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Mind-wandering and falls risk in older adults

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Abstract

While mind-wandering is common, engaging in task-irrelevant thoughts can have negative functional consequences. We examined whether mind-wandering frequency may be related to falls – a major health care problem. Seniors completed a sustained attention task and self-reported their current attentional states. Monthly falls reports were collected over 12 months. Falls were associated with an increased frequency of mind-wandering. Additionally, poorer performance on the sustained attention task was associated with more falls over 12 months. Given that fallers are known to have impaired executive cognitive functioning, our results are consistent with the current theory that poor attentional control may contribute to the occurrence of mind-wandering.

Keywords

Aging; Mind-wandering; Falls

The natural tendency for our thoughts to drift off task – known as mind-wandering – has become an increasingly popular topic of research in neuroscience (e.g., Smallwood, in press). Although it is a ubiquitous phenomenon, with up to 50% of our waking time spent creating and maintaining an inner dialogue secondary to current behavioural goals (Smallwood, in press), variations in mind-wandering are associated with neurocognitive pathologies (e.g., Shaw & Giambra, 1993; Smallwood, O'Connor, Sudbery, & Obonsawin, 2007). Furthermore, mind-wandering frequency is modulated as a function of age – with older adults spending significantly less time engaging in task-unrelated thoughts (e.g., Giambra, 1989; Jackson & Balota, 2012). Given what we now understand about how mind-wandering impacts neurocognitive functioning, the aim of our study was to establish whether alterations in mind-wandering may be also contributing to one of the primary health risks of aging — namely, falling.

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Evidence that mind-wandering may be a heretofore unrecognized risk factor of falling in older adults stems from three core findings regarding the transient effects of mind-wandering on neurocognitive function. First, mind-wandering directly alters how we perceive, analyze, and respond to the external environment. This statement is substantiated by neuroimaging evidence using event-related potentials (ERPs). In a study examining the effects of mind-wandering on sensory gain control, Kam and colleagues (2011) found that during off-task periods, sensory processing was attenuated. Specifically, sensory-evoked responses to stimuli presented in both visual and auditory modalities were reduced during periods of mind-wandering, relative to "on-task" states. In addition, Smallwood et al. (2008) reported decreased cognitive processing of visual stimuli during mind-wandering. Together, these studies converge on the idea that there is a systematic reduction in the depth of stimulus processing at both the sensory/perceptual and cognitive levels. Likewise, behavioral control shifts to a more automatic state (e.g., Carriere, Cheyne, & Smilek, 2008; Cheyne, Carriere, & Smilek, 2006; Reichle, Reineberg, & Schooler, 2010; Smallwood et al., 2008), leading to speeded responses and higher error rates on task performance during mind-wandering compared to on-task periods (Franklin, Smallwood, & Schooler, 2011; Smallwood et al., 2004). In short, mind-wandering may impact a host of neurocognitive functions essential for safe navigation and mobility.

Second, the propensity to mind-wander has been directly linked to executive cognitive functioning and its functional capacity. In particular, the executive failure hypothesis of mind-wandering posits that higher-level executive control is required to sustain external attention, and at the same time, ignore internal and perceptual distractions (Smallwood, in press). Evidence suggests that seniors with a history of falls have impaired executive cognitive functioning, including poorer performance on tasks involving response inhibition and selective attention (e.g., Liu-Ambrose et al., 2008; Lord & Fitzpatrick, 2001; McGough et al., 2011; Springer et al., 2006). Thus, an inability to actively control attention to align with current behavioural goals, while simultaneously inhibiting task-unrelated thoughts, may represent a major obstacle for fallers to safely navigate their environment. Furthermore, mind-wandering results in impaired performance on the primary task (e.g., Grodsky & Giambra, 1990–1991). Such performance decrements are akin to the dual-task costs often observed in healthy adults, which are further exacerbated in senior fallers (see Hsu, Nagamatsu, Davis, & Liu-Ambrose, 2012 for a review; e.g., Lundin-Olsson, Nyberg, & Gustafson, 1997; Nagamatsu, Carolan, Liu-Ambrose, & Handy, 2009; Verghese et al., 2002). Importantly, dual-task impairments are indicative of reduced general processing capacity (e.g., Kahneman, 1973), which may in turn be linked to a greater frequency of mind-wandering (e.g., Kane et al., 2007).

Lastly, mind-wandering, or regular oscillations in the depth of our neurocognitive engagement with the external environment, is normative to healthy human brain function (Schooler et al., 2011; Smallwood, in press; Smallwood & Schooler, 2006). However, increased frequency of mind-wandering has now been tied to several clinical and sub-clinical neurocognitive pathologies. These include clinical signs of depression, such as dysphoria (see also Killingsworth & Gilbert, 2010; Smallwood et al., 2007), ADHD (e.g., Shaw & Giambra, 1993), impulsivity (e.g., Helton, 2009), and schizophrenia (e.g., Elua, Laws, & Kvavilashvili, 2012). On the other hand, seniors show a *decreased* propensity for mind-wandering relative to young adults (e.g., Giambra, 1989, 1993; Jackson & Balota, 2012), which is thought to reflect task-engagement (e.g., Jackson & Balota, 2012). It has also been suggested that mind-wandering frequency is directly associated with processing demands of the current task (Mason et al., 2007); thus, reduced mind-wandering in older adults may reflect a strategy aimed at compensating for reduced cognitive capacity as a function of age. Briefly put, because cognitive capacity is known to decline with age (Craik & Byrd, 1982), older adults must dedicate a greater proportion of their available resources to the task at hand – thus leaving fewer resources to allocate to a secondary task, such as task-unrelated thoughts. Overall, such results indicate that not only are altered patterns of mind-wandering associated with neurocognitive pathology, but that any increased propensity for mind-wandering in senior fallers would be in direct opposition to what is normative for their age group.

In light of the above considerations, our study was designed to examine whether the frequency rate or relative amount of time spent mind-wandering might be associated with falls risk in older adults. Accordingly, participants completed a sustained visual target-detection task (sustained attention to response task, SART). We determined the rate of mind-wandering for each participant via subjective reports of participants current attentional state (on-task versus mind-wandering), collected at regular but unpredictable intervals (see below). The SART is a widely-used paradigm in mind-wandering studies, where participants are required to respond to frequently presented targets, while inhibiting responses to infrequent targets (e.g., Kam et al., 2011; Smallwood et al., 2008). The SART is thought to measure sustained attention – which is influenced by the moment-to-moment efficacy of attentional control mechanisms (Manly, Robertson, Galloway, & Hawkins, 1999). Due to the repetitive and mundane nature of the task, the SART is well-suited to induce periods of mind-wandering over a sustained testing period. Furthermore, SART performance itself can be a measure of attentional state, in that errors of commission are more likely to occur when one is off-task and thus unable to inhibit the prepotent response (Smallwood et al., 2004). Indeed, poor performance on the SART has been attributed to absent-mindedness (Manly et al., 1999; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997).

With respect to identifying the attentional state of our participants during task performance, we used “experience sampling” (Schooler et al., 2011). Considered to be a “direct” measure of mind-wandering, experience sampling relies on the fact that if prompted, we can reliably report on the content of our thoughts at any given moment, and further, determine whether they center on the on-going task being performed (referred to as an “on-task” state), or alternatively, whether they have drifted off to unrelated issues (referred to as an “off-task” or “mind-wandering” state) (for a review, see Gruberger, Ben-Simon, Levkovitz, Zangen, & Hendler, 2011). Although the act of reporting on one’s attentional state interferes with the content of consciousness itself (e.g., Filler & Giambra, 1973), by using the report to categorize a participant’s attentional state in the 10–15 seconds immediately prior to the report, the methodology has been used to demonstrate reliable and replicable differences in neurocognitive functioning between “on-task” and “off-task” states (e.g., Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Franklin et al., 2011; Kam et al., 2011; Kirschner, Kam, Handy, & Ward, 2012; McKiernan, D’Angelo, Kaufman, & Binder, 2006; Smallwood et al., 2008; Smallwood et al., 2004; Stawarczyk, Majerus, Maj, Van der Linden, &

D'Argembeau, 2011). As such, in adopting this methodology here, our approach to defining attentional states aligned with widely-accepted norms in the field of mind-wandering research.

For our study, we hypothesized that falls would be positively associated with frequency of mind-wandering, given that both have underlying relationships with reduced attentional control. Furthermore, while we did not anticipate reaction times to be associated with falls (e.g., Nagamatsu et al., 2009), we did hypothesize that falls would be associated with task accuracy – or errors of commission – based on the idea that older adults with a history of falls have poorer response inhibition (Liu-Ambrose et al., 2008; Liu-Ambrose, Katarynych, Ashe, Nagamatsu, & Hsu, 2009; Lord & Fitzpatrick, 2001; McGough et al., 2011).

Methods

Participants

Eighteen community-dwelling senior women participated in this study. Participants were recruited from a database of people who had participated in previous studies in our laboratory, and who agreed to be contacted to participate in future research. They had previously been recruited through advertisements in the community and local media, and were screened for neurodegenerative disease and depression. Because our previous studies focused on the effects of physical activity on cognitive functions in older adults, and exercise is known to differentially impact cognition between the sexes (e.g., Baker et al., 2010), our sample only included women. Participants were aged 66 to 81 years (mean age 71.89 years, SD = 4.17). All participants were cognitively intact, as indicated by Mini-Mental Status Examination (MMSE) scores above 24 (Folstein, Folstein, & McHugh, 1975) and had normal or corrected-to-normal vision. Participants provided written informed consent and the reported research was approved by the Clinical Research Ethics Board (CREB) at the University of British Columbia.

Falls

We recorded the number of falls experienced by each individual over a twelve-month period prior to study participation. Falls were recorded using monthly falls calendars, where participants were required to mark on a calendar each day whether a fall occurred that day or not. Falls calendars were mailed into our study centre at the end of each month. Any falls that did occur that month were followed up via telephone interview to ascertain the circumstances regarding the fall and whether any injuries were sustained. Importantly, falls calendars are considered a valid and reliable method to track falls, rather than relying on retrospective reports which are subject to memory bias (Hannan et al., 2010; Lamb, Jorstad-Stein, Hauer, & Becker, 2005).

Stimuli and procedure

Participants completed the SART used in previous mind-wandering studies (Kam et al., 2011; Smallwood et al., 2008). Stimuli were presented on a computer monitor with a 24 cm diameter viewing screen, placed 110 cm from the participant. During each trial, participants viewed frequently presented visual targets (i.e., a number from 0–9, presented in a random sequence between trials) for 500 msec (interstimulus interval 900–1100 msec) at fixation and were asked to respond as quickly and accurately as possible to their appearance with a manual button press using their right thumb. Infrequent visual targets ("non-targets"; i.e., the letter "X") were presented either once or twice per experimental block (i.e., half of blocks had one non-target, while the other half had two non-targets), where participants were required to withhold their response. In blocks with two non-targets, the "X"'s were separated by at least ten events.

The end of each block was signaled with a blue coloured screen, upon which participants were asked to verbally self-report their current attentional state at the time of the blue screen appearing –whether they were on-task or mind-wandering. The experimenter noted their attentional state for each block, and these reports were later used to categorize the behavioural data to compare the two attentional states. "On-task" was defined as thoughts that were exclusively focused on the central experimental task. "Mind-wandering", in contrast, was defined as engagement in thoughts external to the experimental task. This distinction was explained to participants at the beginning of the experiment. To reduce demand characteristics, participants were also reassured that mind-wandering during the experiment was natural, and that there would be no negative consequences of doing so. There were 40 experimental blocks altogether. Each block was randomly selected to be 30–90 seconds long (approximately 15–45 trials), with two goals in mind: 1) To minimize predictability of block completion; and 2) To maximize variability in attentional state at the time of block completion. Breaks were permitted between blocks, as requested by participants. We instructed participants to keep their eyes on the central fixation point for the duration of the experiment.

To ascertain the relationship between mind-wandering and falls, we calculated Pearson correlations for both our behavioural measures (reaction times, accuracy, and frequency of mind-wandering) with number of falls over the past 12 months. Correlations were performed using SPSS (Version 20, MAC).

Physical falls risk factors

To examine the relationship between falls and mind-wandering above and beyond physical falls risk factors, we included physiological measures in our study. First, we assessed gait speed, where we recorded the time required to walk four metres. Second, we assessed general cardiovascular capacity using the Six Minute Walk Test (Enright, 2003), where the total distance walked (metres) in six minutes is measured. Third, we administered the Timed Up and Go Test (TUG) (Podsiadlo & Richardson, 1991), which requires participants to rise from a seated position, walk three metres, return to the chair, and sit down. The average time to complete each of two trials is recorded. Last we had participants complete the Physiological Profile Assessment (PPA) (Lord, Menz, & Tiedemann, 2003). This is a valid and reliable measure of physiological falls risk based on a composite score from five distinct measures.

Results

Falls

Descriptive measures for all participants are reported in Table 1. During the 12-month period that falls were reported, 13 out of 18 participants experienced one or more falls. The number of falls reported by each participant varied from zero to four falls, with an average of 1.17 falls per participant (SD = 1.10 falls).

Mind-wandering and task performance

For subjective reports, our participants reported mind-wandering during an average of 12.39 (SD = 6.01) out of 40 – or 31% – of blocks. Participants were able to successfully withhold their response from non-targets 68.89% (SD = 14.11%) of the time. For reaction times, participants responded slightly faster during periods of mind-wandering (mean = 418.16 msec, SD = 83.77 msec) compared to being on-task (mean = 430.46 msec, SD = 96.37 msec), although the difference was not significant, $t(16) = 0.67$, $p = 0.51$.

Correlations between variables of interest

Our correlational data are presented in Table 2 and Figure 1. For our correlational analysis, the number of falls experienced over our 12-month observation period was associated with frequency of mind-wandering. This was established via a significant positive correlation between number of falls and number of subjective mind-wandering reports, $r(18) = 0.47$, $p < 0.05$. In addition, more falls were associated with faster reaction times on the SART; there was a significant negative correlation between reaction time to targets and number of falls during all trials, $r(18) = -0.48$, $p = 0.04$, and on-task trials, $r(18) = -0.48$, $p = 0.04$, and a trend for mind-wandering trials, $r(17) = -0.41$, $p = 0.10$. There was also a significant negative correlation between accuracy (correct rejection of non-targets) and falls, $r(18) = -0.63$, $p = 0.005$. Specifically, more falls over the past year were associated with lower accuracy scores on our sustained attention task. Our physical measures were not significantly correlated with frequency of mind-wandering (all p's > 0.41).

To ensure accuracy of our results, we tested our data for skewness and the presence of outliers. We determined that falls history and our behavioural measures fit within the acceptable range for skewness (highest skew value = 1.56 for reaction times). For outliers, there were no participants that were ± 3 standard deviations from the mean. While there were participants ± 2 standard deviations from the mean, they were not systematically outliers for multiple variables (i.e., one participant was an outlier for reaction times, another was an outlier for accuracy). Thus, we did not have adequate justification for removing these participants from our dataset. Excluding these two outliers, the correlations remained large (−0.43 and −0.53 for reaction time and accuracy, respectively).

Discussion

Our study was designed to examine whether falls are associated with an increased tendency to engage in task unrelated thoughts. Towards answering this question, our results revealed a key relationship between history of falls and frequency of mind-wandering, where more falls were associated with a higher proportion of time spent off-task. Our finding is consistent with the impairments in executive cognitive functioning that are commonly observed in fallers. The relationship between proportion of time spent engaging in thoughts peripheral to the task and falls may be mediated by poor attentional control (Smallwood, in press). This is substantiated by recent findings that people who score poorly on measures of attentional control tend to engage more in task-unrelated thoughts (Kane et al., 2007; McVay & Kane, 2009).

In addition, we report that falls were significantly correlated with poorer behavioural performance on the sustained attention task. That is, faster reaction times and reduced accuracy were observed in those who experienced falls over the past year. That we found impaired behavioural performance on the sustained attention task in fallers is not surprising given that higher mind-wandering frequency and reduced accuracy come hand-in-hand (e.g., Giambra, 1995; Grodsky & Giambra, 1990–1991). Interestingly, falls were also associated with *faster* reaction times, providing evidence for a speed-accuracy trade-off among fallers and suggesting that they may be operating on “pilot mode” during task performance. These results have important implications for seniors; Poor behavioural performance in the context of every day life can mean failing to notice hazards and obstacles in the environment pertinent to safe navigation. Indeed, up to 30% of community-dwelling older adults experience one or more falls per year (Tinetti, Speechley, & Ginter, 1988), representing a major health-care concern for our aging population. Increasing meta-awareness – the knowledge one has about their current attentional state (e.g., Schooler, 2002) – may be one strategy to improve task performance, and thus reduce falls, in seniors. Evidence from McVay and colleages (2009) suggests that performance declines when participants are unaware that they are currently mind-wandering (i.e., lack of “meta-awareness”). Hence, training senior fallers to be more aware of their current attentional state may be an innovative way to improve performance and reduce falls among this at-risk population.

A primary limitation of our study is that our classification of attentional states was based on subjective reports. As mentioned above, self-report is currently the “standard” method for identifying when a person is engaging in task-unrelated thoughts. With increasing use of advanced technology in mind-wandering research, however, neural and physiological signatures may provide an objective measure of mind-wandering in future studies (Smallwood, in press). We highlight that previous work has found that mind-wandering frequency during laboratory-based tasks parallel mind-wandering rates in real-life within a given individual (McVay et al., 2009), providing ecological validation to our laboratory-based paradigm. Our work is also limited by the fact that we only included senior women in our study, due to the sample available to us. Further, we recognize that our sample is relatively small and homogeneous; thus, future work should focus on how the relationship between falls and mind-wandering may differ in a wider range of the population with larger sample sizes. Lastly, a caveat worth mentioning is that the benefits of attending to the task at hand may be context-dependent, based on whether the focus is on internal versus external stimuli. In particular, over-focusing on postural control in older adults may be detrimental for sensory-motor performance (McNevin & Wulf, 2002; Wulf, McNevin, & Shea, 2001).

To conclude, our study reveals an important link between falls and the frequency of engaging in task-unrelated thoughts. To the extent that mind-wandering during performance of an external task can be considered "dual-tasking", our results concur with current findings that fallers exhibit impaired dual-task performance, likely due to reduced processing capacity (e.g., Nagamatsu et al., 2011; Rapport, Hanks, Millis, & Deshpande, 1998; Springer et al., 2006). Such reductions in processing capacity may also contribute to an inability to effectively prioritize tasks (e.g., Yogev-Seligmann, Hausdorff, & Giladi, 2008) –which also may account for our observed relationship between falls and frequency of mind-wandering. This is the first study to examine the frequency of mind-wandering and as a risk factor for falls. Future work should be aimed at elucidating the mechanisms by which mind-wandering may directly or indirectly impact the occurrence of falls. Finally, future research on how mind-wandering may contribute to falls in the context of the real-world – such as through altered gait patterns – would provide further insight into the relationship between falls and mind-wandering.

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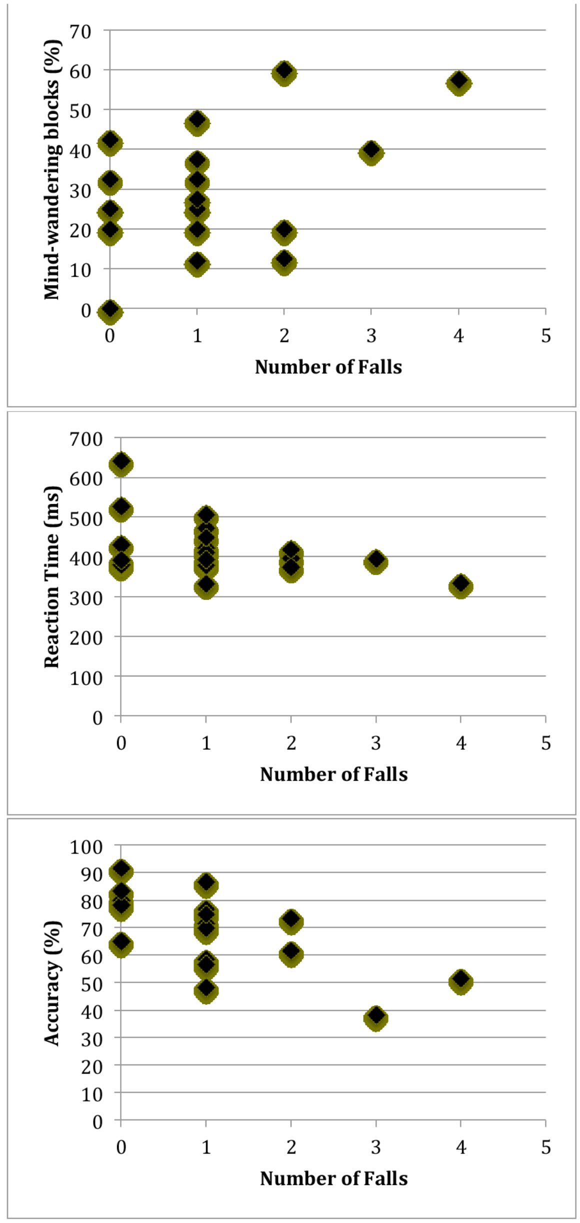

Figure 1.

Scatterplots of significant correlations. Number of falls over the 12 month assessment period as a function of (from top to bottom): percentage of blocks that participants self-reported mind-wandering, average reaction time on the SART task, and accuracy on the SART task.

Table 1

Descriptive characteristics

Variable[a]	**N = 18**
	Mean (SD)
Age, years	71.89 (4.17)
Mini-Mental State Examination[b]	27.78 (2.10)
Falls (past 12 months), number	1.17 (1.10)
Gait Speed, s	3.40 (0.72)
Six Minute Walk Test, m	520.29 (91.64)
Timed Up and Go (TUG), s	7.00 (1.78)
Physiological Profile Assessment (PPA)[c]	0.38 (0.65)

[a]Unless otherwise indicated, data are expressed as mean (SD).

[b]Maximum was 30 points.

[c]Expressed as a z score indicating relative falls risk.

Table 2

Correlations among study variables (n = 18)

	Number of falls	Mind-wandering frequency	SART reaction time	SART accuracy	Gait speed	Six minute walk test	TUG	PPA
Number of falls	—							
Mind-wandering frequency	.471*	—						
SART reaction time	−.480*	−.430	—					
SART accuracy	−.627**	−.491*	.542*	—				
Gait speed	−.316	.005	.409	−.090	—			
Six minute walk test	.439	.209	−.223	.157	−.713**	—		
TUG	−.191	−.105	.134	−.158	.816**	−.646**	—	
PPA	−.302	−.228	.402	.330	.453	−.241	.416	—

** $p < 0.01$ level.

* $p < 0.05$ level.