Results*

We first report age differences in TUTs, TRI, and reading comprehension that replicate previous findings. We next address the issue of thought report validity, examining both comprehension and eye movements. Lastly, we consider whether mood or mindfulness mediates age differences in TUTs and TRI.

**Thought Reports and Comprehension Data**

We coded thought reports of “the text” as on task and reports of “task performance” as TRI. Because “reading-related thoughts and images” might, like TRI, reflect a middle ground between on- and off-task thinking, this thought category (which constituted an *M* of 15% of all thought reports with a range of 0–38%) was excluded from the primary analyses but is reported in separate exploratory analyses at the end of the Results section. All remaining thought reports were coded as TUTs. We then computed the proportion of TUTs and TRI for each participant.

OAs reported fewer TUTs, $t(74) = 5.05$, $p < .001$, $d = 1.17$, and more TRI, $t(74) = 2.03$, $p = .046$, $d = 0.47$, compared to YAs (see Table 2). Importantly, the age difference in on-task thoughts was also significant, $t(74) = 2.10$, $p = .039$, $d = 0.48$, replicating previous findings that OAs’ increased rate of TRI do not fully account for age differences in off-task thinking (McVay et al., 2013). OAs also read more slowly than YAs, $t(74) = 2.69$, $p = 009$, $d = 0.63$. OAs’ and YAs’ comprehension scores did not differ, $t(74) < 0.01$, $p = .991$. These age differences replicate previous findings.

## Thought Report Validity

To address whether OAs' and YAs' thought reports are equally valid, we examine a combination of performance and eye-tracking data.

## Comprehension, TUTs, and TRI

To assess the impact of TUTs and TRI, we conducted a pair of Age × TUT/TRI regressions on comprehension scores. More TUTs were associated with poorer comprehension, $F(1, 72) = 16.10$, $p < .001$, $\eta^2 = .18$, with no age difference or interaction ($F < 1$). Thus, TUTs appeared to hinder OAs' and YAs' comprehension similarly (e.g., McVay et al., 2013). By contrast, neither TRI rate, $F(1, 72) = 0.52$, $p = .473$, nor age, $F(1, 72) < 0.01$, $p = .991$, related to comprehension. A significant Age × TRI Rate interaction, $F(1, 72) = 4.43$, $p = .039$, $\eta^2 = .06$, indicated that higher TRI rates were associated with poorer comprehension for YAs, $F(1, 34) = 4.20$, $p = .048$, $\eta^2 = .11$, but not OAs, $F(1, 38) < 1$.

To foreshadow, this reflects a general pattern in the present data, whereby TRI was associated with greater disruption in processing for YAs than for OAs. This may indicate that TRI affects OAs' and YAs' task processing differently. By contrast, it may be that OAs and YAs have different criteria for indicating TRI, compromising report validity. For example, YAs may be more conservative with the use of the TRI category, reporting less pronounced TRI instances as on-task or TUTs. It is worth noting, however, that increases in TRI reporting by YAs would either increase the magnitude of the obtained age difference in on-task thinking (if TRI were misclassified as on task) or leave the age difference in on-task thinking unchanged (if TRI were misclassified as TUTs). We consider these interpretations further in the Discussion.

## Eye-tracking analyses

Eye-tracking data were analyzed via 2 (age: young, old) × 3 (thought report: on-task, TUT, TRI) mixed models with thought report within subjects. Because some participants did not report all three thought categories, SAS Proc Mixed (Littell, Milliken, Stroup, & Wolfinger, 2000) was used to include participants with missing data. As noted previously, individual words were used as areas of interest. Analyses examine eye movements on the to-be-probed page during the 3–8 s preceding the probe (comparable to the time frame used by Reichle et al., 2010, and Uzzaman & Joordens, 2011).

We examine both fixation and gaze data. Fixation durations measure the time a participant's eye rests on one location before moving to a different location. A participant may make single or multiple fixations within a word (e.g., first fixating the "a," then the "e" in "Napoleon"). Gazes aggregate fixations, measuring the time from first fixation on a word until a fixation is made elsewhere. In the example above, "Napoleon" included two fixations but a single gaze.

Analyses included the following measures: (a) how often participants looked at areas without text (off-text fixation counts, total time off text); (b) number of words fixated on their first pass through the text (first-pass fixations); (c) number of times gaze moved backward to a previous portion of text (between-word regressions); (d) number of total words fixated on a page (words fixated); (e) gaze duration; (f) total time spent on each word, collapsing initial gazes and regressions (total time per word); and (g) blink rate. The omnibus statistical tests are reported in Table 3; data are graphed in Figures 1 and 2.

Table 3. *Statistics for Eye-Tracking Analyses*

| Measure | Predictor | *df*1 | *df*2 | *F* | *p* |
|---|---|---|---|---|---|
| Off-text fixation counts | Age | 1 | 58 | 0.67 | .418 |
| | Thought report | 2 | 88 | 1.42 | .248 |
| | **Age × Thought Report** | **2** | **88** | **4.43** | **.015** |
| Total time outside the AOIs | Age | 1 | 58 | 0.00 | .996 |
| | Thought report | 2 | 88 | 1.98 | .145 |
| | **Age × Thought Report** | **2** | **88** | **6.34** | **.003** |
| First-pass fixation counts | Age | 1 | 58 | 0.32 | .576 |
| | **Thought report** | **2** | **88** | **4.71** | **.011** |
| | Age × Thought Report | 2 | 88 | 1.92 | .153 |
| Words fixated | Age | 1 | 58 | 0.49 | .487 |
| | **Thought report** | **2** | **88** | **4.49** | **.010** |
| | **Age × Thought Report** | **2** | **88** | **5.17** | **.008** |
| Between-word regressions | **Age** | **1** | **58** | **4.50** | **.038** |
| | **Thought report** | **2** | **88** | **10.40** | **<.001** |
| | Age × Thought Report | 2 | 88 | 0.55 | .581 |
| Gaze duration | Age | 1 | 58 | 0.44 | .508 |
| | **Thought report** | **2** | **88** | **4.67** | **.012** |
| | Age × Thought Report | 2 | 88 | 2.92 | .059 |
| Gaze duration by length | Age | 1 | 58 | 0.00 | .947 |
| | Thought report | 2 | 88 | 1.86 | .165 |
| | **Length** | **1** | **5,652** | **212.34** | **<.001** |
| | Age × Thought Report | 2 | 88 | 0.08 | .945 |
| | Length × Age | 1 | 5,652 | 1.42 | .234 |
| | Length × Thought Report | 2 | 5,652 | 2.77 | .063 |
| | Length × Age × Thought Report | 2 | 5,652 | 0.21 | .813 |
| Blinks | Age | 1 | 50 | 0.51 | .479 |
| | Thought report | 2 | 40 | 5.68 | .007 |
| | Age × Thought Report | 2 | 40 | 1.90 | .163 |

*Note*. Bold values in Tables 3 and 4 indicate effects significant at the $p < .05$ level. *df* = degrees of freedom.

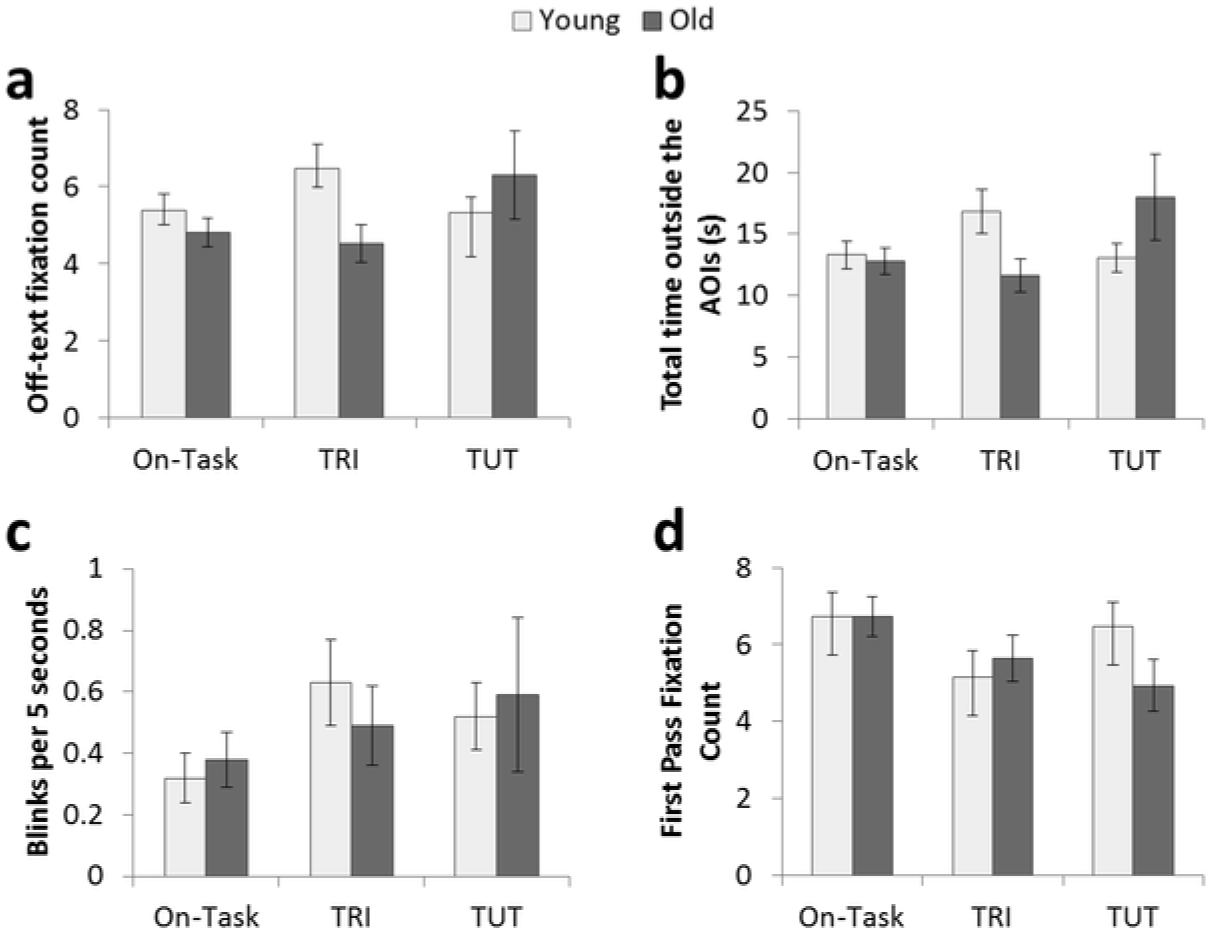


*Figure 1.* *Means and standard errors for off-text fixation count (a), total time outside the areas of interest in seconds (b), and blink count in the 5 s preceding the probe (c). All measures are collapsed across the 3–8 s of reading on the page preceding the probe except blink count.*

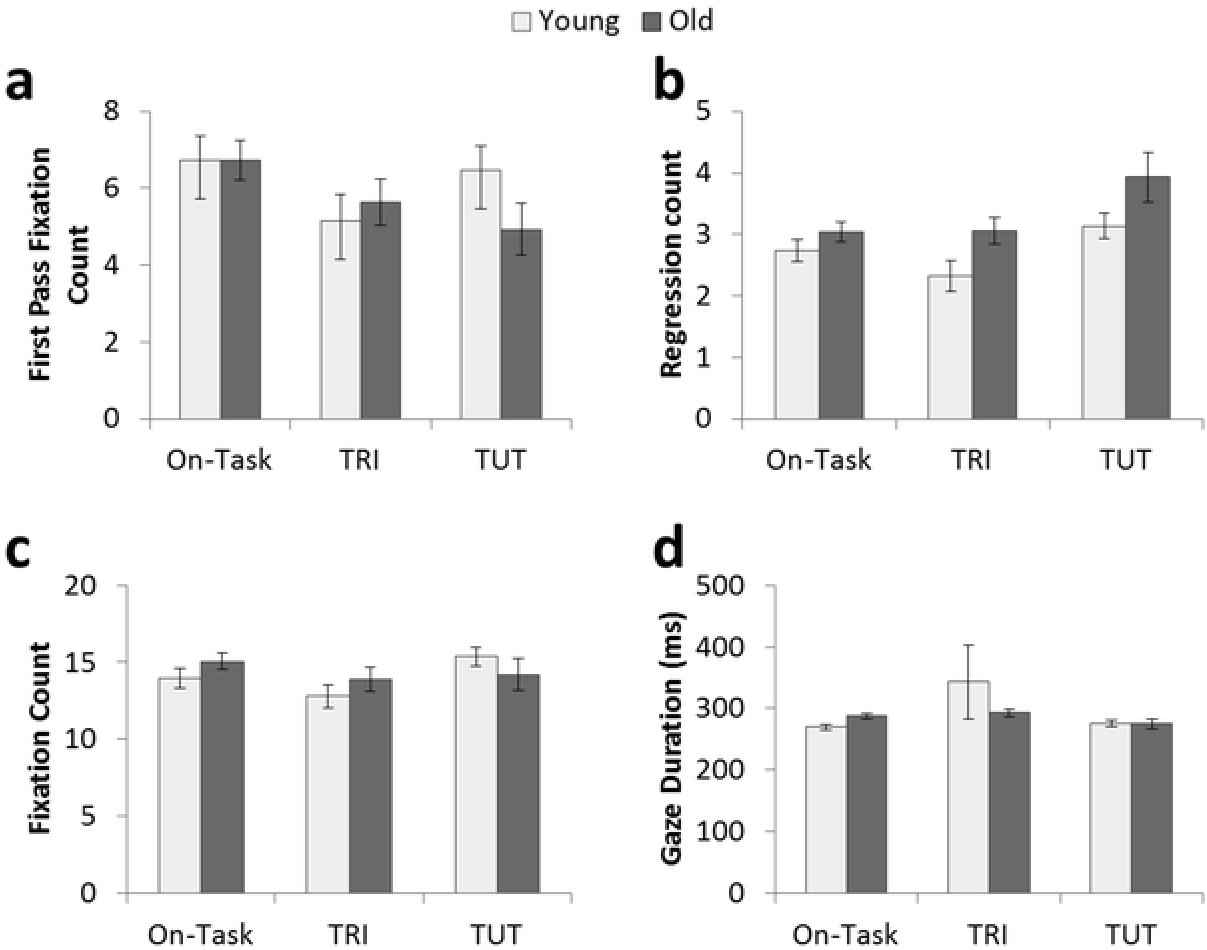


*Figure 2. Means and standard errors for first-pass fixation count (a), regression count (b), fixation count (c), and gaze durations in milliseconds (d). All measures are collapsed across the 3–8 s of reading on the page preceding the probe.*

### Off-text fixation counts

Off-text fixations may occur when a participant is mind-wandering and allows their gaze to fall outside the text. Off-text fixation counts did not differ by age. However, there was a significant Age × Thought Report interaction. For YAs, focused comparison revealed a trend toward more off-text fixations when reporting TRI compared to on-task thoughts, $t(88) = 1.63$, $p = .108$, $d = 0.41$, and TUTs, $t(88) = 1.58$, $p = .118$, $d = 0.45$, which did not differ from each other, $t(88) = 0.05$, $p = .959$. For OAs, focused comparison revealed significantly more off-text fixations when reporting TUTs compared to when reporting on-task thoughts, $t(88) = 2.16$, $p = .033$, $d = 0.41$, or TRI, $t(88) = 2.58$, $p = .012$, $d = 0.47$, which did not differ, $t(88) = 0.54$, $p = .594$.

Similar to Reichle et al. (2010), then, we found no difference in YAs' off-text fixations for on-task thoughts and TUTs. However, TUTs were associated with more off-text fixations for OAs. We also found that TRI was (nonsignificantly) associated with more off-text fixations for YAs. As will be seen, this general pattern of greater disruption in eye movements for OAs preceding TUT reports and YAs preceding TRI reports occurs for several measures. Importantly, these results are inconsistent with the hypothesis that OAs report fewer TUTs because they classify

TUTs as on-task thoughts or TRI. If that hypothesis were supported, we would see less (not more) differentiation between OAs' TUT and on-task reports relative to YAs'.

**Total time off text**

Off-text fixation counts treat single brief fixations outside the AOIs the same as more extended fixations; the extent to which a participant gazes outside the text is better captured by a duration measure. However, outcomes for total time off text were similar to those for fixation counts. Total time outside the AOIs did not differ by age, and the Age × Thought Report interaction was again significant. For YAs, focused comparison indicated a nonsignificant trend toward greater time spent off text when reporting TRI compared to on-task thoughts, $t(88) = 1.83$, $p = .070$, $d = 0.47$, and TUTs, $t(88) = 1.84$, $p = .070$, $d = 0.50$, which did not differ from each other, $t(88) < 0.01$, $p = .997$. In OAs, focused comparison revealed significantly more time spent off text when reporting TUTs compared to on-task thoughts, $t(88) = 2.61$, $p = .011$, $d = 0.47$, and TRI, $t(88) = 3.13$, $p = .002$, $d = 0.56$, which did not differ from each other, $t(88) = 0.67$, $p = .504$.

**First-pass fixation counts**

First-pass fixations include only fixations that occur during the first pass through the text and are thought to represent early low-level text processing (Reichle et al., 2010). First-pass fixations did not differ with age but did differ by thought report. Focused comparisons indicated that on-task thoughts were associated with more first-pass fixations relative to TUTs, $t(88) = 2.11$, $p = .037$, $d = 0.27$, and TRI, $t(88) = 2.92$, $p = .004$, $d = 0.43$, which did not differ, $t(88) = 0.64$, $p = .525$.

The Age × Thought Report interaction was not reliable. However, to directly consider the hypothesis that OAs' and YAs' eye movements are similarly affected by TUTs and TRI relative to on-task thoughts, we examined focused comparisons between on-task thoughts and TUTs and TRI in each age group. Compared to when reporting on-task thoughts, YAs made significantly fewer first-pass fixations when reporting TRI, $t(88) = 2.43$, $p = .017$, but not TUTs, $t(88) = 0.54$, $p = .590$. This pattern was reversed for OAs, with fewer first-pass fixations for TUTs, $t(88) = 2.30$, $p = .024$, but only a nonsignificant trend for TRI, $t(88) = 1.69$, $p = .095$. Thus, we are hesitant to conclude that TUTs and TRI similarly reduce the number of first-pass fixations in OAs and YAs.

**Words fixated**

This count includes words fixated during the first pass and during rereading/regressions and may indicate TUTs if people are more or less likely to fixate words during off-task thinking. By contrast, people often skip highly predictable words during on-task reading (e.g., Rayner, Reichle, Stroud, Williams, & Pollatsek, 2006) and thus may fixate more words during TUTs if they fail to skip these predictable words. Data from previous studies are mixed, either supporting fewer fixations during TUTs (Uzzaman & Joordens, 2011) or no difference (Reichle et al., 2010).

Here, words fixated did not differ by age, but the main effect of thought report was qualified by an Age × Thought Report interaction. Focused comparisons indicated that YAs fixated fewer words when reporting TRI compared to on-task thought reports, $t(88) = 2.72$, $p = .008$, $d = 0.58$, and TUTs, $t(88) = 3.85$, $p < .001$, $d = 0.87$, which did not differ from each other, $t(88) = 1.21$, $p = .230$. By contrast, OAs fixated fewer words when reporting TUTs compared to on-task thoughts, $t(88) = 2.01$, $p = .047$, $d = 0.62$; words fixated did not differ between TRI and TUTs, $t(88) = 0.79$, $p = .434$, or TRI and on-task thoughts, $t(88) = 1.41$, $p = .163$.

**Between-word regression counts**

Regressions occur when fixations move backward (e.g., from the fifth word to the third). Regressions are common during reading and can represent meaningful reprocessing of text (Rayner, 1998; Rayner et al., 2006); thus, regressions should be less common during TUTs. However, neither Reichle et al. (2010) nor Foulsham et al. (2013) found a difference in regressions preceding TUTs and on-task thoughts.

Here, OAs made more regressions compared to YAs—consistent with general research on aging and reading (Rayner et al., 2006). Contrary to predictions, participants made more between-word regressions when reporting TUTs compared to on-task reports, $t(88) = 3.62$, $p < .001$, $d = 0.47$, and TRI, $t(88) = 4.33$, $p < .001$, $d = 0.58$, which did not differ, $t(88) = 0.92$, $p = .360$. The Age × Thought Report interaction was not significant.

As with first-pass fixations, we examined focused comparisons within each age group to directly test whether OAs' and YAs' eye movements are similarly affected by TUTs. YAs made significantly more regressions preceding TUTs compared to on-task reports, $t(88) = 2.13$, $p = .036$, and TRI, $t(88) = 3.24$, $p = .002$. This pattern held for OAs as well, $t(88) = 2.94$, $p = .004$, and $t(88) = 2.92$, $p = .004$, respectively. Thus, we conclude that TUTs increase between-word regressions in both OAs and YAs.

**Gaze duration**

Gaze durations measure the amount of time spent on each word, whether an initial or subsequent gaze. Reichle et al. (2010) found that participants made longer gazes prior to TUTs. We found no age difference in gaze durations but did find a main effect for thought report. Focused comparisons show that gazes were longer when reporting TRI compared to on-task reports, $t(88) = 2.70$, $p = .008$, $d = 0.13$, and TUT reports, $t(88) = 2.68$, $p = .009$, $d = 0.15$, which did not differ, $t(88) = 0.50$, $p = .620$. An Age × Thought Report interaction ($p = .059$) suggests that the effect of thought report was driven primarily by YAs. For YAs, gaze durations were longer for TRI compared to on-task reports, $t(88) = 3.28$, $p = .002$, $d = 0.19$, and TUT reports, $t(88) = 3.40$, $p = .001$, $d = 0.17$, which did not differ, $t(88) = 0.09$, $p = .925$. By contrast, there were no differences in gaze durations between thought reports for OAs, all $t < 1.00$, all $p > .50$. Again, YAs showed greater disruption in gaze patterns when reporting TRI compared to on-task and TUT reports.

*Word length effects*

Reichle et al. (2010) found that participants gazed at longer words for longer durations, but only when on task. We thus added the number of letters as a continuous variable to the gaze duration model that already included age and thought report as predictors. Only the main effect of length, with longer words receiving longer gazes, was significant. A nonsignificant Length × Thought Report interaction suggests that the effect may have been larger in TRI relative to TUTs and on-task thoughts.

As with the above measures, we examined the pattern within age groups to test the hypothesis that OAs' and YAs' eye movements are similarly affected by TUTs and TRI but using Thought Report × Length mixed models for each age group. For YAs, longer words received longer gazes, $F(1, 2{,}771) = 105.53$, $p < .001$. The main effects of thought report, $F(2, 48) = 1.41$, $p = .254$, and Length × Thought Report interaction were not significant, $F(2, 2{,}771) = 1.61$, $p = .201$. This pattern held for OAs as well, with longer words receiving longer gazes $F(1, 2{,}881) = 106.98$, $p < .001$. The main effects of thought report, $F(2, 40) = 0.65$, $p = .530$, and Length × Thought Report interaction were not significant, $F(2, 2{,}881) = 1.69$, $p = .184$. In summary, word length effects on gaze duration were present for both OAs and YAs but did not vary by thought report. It is noteworthy that the *War and Peace* text uses a number of uncommon words and complex sentence structure, both of which can influence reading times (Rayner et al., 2006). We elaborate on this issue in the Discussion.

**Blink rate**

Blink rates had a strong positive skew, and the majority (YAs, 68%; OAs, 71%) of probed trials involved zero blinks in the preceding 5 s. Because neither data transformation nor nonparametric comparisons can account for these issues, we simply note the data patterns rather than using inferential statistics.

Smilek et al. (2010) found that blinks were more common in the 5 s preceding a TUT report. Using their analyses, we obtain a similar pattern, with both OAs and YAs blinking more preceding TUT and TRI reports versus on-task reports (see Table 3). This pattern seems to support the thought report validity of both OAs and YAs. However, whereas Smilek et al. (2010) report this directional difference for all 15 of their participants, the current study found more blinks preceding TUTs for only 52% of YAs and 38% of OAs; comparable numbers for TRI were 59% of YAs and 46% of OAs. Thus, blinks seem inadvisable as a substitute measure for thought self-reports.

*Validity summary*

Previous studies (McVay & Kane, 2012; Smallwood, McSpadden, & Schooler, 2008; Unsworth & McMillan, 2013) demonstrated that frequent TUTs are associated with poorer comprehension for YAs, and we obtained the same decrement for both age groups. By contrast, reporting more TRI was only associated with poorer performance among YAs. This pattern supports the validity of thought reports but also suggests that TRI during reading may be qualitatively different between YAs and OAs.

Both age groups made more regressions when reporting TUTs and blinked more when reporting TUTs and TRI. However, off-text fixations, total time off text, and number of words fixated suggested greater disruption in text processing for OAs when reporting TUTs and greater disruption in YAs when reporting TRI. These results may indicate that OAs and YAs are differentially affected by TUTs and TRI or that OAs and YAs classify TUTs and TRI differently. Importantly, these results do not support the hypothesis that OAs misclassify TUTs as on-task thoughts.

## Dispositional Influences

Our consideration of possible dispositional factors underlying OAs' less frequent mind-wandering focused on mood and mindfulness. We expected that OAs would score higher overall on positive affect and mindfulness and lower on negative affect. Furthermore, we predicted that these might protect against TUTs. Although there is little previous work to guide predictions for the relationships between TRI and mood, we conducted exploratory analyses. Mood assessed after reading correlated more strongly with thought reports during the reading than did mood assessed before reading. Because mood is probably influenced by the task, we focus on mood after testing here but report means (see Figure 3) for mood at both times.

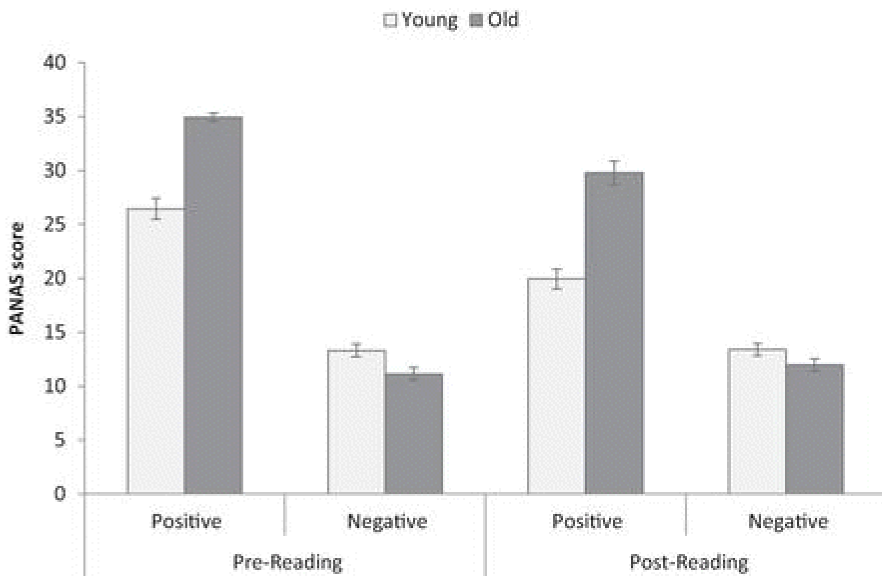


*Figure 3. Means and standard errors for PANAS scores.*

OAs scored higher on positive affect, $t(74) = 6.87$, $p < .001$, $d = 1.59$, and on all facets of mindfulness (all $p < .05$, $d = .52–.68$; Figure 4) compared to YAs. By contrast, negative affect was near the floor for both age groups, with only a trend toward OAs being less negative, $t(74) = 1.95$, $p = .055$, $d = .45$.

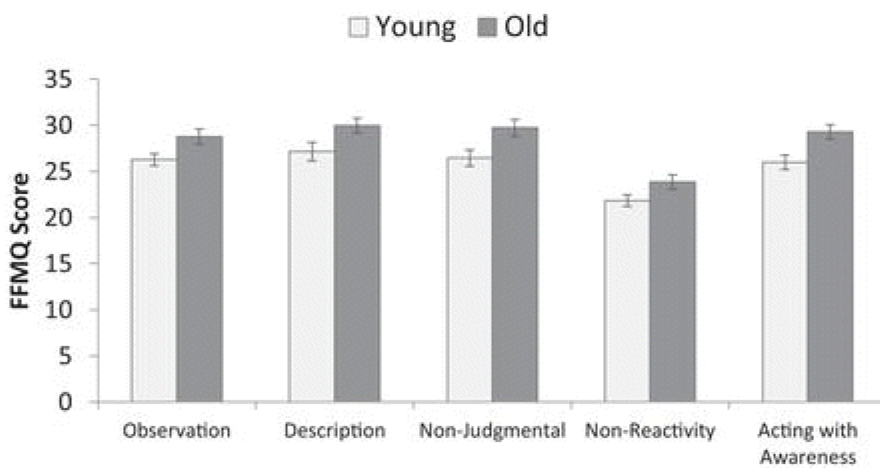


*Figure 4. Means and standard errors for mindfulness (FFMQ) scores.*

Correlations with TUTs and TRI are reported in Table 4. We also report the outcomes of exploratory mediation models, but we caution against overinterpreting null results, as the tests are underpowered. Among mindfulness measures, only the ability to describe sensations (FFMQ description scale) was related to fewer TUTs. As predicted, greater negative affect was related to more TUTs, and greater positive affect was related to fewer TUTs. The indirect effect of age on TUTs through positive affect was also significant, suggesting that OAs' more positive affect may in part explain their lower TUT rate, perhaps by increasing their available cognitive resources to inhibit distraction (Fredrickson, 2001). Regarding our exploratory consideration of TRI, only those scoring higher on the tendency to observe and notice surroundings (FFMQ observation scale) were more likely to report TRI. The indirect effect of age on TRI through FFMQ observation was also significant, suggesting that OAs' increased tendency to observe their surroundings may partially explain their greater reporting of TRI.

Table 4. *Correlations and Mediation Analyses*

| | Correlations | | Test for TUT mediation | | | | | | Test for TRI mediation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mediator | TUT | TRI | Effect | Bootstrapped *SE* | 95% CI LL | | 95% CI UL | $r^2$ | Effect | Bootstrapped *SE* | 95% CI LL | | 95% CI UL | $r^2$ |
| PANAS | | | | | | | | | | | | | | |
| Positive | **−.54** | .18 | **−.094** | **.035** | **−.169** | — | **−.032** | **.21** | .014 | .028 | −.037 | — | .076 | .03 |
| Negative | **.27** | .09 | −.017 | .017 | −.057 | — | .006 | .05 | −.012 | .013 | −.043 | — | .005 | .01 |
| FFMQ | | | | | | | | | | | | | | |
| Observation | −.20 | **.29** | −.007 | .011 | −.033 | — | .013 | .04 | **.021** | **.014** | **.001** | — | **.054** | **.03** |
| Description | **−.23** | .15 | −.012 | .013 | −.043 | — | .095 | .04 | .010 | .011 | −.007 | — | .036 | .01 |
| Nonjudgmental | −.01 | −.07 | .020 | .015 | −.001 | — | .055 | .02 | −.013 | .015 | −.046 | — | .016 | .02 |
| Nonreactivity | −.12 | .05 | .010 | .011 | −.019 | — | .026 | .01 | .001 | .001 | −.017 | — | .017 | .01 |
| Acting with awareness | −.15 | .01 | .003 | .014 | −.022 | — | .037 | .02 | −.009 | .015 | −.043 | — | .020 | .01 |
| Motivation | **−.51** | .13 | **−.075** | **.033** | **−.152** | — | **−.022** | **.18** | .003 | .024 | −.045 | — | .052 | .02 |
| Reading for pleasure | **−.39** | .01 | −.031 | .032 | −.098 | — | .029 | .15 | −.052 | .041 | −.134 | — | .029 | .03 |

*Note*. The sample size for these analyses is $N = 76$, as we were able to use data from participants who did not provide adequate eye-tracking data. Mediation analyses were computed using bootstrapped confidence intervals (based on 5,000 resamples) around the indirect effects (Hayes, 2009). Bold values in Tables 3 and 4 indicate effects significant at the $p < .05$ level. 95% CI LL = lower limit for 95% confidence interval; 95% CI UL = upper limit for 95% confidence interval.

Age differences in task interest and engagement may also influence mind-wandering (Jackson & Balota, 2012; Krawietz et al., 2012; McVay et al., 2013; Zavagnin et al., 2014). Participants' motivation to keep their thoughts on the task was greater among OAs and correlated negatively with TUTs. The indirect effect of age on TUTs through motivation was significant, suggesting that motivation may play a role in OAs' lower TUT rate. Because our motivation question was framed in reference to the just-completed task, which included thought probes, we interpret these effects cautiously; the validity of this measure might be compromised by the recollection and interpretation of individuals' mind-wandering experiences.

An influence of task engagement on age differences in mind-wandering is also suggested by a correlation between a *pre*task report of how often the participants read for pleasure and TUTs. However, more targeted research is needed to understand the role of task interest and engagement on age differences in mind-wandering. This research must carefully consider pre- versus posttask assessments, as the latter may be compromised by reactive effects and cause–effect ambiguities (i.e., does low interest increase TUTs, or do frequent TUTs lower retrospective evaluations of interest?).

Analysis of our posttask survey revealed other outcomes that might warrant further investigation (see Table 2). OAs reported having generally better control over their thoughts during the task, consistent with the age comparison for individual thought reports. However, OAs were less aware of TRI prior to thought probes (i.e., less frequently "tuned out"). YAs reported being more fatigued by the eye-tracking headgear and were more conscious of their eye movements, which might indicate that they were more prone to distracting thoughts from external sources.

## Reading-Related Thoughts

In addition to on-task, TRI, and TUT reports, we also included (in an exploratory vein) an option for "reading-related images or thoughts related to the content of the text, but not directly corresponding to the actual words on the screen." Both age groups reported a similar number of reading-related thoughts, $t(74) = 0.10$, $p = .932$, $d = 0.15$. However, these thought reports were not related to comprehension scores, $r = .09$, $p = .440$. When compared with TRI and on-task reports, reading-related thoughts were indistinguishable on all eye movement variables ($p > .05$), with the exception of first-pass fixations. Reading-related thoughts were associated with fewer first-pass fixations than TRI, $t(98) = 2.27$, $p = .025$, $d = 0.37$, and were therefore more similar to on-task thoughts.

*Discussion*

## Thought Report Validity

Our data generally support thought reports as a valid measure of mind-wandering in both age groups. Neither performance nor eye movements demonstrated less pronounced distinctions between on-task thoughts and TUTs for OAs compared to YAs. We replicated previous findings of fewer TUT reports and more TRI reports by OAs, and our data argue against the idea that OAs are less likely to report TUTs due to a bias against or lack of awareness of mind-wandering. Eye movement regressions were more frequent preceding TUTs than on-task reports for both age groups. OAs showed greater differentiation in eye movements between TUTs and on-task thoughts for off-text fixations, total time off text, and words fixated, whereas YAs showed greater differentiation between TRI and on-task thoughts for these measures.

Previous studies on eye movements and mind-wandering produced contradictory findings (Foulsham et al., 2013; Reichle et al., 2010; Smilek et al., 2010; Uzzaman & Joordens, 2011), perhaps due to methodological differences. If differences in eye movements are not dependably found across texts and thought-probe methodologies, then eye-tracking data are unlikely to be useful as a behavioral measure of mind-wandering and replacement for self-reports. However, we do believe that eye movements can be a useful tool for comparing the impact of mind-wandering between groups for a given task, as we demonstrate here.

We consistently found that eye movements and comprehension in YAs were more disrupted by TRI than TUTs. This pattern may suggest that experiencing TRI disrupts reading or that comprehension difficulties cause both disruptions in reading and thoughts about task performance. Prior studies of eye movements with mind-wandering have not accounted for TRI (Foulsham et al., 2013; Reichle et al., 2010; Uzzaman & Joordens, 2011) or have instructed participants to categorize TRI as TUTs (Smilek et al., 2010). As a result, TRI may have been misclassified as TUTs in prior studies and thus driven relationships between eye movements and TUTs in YAs. By contrast, our data suggest that OAs' eye movements are disrupted more by TUTs than TRI. As noted above, this is inconsistent with a reporting bias explanation of age differences in TUTs. If OAs misreport TUTs as on-task thoughts, then eye movements preceding TUT reports and on-task reports should be more similar for OAs than for YAs.

Alternatively, it may be that the interaction between age and thought reports for eye movement measures indicates a difference in the use of thought report categories by OAs and YAs. Although our data are inconsistent with the hypothesis that OAs misclassify TUTs as on-task thoughts, it is possible that OAs have a more liberal criterion for reporting TRI compared to YAs. That is, OAs may classify some relatively on-task thoughts as being TRI—hence the greater similarity between OAs' on-task and TRI reports. By contrast, YAs may have a more liberal definition of TUTs—hence the greater similarity between their on-task and TUT reports.

TRI may be proactive in some cases, reflecting intentional comprehension monitoring and strategic planning. It may also be reactive in response to comprehension failures. OAs typically show similar metacognitive monitoring accuracy relative to YAs (Hertzog & Dunlosky, 2011). The "cognitive sparing" of metacognitive monitoring might reflect a greater tendency to self-assess performance by OAs, making monitoring a well-practiced skill. This could explain the lesser disruption in OAs' eye movements when reporting TRI. Compared to YAs, OAs were less likely to report that they were aware of their TRI prior to the thought probe. This is consistent with the hypothesis that monitoring may be fairly automatic in OAs and might thus occur without effort, awareness, or disruption. By contrast, if YAs engage in self-assessment less often than do OAs, they may report TRI primarily when reacting to markedly poor performance. If this is the case, it could explain the greater disruptions in eye movement patterns and the negative TRI–comprehension correlation for YAs. In accordance with the idea of TRI being more reactive in YAs, YAs reported greater consciousness of their eye movements during the task (see Table 2). However, these explanations are largely speculative and thus warrant additional research.

It is important to note that our task departed substantially from naturalistic reading. Accurate measurement of word fixations required use of a large font, and the number of words per screen was therefore always <100 words. The *War and Peace* text also contains long sentences, which sometimes required limiting a screen to a single sentence. We used this text to allow relatively direct comparisons to previous work, but future research should examine mind-wandering and eye movements in a wider variety of reading and other tasks to more fully understand how and when mind-wandering occurs in OAs and YAs.

## Dispositional Influences

Age differences in off-task thoughts (combining TUTs and TRI) were reduced but remained significant after accounting for OAs' greater TRI (see also McVay et al., 2013). OAs' more positive mood and interest/motivation after the reading task also contributed to their lower TUT rate but not their higher TRI rate. By contrast, we did not find evidence that mindfulness contributes to OAs' lower TUT rate and found evidence for only minor contributions to OAs' higher TRI rate.

### Mindfulness

OAs scored higher on all five facets of mindfulness. Prior studies have found that brief mindfulness training (Mrazek et al., 2013) and dispositional mindfulness (Mrazek, Smallwood, & Schooler, 2012) are associated with reduced TUTs. However, we did not find consistent relationships between mindfulness and mind-wandering reports; only one subscale correlated with TUTs (description scale), and only one subscale correlated with TRI (observation scale).

In addition to low power, the failure to find a strong TUT/TRI–mindfulness relationship may also stem from the mindfulness scale we used. The FFMQ comprises general statements about one's propensity to behave in certain ways and thus should tap trait-level, as opposed to state-level, mindfulness. State mindfulness is likely to vary based on situational factors and might better relate to age differences in mind-wandering (e.g., State–MAAS; Brown & Ryan, 2003). Indeed, recent research finds only moderate (and varied) correlations between state- and trait-level mindfulness measures (Tanay & Bernstein, 2013).

### Negative affect

Negative moods, whether induced (Antrobus et al., 1966; Smallwood & O'Connor, 2011) or preexisting (Smallwood et al., 2005), are associated with increased TUTs and TRI. Negative affect is generally low in laboratory settings and in our study did not mediate age differences in either TUTs or TRI. It remains unknown whether more extreme levels of negative affect, as from mood induction, would impact TRI (particularly its more reactive form) in either OAs or YAs. Alternatively, other measures may be more sensitive to differences in negative affect likely to be found under normal laboratory conditions.

### Positive affect

Positive affect did mediate the age–TUT (but not the age–TRI) relationship, with greater positive affect associated with fewer TUTs. Mrazek, Smallwood, and Schooler (2012) did not find this association in YAs, but their research did not separate TRI (which does not correlate with positive affect) from TUTs and on-task thinking, which may have diluted any affect–TUT relationships in their data. It is important to note that the current TUT–positive affect correlation was found within both age groups and so was not an artifact of age.

The broaden-and-build perspective suggests that positive affect broadens attention, either by more widely distributing attention to peripheral details or increasing available cognitive resources (Fredrickson, 2001). The latter explanation is consistent with our results and may explain why positive affect partially accounted for OAs' lower TUT rate, with OAs having more available resources to inhibit distracting thoughts. A contrasting view suggests that mind-wandering produces negative mood (Killingsworth & Gilbert, 2010), and so OAs may remain more positive because they mind-wander less. It is important to note, however, that Killingsworth and Gilbert (2010) measured mood with a single 0 (*completely unhappy*) to 100 (*completely happy*) scale, whereas the PANAS independently measures positive and negative affect (as in having high levels of both excitement [positive] and anxiousness [negative]). Our results do not indicate that mind-wandering produces negative affect; changes in negative affect from pre- to posttask were not correlated with TUTs, $r = .08$, $p = .468$. In contrast, both our data and those from Killingsworth and Gilbert (2010) could be interpreted as mind-wandering decreasing positive affect. In our study, changes in positive affect from pre- to posttask correlated with TUTs, $r = -.37$, $p = .001$.

## Motivation

Unsworth and McMillan (2013) demonstrated that self-reported interest and motivation correlated with TUTs among YAs, and Krawietz et al. (2012) showed a similar pattern for interest in OAs. The current study found that motivation mediated age differences in TUTs. However, motivation reports in our study, as well as those in Unsworth and McMillan (2013) and Krawietz et al. (2012), were collected following the task and so might have been reactive to thought-probe responses and task performance. We also obtained a relationship between TUTs and pretask reports of how often people read for pleasure, which provides a less problematic connection between task interest and mind-wandering.

### *Conclusions*

Our data indicate that OAs' less frequent TUTs cannot be explained by a reporting bias. We did obtain evidence that positive affect and task engagement may be partly responsible for OAs' lower TUT rate compared to that of YAs. Future research should further examine the impact of dispositional factors such as mood, mindfulness, and task engagement on TUTs and TRI (distinguishing proactive from reactive TRI) using measures that are focused on both state- and trait-level measures (e.g., State–MAAS and FFMQ), as well as within other task domains.

Footnotes

1 Reichle, Reineberg, and Schooler (2010) also found a number of effects for self-caught TUTs (where the participant presses a key whenever he or she notices that he or she is thinking about something other than the task) that were not found for probe-caught TUTs, and they interpret these differences as due to meta-awareness rather than meaningful eye movements.

2 This data loss is typical for tracking studies (Frank, Touron, & Hertzog, 2013; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Rayner, personal communication, August 4, 2011; Stine-Morrow et al., 2010; Touron, Hertzog, & Frank, 2012).

3 The DotumChe font was chosen because it is a monospace font, meaning that each letter subtends the same degree of visual angle, allowing for longer words to subtend a proportionally larger degree of visual angle irrespective of the particular letters in the word. This simplifies the analysis of word length effects.

4 We obtained one observation with a gaze duration greater than 3 standard deviations above the mean. However, exclusion of this outlier did not influence the pattern of results for any measure; thus, it is included in all reported analyses and figures.

5 When trials with 0 blinks are eliminated, 60% of YAs and 33% of OAs blink more during TUTs than on-task reports, and 70% of YAs and 50% of OAs blink more during TRI compared to on-task thoughts.

6 Mrazek, Smallwood, and Schooler (2012) did not report means or standard deviations for the PANAS, so a direct comparison is not possible. Their study also did not produce a negative correlation between TUTs and performance, which could indicate important differences between the methods (categorical vs. continuous measures of mind-wandering) and samples used in their study and the current study.

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