Off-track thoughts: Intentional and unintentional mind wandering in Alzheimer's disease

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Short title: Mind wandering

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Abstract

Aim: Despite the recent upsurge of interest in mind wandering (i.e., the occurrence of task-unrelated and stimulus-independent thoughts), little research has attempted to evaluate mind wandering in Alzheimer's Disease (AD). We addressed this issue by evaluating intentional and unintentional mind wandering, as well as the relationship between both mind wandering domains. We also investigated relationship between mind wandering and depression and working memory.

Methods: Thirty participants with AD and 33 control participants participated in the study.

Results: Results demonstrated higher intentional and unintentional mind wandering in AD participants than in controls. In AD participants and controls, both mind wandering domains were significantly correlated with depression, but not with working memory.

Conclusions: Our findings demonstrate a tendency of AD patients to shift from external stimuli to task-unrelated thoughts and concerns, a tendency that seems to be related with depression.

Keywords: Alzheimer's Disease; depression; intentional mind wandering; unintentional mind wandering; working memory;

Introduction

Consciousness is not always oriented toward the here and now; instead it ebbs and flows between mental representations from both extrinsic sources (e.g., visual stimuli) and intrinsic (e.g., thoughts) sources. Shifting consciousness experience from external environment to thoughts refers to mind wandering (1). When the mind wanders, attention typically shifts from processing stimuli generated by external environment to internal representations such as thoughts and concerns. There are two types of mind wandering: intentional (deliberate) and unintentional (spontaneous); intentional mind wandering refers to voluntary engagement of consciousness experience toward intrinsic sources, whereas unintentional mind wandering refers to involuntary engagement of consciousness experience toward these sources (2). Considering the distinction between the two categories of mind wandering (intentional and unintentional mind wandering), our study investigates these two categories in Alzheimer's Disease (AD). We further investigate the relationship between both intentional and unintentional mind wandering as well as between both domains and depression and working memory. In order to justify these aims, we summarize below studies that emphasize relationship between mind wandering and depression and working memory. We also describe current knowledge regarding mind wandering in AD.

Research suggests unhappiness in particular (a core feature of depression) as a correlate of mind-wandering; also, research demonstrates a relationship between mind wandering and rumination and worry, two core symptoms of depression (3). The relationship between mind wandering and depression was reported to be bi-directional. Research provides evidence of mind wandering as a consequence of depression. For example, Smallwood, Fitzgerald (4) induced positive, neutral, and negative moods in participants prior to completing a sustained attention task in which mind wandering was evaluated by measuring the frequencies of both behavioral

lapses and subjective experience during the task. Compared to positive mood, the induction of negative mood resulted in more lapses and a high frequency of task-irrelevant thoughts. According to Smallwood, Fitzgerald (4), these results demonstrate that negative mood reduces the amount of attentional commitment to a task, probably by enhancing the focus on task irrelevant thoughts. Because AD is characterized by high rates of depression, we investigated whether it may be associated with high rates of mind wandering in the disease.

Besides investigating the relationship between mind wandering and depression, our study investigated the relationship between mind wandering and working memory in AD. Generally speaking, research suggests that executive function, which is closely related to working memory, may underlie mind wandering. According to Kane and McVay (5), individuals with good cognitive control succeed to limit their task-unrelated-thoughts when external task demands are high. Also, and according to Kane and McVay (5), working memory consistently predicts rates of task-unrelated thoughts during cognitively demanding activities; the authors further suggested that the assessments of task-unrelated thoughts during cognitive tasks can be a useful tool for informing researchers about executive control and working memory ability. Considering the relationship between mind wandering and working memory, we assessed this relationship in AD. Because AD has been widely associated with a compromise of working memory ability (6, 7), we investigated whether this compromise may be associated with high rates of mind wandering.

In a pioneer study, O'Callaghan, Shine (8) assessed mind wandering in AD. The authors asked AD patients to view static geometric shapes presented individually on a computer screen for 15 minutes. After the shapes were presented, patients had to report on their thoughts that arose during shapes presentation. Interestingly, O'Callaghan, Shine (8) assessed brain activity during this task to find that mind wandering was associated with decreased connectivity between

the posterior cingulate cortex and the dorsolateral prefrontal cortex. According to the authors, these findings support the engagement of the default network and frontoparietal network in mind wandering, and more specifically in autobiographical planning and mental simulation as engaged during mind wandering. Also, Gyurkovics, Balota (9) assessed mind wandering in patients with very mild AD as well as in a healthy middle-aged group and a healthy older adult group. In their study, Gyurkovics, Balota (9) assessed mind wandering with the Sustained Attention to Response Task on which participants are typically asked to press a key in response to frequently presented non-target stimuli, and to withhold the response to very infrequent target stimuli. Participants are also asked to report any mind wandering experience during the task. Using this task, Gyurkovics, Balota (9) found that the frequency of mind-wandering decreased as a function of age; the authors also observed a further decrease of mind wandering in AD patients. Although the studies of O'Callaghan, Shine (8) and Gyurkovics, Balota (9) have the merit to be the first published studies on mind wandering in AD, these studies did not dissociate between intentional and unintentional mind wandering. Further, these studies did not assess affective or working memory correlates of mind wandering in the disease.

To address the above-mentioned challenges, we evaluated intentional and unintentional mind wandering in AD. We also evaluated affective and working memory correlates of both mind wandering domains in AD.

Method

Participants

We recruited 30 participants with a clinical diagnosis of probable mild AD (20 women and 10 men; *M* age = 72.83 years, *SD* = 6.55; *M* years of formal education = 8.60, *SD* = 2.61)

and 33 control older adults (23 women and 10 men; *M* age = 73.45 years, *SD* = 7.89; *M* years of formal education = 9.73, *SD* = 2.92). The AD patients were recruited from local retirement homes and the diagnosis (i.e., probable AD) was made by an experienced neurologist or geriatrician according to the criteria developed by the National Institute on Aging and the Alzheimer's Association criteria for probable Alzheimer's disease (10). The control participants were independent and living at home, they were matched with the AD patients according to age [$t(61) = .34$, $p > .10$], sex [X^2 (1, $N = 63$) = .07, $p > .10$], and educational level [$t(63) = 1.61$, $p > .10$].

The exclusion criteria for all participants were significant neurological or psychiatric illness and alcohol or drug use. No participants presented any major visual or auditory acuity difficulties that could prevent assessment. All subjects freely consented to participate and were able to withdraw whenever they wished.

Cognitive characteristics

Scores are summarized in Table 1.General cognitive functioning was evaluated with the Mini Mental State Exam and the maximum score was 30 points. Episodic memory was evaluated with the episodic task of Grober and Buschke in which the participants had to retain 16 words, each describing an item belonging to a different semantic category. Immediate cued recall was followed by a distraction phase during which participants had to count backwards from 374 in 20 s. This distraction phase was followed by two minutes of free recall and the score from this phase provided a measure of episodic recall (16 points maximum). Working memory was evaluated with span tasks. Participants were asked to repeat a string of single digits in the same order (i.e., forward spans) or in reverse order (i.e., backward spans). Scores referred to number of correctly repeated digits. Depression was evaluated with the Hospital Anxiety and Depression Scale which

consists of seven items that were scored by participants on a four-point scale ranging from 0 (not present) to 3 (considerable); the maximum score was 21 points.

[INSERT TABLE1 HERE]

Mind wandering

Mind wandering was evaluated with a scale developed by Seli et al. (2, 11). The scale included eight items, half of which evaluating intentional mind wandering and the other half unintentional mind wandering. The four items evaluating intentional of mind wandering were: "I allow my thoughts to wander on purpose", "I enjoy mind-wandering", "I find mind-wandering is a good way to cope with boredom", and "I allow myself to get absorbed in pleasant fantasy". The items were scored on a seven-point Likert scale ranging from rarely (one point) to a lot (seven points) for items 1, 2, and 4; item 4 was evaluated on a scale ranging from not at all true (one point) to very true (seven points). The remaining four items of unintentional mind wandering were: "I find my thoughts wandering spontaneously", "When I mind-wander my thoughts tend to be pulled from topic to topic", "It feels like I don't have control over when my mind wanders", and "I mind-wander even when I'm supposed to be doing something else". These items were also scored using a seven-point Likert scale ranging from rarely (one point) to a lot (seven points) for Items 1, 2, and 4, and ranging from almost never (one point) to almost always (seven points) for Item 3. In both intentional and unintentional scales, participants were provided the following instruction: "Mind-wandering refers to the situation in which attention shifts away from what you are doing to thoughts unrelated to what you are doing. For the following items please select the degree that most accurately reflects your everyday mind wandering". We analyzed scores on the intentional and unintentional scales regarding means on

each scale, high scores indicated a higher a great tendency to engage in mind wandering in everyday life.

Results

We compared mean scores on the intentional and unintentional mind wandering scales between AD participants and controls. Non-parametrical tests were used due to abnormal distribution of variables. Between-group comparisons were performed using the Mann-Whitney U test and within-group comparisons were performed using the Wilcoxon signed rank test. We also assessed (Spearman) correlations between mind wandering, working memory span tasks, and depressions in AD participants and controls. Results were reported with effect size; $d = 0.2$ can be considered a small effect size, $d = 0.5$ represents a medium effect size and $d = 0.8$ refers to a large effect size. For all tests, level of significance was set as $p \leq 0.05$, p values between 0.051 and 0.10 was considered as trends, if any.

Differences in mind wandering between AD participants than in controls.

Mean scores on the intentional and unintentional mind wandering scales in AD participants and controls are described in Figure 1. Compared to controls, AD participants reported higher intentional ($Z = -4.09$, $p < .001$, Cohen's $d = 1.20$) and unintentional mind wandering ($Z = -3.23$, $p < .01$, Cohen's $d = .89$). Intentional and unintentional mind wandering were similar (not significantly different) in AD participants ($Z = -.44$, $p > .1$, Cohen's $d = .16$) and controls ($Z = -.20$, $p > .1$, Cohen's $d = .07$).

[INSERT FIGURE1 HERE]

Correlations between mind wandering and depression in AD participants and controls.

As illustrated in Table 1, positive significant correlations were observed between intentional and unintentional mind wandering in AD participants and controls. Positive correlations were also observed between both types of mind wandering and depression in AD participants and controls; in other words, high mind wandering was associated with high depression. No significant correlations were observed between mind wandering and working memory.

Complementary analysis.

We investigated whether intentional or unintentional mind wandering might contribute to episodic memory in AD patients. We carried out a stepwise regression analysis with intentional or unintentional mind wandering as predictors and episodic memory as dependent variable and found no significant contribution of intentional (β = .17, adjusted R^2 = .08, t = .89, p > .1) or unintentional mind wandering (β = .21, adjusted R^2 = .11, t = 1.01, p > .1) to episodic memory in AD. Regarding control participants, we carried out a stepwise regression analysis with both intentional or unintentional mind wandering as predictors and episodic memory as dependent variable and found no significant contribution of both mind wandering categories (β = .13, adjusted R^2 = .05, t = .89, p > .1) to episodic memory. We also investigated whether intentional or unintentional mind wandering might contribute to depression in AD patients. We carried out a stepwise regression analysis with intentional or unintentional mind as predictors and depression as dependent variable and found significant contribution of intentional (β = 1.15, adjusted R^2 = .31, t = 3.78, p < .001) and unintentional mind wandering (β = 1.11, adjusted R^2 = .29, t = 3.58, p < .01) to depression in AD. Regarding control participants, we carried out a stepwise

regression analysis with both intentional or unintentional mind wandering as predictors and depression as dependent variable and found significant contribution of both mind wandering categories (β = .82, adjusted R^2 = .41, t = 2.58, p < .05) to depression.

[INSERT TABLE2 HERE]

Discussion

We investigated intentional and unintentional mind wandering, as well as their relationship with depression and working memory, in AD. Compared to controls, AD participants reported higher rates of intentional and unintentional mind wandering. In AD participants and controls, intentional and unintentional mind wandering were significantly correlated with depression, but not with working memory.

Our main finding was the higher rates of intentional and unintentional mind wandering in AD participants than in controls. Thus, AD patients seem to demonstrate a tendency to shift from external stimuli to task-unrelated thoughts and concerns. Our findings can be compared with a recent study by Gyurkovics, Balota (9) who found that the frequency of mind-wandering decreased as a function of age; the authors also observed a further decrease of mind wandering in AD patients. These conflicting findings of Gyurkovics, Balota (9) and those observed in our study can be reconciled by emphasizing a crucial difference between our procedures and those used by Gyurkovics, Balota (9). In our study, participants' mind wandering was assessed using a scale describing everyday life situations, whereas Gyurkovics, Balota (9) used a laboratory task assessing mind wandering in the "here and now" (i.e., in the lab). Further, unlike our task, the Sustained Attention to Response Task requires more sustained attentional processing (e.g.,

retaining a stimuli, pressing the key) and, therefore, it may trigger less mind wandering than our scale in which patients had to reflect on their daily experiences. This said, our findings and those of Gyurkovics, Balota (9) demonstrate how mind wandering in AD can variate according to the assessment, in our view, AD patients may demonstrate increased mind wandering in everyday life and decreased mind wandering on tasks requiring sustained attention.

Our findings also demonstrated significant correlations between depression and mind wandering, mirroring a body of research suggesting unhappiness as a correlate of mind-wandering (12, 13). Research has also demonstrated that individuals with depressive symptoms have high levels of mind-wandering, findings that have been observed in clinically depressed individuals (14) and dysphoric individuals (15). In contrast, other studies described mind wandering as a consequence (but not a cause) depression as observed by Killingsworth and Gilbert (13) who collected real-time reports of mind-wandering and happiness from a large cohort to find that mood was lower after, than prior to, mind-wandering. Regardless of direction of this relationship, mind wandering seems to be intimately intertwined with depression, a relationship that may be mediated by mechanisms such as worry and rumination. The relationship between mind wandering and worry and rumination was evaluated by Ottaviani, Shapiro (16) who suggested that mind wandering becomes a rigid and inflexible mechanism, and therefore fails to serve its adaptive function and turns into a risk factor for mental health, whenever it takes the form of rumination or worry. This suggestion is of interest because rumination and worry have been typically described as a major symptomatology of depression as well as a vulnerability factors for the onset, maintenance, and recurrence of major depression disorder (17). In our view, rumination and worry, which are core characteristics of depression, could have influenced mind wandering in AD through the activation of negative thoughts and

memories, exacerbating mind wandering and increasing the likelihood that AD patients shift towards internal negative thoughts and concerns. Alternatively, patients with AD may view themselves more negatively than the controls, owing to this negative response bias, patients may demonstrate higher mind wandering and higher depression than controls. Future research can examine this possibility further by assessing negative aspects of mind wandering.

Unlike depression, no significant correlations were observed between mind wandering and working memory in AD participants or controls. These findings are at odds with research suggesting that executive function may underlie mind wandering (5), as well as research demonstrating a relationship between low working memory and the occurrence of mind wandering (18-21). For instance, Kane et al. (22, 23) have reported that more mind-wandering occurs in individuals with smaller working memory capacities, probably because failures in cognitive control may produce more mind-wandering (i.e., task-unrelated thoughts). This apparent inconsistency can be explained in terms of sample size which could have influenced, for instance, the reasonable, but non-significant, correlations between forward span and intentional mind wandering in AD participants. Another explanation is that we solely used span tasks, so future studies should assess the relationship between mind wandering and working memory using tests assessing a variety of working memory and executive functions. One executive function to be evaluated is inhibition (with Strrop taks). According to the inhibition theory (24), decline in cognitive performance in aging may reflect an inability to maintain task goals, thereby influencing working memory capacity and attentional control (for a similar view on AD, see (25). Therefore, deficits of inhibition may lead to processing of task-irrelevant thoughts rather than of the ingoing activity; this assumption leads to the prediction that inhibitory compromise in normal aging and AD may be associated with mind wandering. The involvement

of working memory in mind wandering may also depends on the characteristics of the task, for instance, Krimsky, Forster (26) found that mind wandering may vary as a function of both load and time on task.

Regarding control participants, there is a large body of research on mind wandering in normal aging. Research has consistently showed that older adults report less mind wandering than younger adults (2, 27-29). For instance, Krawietz, Tamplin (29) found less mind wandering in older adults than in younger adults. Mirroring our findings, mind wandering frequency was not related with working memory spans. In a similar vein, Shake, Shulley (30) evaluated age-related differences in mind wandering during texts reading. Older adults reported finding the texts more interesting than younger adults and also reported less mind wandering compared to young during texts reading. Age and text interest accounted for a significant amount of variance in mind wandering. Further, cognitive abilities (working memory, processing speed, vocabulary and inductive reasoning) did not account for variance in mind wandering once age and text interest were taken into account. The motivation account was also investigated by Seli, Maillet (2) who found that older adults were more motivated to perform a mind wandering task than young adults; interestingly, motivation levels were negatively associated with rates of unintentional mind wandering. These findings provide further support to the relationship between depression, typically resulting in a lack of motivation, and mind wandering in our control participants.

Several issues remain to be addressed about mind wandering in AD, such as the phenomenological aspects of mind wandering, such as the content and emotional experience of patients during mind wandering. Research may also assess whether mind wandering is oriented toward the past (e.g., memories) or future (e.g., projects or expectations). Research should also

focus on the relationship between mind-wandering and meta-awareness to underlet whether patients have enough awareness of the occurrence and content of mind wandering.

To summarize, mind wandering is still a poorly studied field and possibly a neglected phenomenon in AD. By addressing this issue, our study paves the way to better understand the subjective experience of AD patients who, as demonstrated by our results, seem to demonstrate a tendency to shift from external environment to internal thoughts and concerns. Further, studies on mind wandering in AD may explain why, despite effort to focus attention on what they are doing, AD patients' thoughts drift away from the task at hand.

Disclosure statement

The authors declare no conflict of interest.

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Figure 1.

The means on intentional mind wandering scale and unintentional mind wandering scale in Alzheimer's disease participants and controls; error bars are within a 95% confidence interval

Note. Scores ranged from one to seven points.