The subjective experience of mind wandering in Alzheimer's disease

Mohamad El Haj, Philippe Allain, Pascal Antoine, Karim Gallouj, Ahmed Moustafa, Véronique Quaglino, Jean Roche

Short title: Mind wandering

The subjective experience of mind wandering in Alzheimer's Disease

Mohamad EL HAJ [1, 2, 3]

Philippe ALLAIN [4]

Pascal ANTOINE [5]

Karim GALLOUJ [2]

Ahmed A. MOUSTAFA [6]

Véronique QUAGLINO [7]

Jean ROCHE [8]

[1] Nantes Université, Univ Angers, Laboratoire de Psychologie des Pays de la Loire (LPPL - EA 4638), F-44000 Nantes, France

[2] Unité de Gériatrie, Centre Hospitalier de Tourcoing, Tourcoing, France

[3] Institut Universitaire de France, Paris, France

[4] Laboratoire de Psychologie des Pays de la Loire, LPPL EA 4638, SFR Confluences, UNIV Angers, Nantes Université, Maison de la recherche Germaine Tillion, 5 bis Boulevard Lavoisier, 49045 Angers Cedex 01

[5] Univ. Lille, CNRS, CHU Lille, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000 Lille, France

[6] School of Social Sciences and Psychology & Marcs Institute for Brain and Behaviour, Western Sydney University, Sydney, Australia

[7] CRP-CPO, EA 7273, Université de Picardie Jules Verne, Amiens, France

[8] CHU de Lille, Unité de Psychogériatrie, Pôle de Gérontologie, F-59037 Lille, France

Correspondence concerning this manuscript should be addressed to: Mohamad EL HAJ, Faculté de Psychologie, LPPL – Laboratoire de Psychologie des Pays de la Loire, Université de Nantes, Chemin de la Censive du Tertre, BP 81227, 44312 Nantes Cedex 3, France. E-Mail: mohamad.elhaj@univ-nantes.fr

Authors' emails

philippe.allain@univ-angers.fr

pascal.antoine@univ-lille.fr

karim.gallouj@chu-tourcoing.fr

A.Moustafa@westernsydney.edu.au

veronique.quaglino@u-picardie.fr

Jean.ROCHE@chru-lille.fr

Abstract

Introduction: Little is known about mind wandering in Alzheimer's disease (AD). In this study, we evaluated the subjective experience of mind wandering in AD.

Methods: We invited AD patients and control participants to rate the occurrence, intentionality, emotionality, visual imagery, specificity, self-relatedness and temporal orientation of mind wandering.

Results: Analysis showed that AD patients rated their mind wandering as more frequent, negative, and more oriented toward the past, but less vivid and specific than that of control participants. No significant differences were observed between AD patients and control participants regarding the intentionality or self-relatedness of mind wandering.

Conclusions: These findings demonstrate the negative content in AD. Regarding the reduction of visual imagery and specificity during mind wandering, this reduction may mirror a diminished subjective experience of mind wandering in AD. Regarding temporality, our results may reflect a tendency of AD patients to reminisce over past experiences. Finally, mind wandering in AD seems to trigger significant self-related content.

Key words*:* Alzheimer's Disease; mind wandering; subjective experience;

Introduction

Mind wandering, which is the tendency to withdraw from the immediate external environment to generate internally driven thoughts (Smallwood, Fitzgerald, Miles, & Phillips, 2009; Smallwood & Schooler, 2015), has been a topic of burgeoning interest in the fields of psychology and neuroscience in recent years. When performing automatic or redundant activities, our mind may wander towards memories, present concerns, future plans, or other thoughts which are not directly related to task at hand. While mind wandering content typically arises from episodic and affective mechanism, its regulation relies on working memory and executive control (McVay & Kane, 2009; Smallwood & Schooler, 2015). Converging evidence suggests that we spend approximately half of our waking time in mind wandering (Killingsworth & Gilbert, 2010). This amount of time is not purposeless as mind wandering can enhance our emotional state and our ability to engage in problem solving, planning, decision making and self-reflection. While it has been extensively studied in healthy older adults, little research evaluated mind wandering in patients with Alzheimer's disease (AD). This issue is important for two reasons. First, research on mind wandering in AD may help determine whether patients are able to withdraw from the constraints of the here-and-now to wander toward internal thoughts. Second, such research may help understand what the characteristics of these thoughts are in AD. Building on these considerations, we evaluated the occurrence and subjective characteristics of mind wandering in AD.

In a pioneer study on mind wandering in AD, O'Callaghan, Shine, Hodges, Andrews-Hanna, and Irish (2019) invited AD patients and control participants to view static geometric shapes presented on a computer screen. Participants were also invited to report any mind wandering experience during this task. Results demonstrated no significant difference between

AD patients and control participants regarding the occurrence of mind wandering. Results also demonstrated an association between mind wandering and decreased connectivity between the dorsolateral prefrontal cortex and the posterior cingulate cortex in AD. O'Callaghan et al. (2019) attributed this brain activity to the engagement of the default and frontoparietal network in cognitive processes such as autobiographical thinking and mental simulation during mind wandering. Mind wandering in AD was also evaluated by Gyurkovics, Balota, and Jackson (2018) who invited AD patients and control participants to press a key in response to frequently presented non-target stimuli, and to withhold their response to infrequent target stimuli. Participants were also invited to report any mind wandering experience during this task. Results demonstrated a decrease in mind wandering in AD compared with control participants. In another study on mind wandering in AD, El Haj, Antoine, et al. (2019) evaluated differences between intentional (i.e., voluntary) and unintentional (i.e., involuntary) mind wandering using a self-rated scale. Results showed higher intentional and unintentional mind wandering in AD patients than in control participants.

While the above-mentioned research has evaluated the occurrence and intentionality of mind wandering, other characteristics of mind wandering are yet to be evaluated in AD. Accordingly, in this study, we invited AD patients and control participants to rate not only the occurrence and intentionality but, critically, emotionality, visual imagery, specificity, self-relatedness, and temporal orientation of mind wandering. We evaluated these characteristics based on the above-mentioned literature in AD (El Haj, Antoine, et al., 2019; Gyurkovics et al., 2018; O'Callaghan et al., 2019). Regarding emotion, studies have shown that inducing negative mood increases mind-wandering (Smallwood, Fitzgerald, et al., 2009) and vice versa, how emotionally-negative mind wandering increases negative mood (Killingsworth & Gilbert, 2010).

As AD has been widely associated with depression (Chi, Yu, Tan, & Tan, 2014), we predicted our patients to show negative content of mind wandering.

Besides the emotionality of mind wandering, we evaluated the richness of visual imagery during mind wandering in AD. Research has demonstrated that this subjective process is typically reduced in AD. For instance, a study on autobiographical memory (i.e., the ability to retrieve personal information) has demonstrated a decreased subjective experience during memory retrieval in AD patients, especially regarding visual imagery (El Haj, Kapogiannis, & Antoine, 2016). In a similar vein, a study reported a relationship between the decline of autobiographical memory and the ability to retrieve and manipulate mental images in AD (El Haj, Gallouj, & Antoine, 2019). Visual imagery has not been only associated with the reduced ability to retrieve past events but also with the reduced ability to imagine future events in AD (El Haj, Moustafa, Gallouj, & Robin, 2019; Moustafa & El Haj, 2018). The reduced ability to construct both past and future events in AD has been demonstrated by research showing decreased ability to produce semantic and episodic information during past and future thinking (Addis, Sacchetti, Ally, Budson, & Schacter, 2009) (for a review, see (Irish & Piolino, 2016). Taken together, research demonstrates a reduced ability of AD patients to construct visual images during the retrieval of past events and imagining of future scenarios. Therefore, we predicted a reduced visual imagery during mind wandering in AD.

As mentioned above, visual imagery has been associated with difficulties to construct specific events in AD (El Haj, Moustafa, et al., 2019). We therefore investigated the specificity of mind wandering in AD. This aim was also inspired by research demonstrating autobiographical overgenerality in AD patients, that is, reduced ability of patients to retrieve specific past events situated in time and space (El Haj et al., 2015, 2017). Difficulties to retrieve

specific events have been considered as the main feature of decline of both past thinking (El Haj et al., 2015, 2017) and future thinking in AD (El Haj, Antoine, & Kapogiannis, 2015a, 2015b). Difficulties to retrieve specific events have been even considered as a main marker of the cognitive decline in AD (Grilli, Wank, Bercel, & Ryan, 2018). Considering the difficulties of AD patients to construct specific past and future events, we expected difficulties to construct specific events and thoughts during mind wandering in AD. Besides specificity, we evaluated self-relatedness of mind wandering. In other words, we evaluated whether AD patients process self-related events and thoughts during mind wandering. We evaluated self-relatedness in light of research demonstrating that, despite the diminished sense of self (El Haj et al., 2015, 2017), AD patients may demonstrate high processing of self-related information. For instance, research has demonstrated beneficial effects of self-reference on recognition memory in AD (Kalenzaga, Bugaiska, & Clarys, 2013; Kalenzaga & Clarys, 2013). Building on this research, we expected that AD patients would rate events and thoughts experienced during mind wandering as self-related.

Besides occurrence, intentionality, emotionality, visual imagery, specificity and self-relatedness, we also evaluated the temporal orientation of mind wandering. Generally speaking, mind wandering can be oriented toward the past, present, or future (Smallwood, Nind, & O'Connor, 2009). While past-oriented mind wandering may allow for the reappraisal of previous situations (i.e., counterfactual thinking) (Barbey, Krueger, & Grafman, 2009; Epstude & Roese, 2008), future-oriented mind wandering may allow planning and decision making (Webb & Sheeran, 2006). Future mind wandering is typically more cognitively taxing than past mind wandering, as it is associated with high cognitive resources, such as prospecting, planning,

integration of past experiences (Smallwood, Fitzgerald, et al., 2009). Therefore, due to cognitive decline, we expected less future-oriented than past-oriented mind wandering in AD.

To summarize, while previous research has assessed the occurrence and intentionality of mind wandering in AD (El Haj, Antoine, et al., 2019; Gyurkovics et al., 2018; O'Callaghan et al., 2019), little is known about other characteristics (i.e., emotionality, visual imagery, specificity, self-relatedness, and temporal orientation). We therefore invited AD patients and control participants to rate all these characteristics. We expected that, compared with control participants, AD patients would rate their mind wandering as more frequent, unintentional and negative, but triggering few visual imagery and specificity. We also expected that mind-wandering would trigger more self-related and past-oriented content in AD patients than in control participants. Regarding temporality, we expected less future-oriented than past-oriented mind wandering in AD.

Method

Participants

The study included 32 participants with a clinical diagnosis of probable mild AD (19 women and 13 men; *M* age = 71.32 years, *SD* = 6.33, *range* = 63-82; *M* years of formal education = 8.02, *SD* = 2.26, *range* = 5-15) and 35 control older adults (22 women and 13 men; *M* age = 72.16 years, *SD* = 7.33, *range* = 60-86; *M* years of formal education = 8.66, *SD* = 2.54, *range* = 6-16). The AD patients were recruited from local retirement homes and the diagnosis was made by an experienced geriatrician or neurologist based on criteria developed by the National Institute on Aging and the Alzheimer's Association criteria for probable Alzheimer's disease (McKhann et al., 2011). The control participants were independent and living at home

and were matched with the AD patients according to sex [X^2 (1, N = 67) = .08, p > .10], age [t(65)=.50, p >.10], and educational level [t(65) =1.08, p > .10]. For all participants, exclusion criteria were significant neurological or psychiatric illness and alcohol or drug use. Participants presented no major visual or auditory acuity difficulties that could prevent assessment. They freely consented to participate and were able to withdraw whenever they wished.

To evaluate cognitive performances of participants, we assessed general cognitive functioning using the Mini Mental State Exam and the maximum score was 30 points [*M* AD patients = 22.02, *SD* = 1.52, *range* = 20-24, *M* control participants= 28.12, *SD* = 1.11, *range* = 26-30 t(65)= 18.87, p < .001]. We evaluated verbal episodic memory with the episodic task of Grober and Buschke (Grober & Buschke, 1987) 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) [*M* AD patients = 5.82, *SD* = 2.41, *range* = 2-9, *M* control participants = 10.55, *SD* = 2.65, *range* = 6-14, t(65) = 7.62, p< .001]. We evaluated working memory using span tasks, in which 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 [forward spans: *M* AD patients = 5.01, *SD* = 1.12, *range* = 3-8, *M* control participants = 6.21, *SD* = 1.58, *range* = 3-9, t(65) = 3.45, p < .001; backward spans: *M* AD patients = 3.62, *SD* = 1.44, *range* = 2-5, *M* control participants = 5.33, *SD* = 1.32, t(65) = 5.07, *range* = 3-7, p < .001].

Mind Wandering Questionnaire

After the cognitive assessments, each participant was provided with a printed-questionnaire. The questionnaire began with the following definition, inspired by general definitions of mind wandering (Smallwood, Nind, et al., 2009; Smallwood & Schooler, 2015) : "Mind wandering is a term used to describe what happens when your attention shifts from what you are doing. When your mind wanders, you typically think about your past, your future, or present concerns rather than your current task. Furthermore, your mind can wander when you are tired or bored and you do not really know what you are thinking about but all you know is that you are no longer thinking about what you are doing". The participants were then invited to rate (written or verbally) the following seven items:

- Item1- Mind wandering occurs 1 "never", 2 "rarely", 3 "occasionally", 4 "sometimes" or 5 "frequently"
- Item2- Mind wandering occurs 1 "not at all voluntary", 2 "slightly voluntary", 3 "voluntary", 4 "very voluntary" or 5 "totally voluntary".
- Item3- The content of mind wandering is 1 "very negative", 2 "negative", 3 "neutral", 4 "positive" or 5 "very positive".
- Item4- The content of mind wandering is: 1 "not at all clear", 2 "slightly unclear", 3 "clear", 4 "very clear" or 5 "totally clear".
- Item5- The content of mind wandering is 1 "not at all specific", 2 "slightly specific", 3 "specific", 4 "very specific" or 5 "totally specific".
- Item6- The content of mind wandering is 1 "not at all self-related", 2 "slightly self-related", 3 "self-related", 4 "very self-related" or 5 "totally self-related".
- Item7- The content of mind wandering is oriented toward the past, present, or future.

For all items, we provided examples when needed. For instance, when needed, we explained that clarity refers the ability to see the thoughts in the mind eyes. For another participant, we explained that specificity refers to the amount of information that she could remember about the thoughts.

Statistical analyses

We compared differences between AD patients and control participants on the occurrence, intentionality, emotionality, visual imagery, specificity, and self-relatedness using Mann-Whitney's U test. We used this non parametric test due to the scale nature of variables and their non-normal distribution. Regarding the temporality of mind wandering, we investigated differences regarding the number of AD patients and control participants who considered their mind wandering as past- present- or future-oriented. We compared these differences with Chi square tests, more specifically, with an online calculator provided by Preacher (2001). We used Chi square test because data was categorical, that is, participants had to choose between three categories: past, present or future. We also reported effect size: d = .2 can be considered as a small effect size, d = .5 a medium effect size and d = .8 a large effect size (Cohen, 1988). Note that effect size was calculated for non-parametric tests according to the recommendations of Rosenthal and DiMatteo (2001) and Ellis (2010).

Results

Negative and little vivid/specific mind wandering in AD.

As shown in Table1, and compared to control participants, AD patients rated their mind wandering as more frequent ($Z = -3.83$, $p < .001$, Cohen's $d = 1.06$). Regarding intentionality, no

significant differences were observed between AD patients and controls (Z = -.47, $p > .1$, Cohen's $d = .11$). Further, and compared to control participants, AD patients rated their mind wandering as more negative (Z= -5.81, $p < .001$, Cohen's $d = 2.01$), and triggering less visual imagery (Z= -4.26, $p < .001$, Cohen's $d = 1.22$) and less specificity (Z = -4.73, $p < .001$, Cohen's $d = 1.41$). Regarding self-relatedness, no significant differences were observed between AD patients and controls (Z = -.73, $p > .1$, Cohen's $d = .18$).

INSERT TABLE1 APROXIMATELY HERE

Past-oriented mind wandering in AD.

As shown in Table 2, no significant differences between were observed between AD patients and controls regarding the total number of memories [$\chi(1, N = 67) = .13$, $p > .01$, Cohen's $d = .09$]. However, compared to controls, AD patients demonstrated more past-oriented [$\chi(1, N = 27) = 4.48$, $p < .05$, Cohen's $d = .89$] but less present-oriented [$\chi(1, N = 27) = 6.26$, $p < .05$, Cohen's $d = 1.09$] mind wandering. No significant differences were observed between the two populations regarding future-oriented mind wandering [$\chi(1, N = 13) = .07$, $p > .01$, Cohen's $d = .14$]. AD patients demonstrated more past-oriented than present-oriented [$\chi(1, N = 26) = 5.54$, $p < .05$, Cohen's $d = 1.04$] or future-oriented mind wandering [$\chi(1, N = 25) = 6.76$, $p < .01$, Cohen's $d = 1.22$], but no significant differences between present-oriented and future-oriented mind wandering [$\chi(1, N = 13) = .07$, $p > .01$, Cohen's $d = .15$]. Control participants demonstrated more present-oriented than past-oriented [$\chi(1, N = 28) = 5.14$, $p < .06$, Cohen's $d = .94$] or future-oriented mind wandering [$\chi(1, N = 27) = 6.26$, $p < .05$, Cohen's $d = 1.10$] but no significant differences between past-oriented and future-oriented mind wandering [$\chi(1, N = 15) = .07$, $p > .1$, Cohen's $d = .13$].

INSERT TABLE2 APROXIMATELY HERE

Complementary analysis.

We investigated correlations between scores on the seven items of the mind wandering scale and scores on the Mini Mental State Exam, Grober and Buschke task, and span tasks. No significant correlations were observed between any of the mind wandering items and scores of these of tests ($p > .1$).

Discussion

In this study, we evaluated the phenomenological experience of mind wandering in AD. Compared to control participants, AD patients rated their mind wandering as more frequent. No significant differences were observed between the two populations regarding intentionality. Compared with control participants, AD patients also rated mind wandering as more negative but less vivid and specific. Regarding self-relatedness, no significant differences were observed between the two populations. Finally, mind wandering was mainly past-oriented in AD patients but present-oriented in control participants.

First, we will discuss the occurrence of mind wandering. Mind wandering was rated as occurring more frequently by AD patients than by control participants. In other words, AD patients demonstrated a tendency to shift from external stimuli to task-unrelated thoughts and concerns. These findings mirror previous research demonstrating high occurrence of mind wandering in AD (El Haj, Antoine, et al., 2019). These findings disagree with the study of O'Callaghan et al. (2019) who reported no significant differences between AD patients and control participants regarding the occurrence of mind wandering, and also with the study of Gyurkovics et al. (2018) who reported a decrease of mind wandering in AD patients compared

with control participants. These conflicting findings can be reconciled by emphasizing the laboratory-based task as used by O'Callaghan et al. (2019) and Gyurkovics et al. (2018). This kind of tasks (e.g., Sustained Attention to Response Task) requires more sustained attentional processing (e.g., retaining a stimulus, pressing the key) than our questionnaire. Furthermore, these laboratory-based tasks assess mind wandering in the "here and now" (i.e., in the lab) unlike our questionnaire in which patients can reflect on their daily experiences. These seemingly conflicting findings demonstrate how mind wandering in AD can vary according to the nature of assessment, more specifically, and as demonstrated in our study, AD patients may demonstrate increased mind wandering on tasks reflecting everyday life and decreased mind wandering on laboratory-tasks. Another explanation may be that, while control participants were living at home, AD patients were institutionalized which may limit the type of tasks or activities the patients could participate in, resulting in the high occurrence of mind wandering in these patients.

Unlike the significant differences between AD patients and control participants on the occurrence of mind wandering, no significant differences were observed regarding intentionality. In other words, both populations described their mind wandering as involuntary. Generally speaking, there are two categories of mind wandering: voluntary and involuntary. While voluntary mind wandering involves intentional engagement of consciousness experience toward intrinsic sources, involuntary mind wandering involves unintentional engagement of consciousness experience toward these sources (Giambra, 1993; Seli, Maillet, Smilek, Oakman, & Schacter, 2017). The involuntary nature of mind wandering as observed in our study can mirror difficulties of AD patients to inhibit unwanted thoughts (Amieva, Phillips, Della Sala, & Henry, 2004; El Haj, 2016), resulting in the shift from external stimuli to task-unrelated thoughts

and concerns (i.e., mind wandering). In our view, an important challenge for AD patients is to maintain attention on the ongoing task and to process task-relevant information; due to inhibitory failures, AD patients experience difficulties to suppress internal thoughts which results in the involuntary pop-out of these thoughts at the expense of the ongoing task. The same thing can be said for controls as older adults generally demonstrate deficits in inhibition (Hasher, Lustig, & Zacks, 2007; Hasher & Zacks, 1988), and more specifically, difficulties to intentionally suppress irrelevant information (Collette, Germain, Hogge, & Van der Linden, 2009; El Haj, Fasotti, & Allain, 2015; Zacks, Radvansky, & Hasher, 1996)

Another finding of our study was that, compared to control participants, AD patients rated their mind wandering as more negative. This outcome mirrors research in general populations suggesting unhappiness as a correlate of mind-wandering (Killingsworth & Gilbert, 2010; Smallwood & O'Connor, 2011). Research has also associated mind wandering with depressive symptoms (Carriere, Cheyne, & Smilek, 2008; Watts, MacLeod, & Morris, 1988). Regarding AD, the negative content of mind wandering is not surprising given the high levels of depression in the disease (Chi et al., 2014). The negative content of mind wandering may thus be associated with some depressive symptomatology such as rumination or worry. Rumination or worry may influence mind wandering in AD through the activation of negative memories and/or thoughts, exacerbating the content of mind wandering and increasing the likelihood that AD patients shift towards internal negative thoughts and concerns.

Besides reporting negative content, AD patients described their mind wandering as triggering little vividness and specificity. These findings are important as they demonstrate, for the first time, how the decreased vividness and specificity in AD, as typically observed for autobiographical memory, can also be observed for mind wandering. The ability to construct and

manipulate mental images (i.e., visual imagery) has been considered as a main feature of the subjective experience of internal states (Kosslyn, Ganis, & Thompson, 2001), therefore, any compromise of visual imagery may lead to diminished subjective experience during mind wandering. In our view, the decline of visual imagery during mind wandering in AD mirrors not only difficulties of patients to construct and manipulate mental images during these mental states, but also their difficulties to generate real-life three-dimensional quality images of the constructed events and thoughts. In other words, it is likely that, during mind wandering, AD patients may see the constructed events and thoughts as a spectator would (i.e., third person perspective) rather than through their own eyes (i.e., first person perspective). This assumption can be supported by research demonstrating difficulties of AD patients to construct a first person perspective during past and future thinking (El Haj, Moustafa, et al., 2019). Another explanation for the little vividness of mind wandering in AD, as observed in this study, is that AD patients may construct visual images resembling static snapshots akin to photographs or hazy images rather than specific images. This assumption can be supported by the fact that, in our study, AD patients rated their mind wandering as triggering little specificity. While this lack of specificity has been typically observed for autobiographical memory in AD (El Haj, Antoine, Nandrino, & Kapogiannis, 2015; El Haj, Roche, Gallouj, & Gandolphe, 2017), this is, to our knowledge, the first paper to investigate and report the lack of specificity during mind wandering in AD. Together, the decrease of visual imagery and specificity during mind wandering in AD may mirror a diminished subjective experience of these internal thoughts in the disease.

Another finding of our study was the lack of significant differences between AD patients and control participants regarding self-relatedness as both populations have considered mind wandering as triggering self-related content. Despite a general diminished sense of self in AD,

AD patients tend to demonstrate high processing of self-related information. For instance, research has demonstrated beneficial effects of self-reference on recognition memory in AD (Kalenzaga et al., 2013; Kalenzaga & Clarys, 2013). Research has also demonstrated that despite diminished subjective experience during autobiographical retrieval, AD patients consider the retrieved memories as self-related (El Haj & Antoine, 2017). Research has also demonstrated that despite diminished autobiographical memory, patients with mild AD may demonstrate significant access to self-defining memories (El Haj, Antoine, Nandrino, et al., 2015), that is, events that are vivid, specific, emotionally intense, and which include enduring concerns about oneself (Singer & Blagov, 2002). Together, research has demonstrated a preference for processing self-related information in AD which may explain why, in our study, AD patients have described mind wandering as triggering self-related content.

Regarding temporality, mind wandering was mainly past-oriented in AD patients but present-oriented in control participants. The past-oriented temporality in AD may reflect a tendency of patients to reminisce over past experience or even to retrieve these events to deal with current problems. Besides this problem-solving strategies, past-oriented mind wandering may allow patients an escape from monotonous situations, or even from boredom, by reflecting on the past. AD patients, especially those institutionalized, tend to complain about monotony, boredom, and time stagnation (El Haj, Jardri, Laroi, & Antoine, 2016). Therefore, mind wandering may help patients to cope with this boredom or even to fulfil their need to cope with the cycle of emptiness. Unlike AD patients, mind wandering in control participants was mainly present-oriented. In our view, these findings are important as they reflect shifts in mood and goals from normal aging to AD. Older adults typically report a present-moment focus characterized by a preference to process positive information (Carstensen, Isaacowitz, & Charles,

1999). The socioemotional selectivity theory stipulates that healthy older adults prioritize their present moment experience over past or future experiences due to their shrinking ‘temporal horizon’ (Carstensen et al., 1999; Carstensen et al., 2011).

While our study mainly deals with the subjective experience of mind wandering it would be of interest to discuss some neurological research that may provide better understanding of mind wandering in AD. In general populations, mind wandering has been associated with activity in the default network (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011). This brain network includes regions in the prefrontal, temporal, and parietal areas, which converge on core midline hubs in the posterior cingulate and anteromedial prefrontal area (Andrews-Hanna, Reidler, Sepulcre, Poulin, & Buckner, 2010). While the precise functions of the default network remain a matter of debate, this network seems to support internal mentation such as memory-based processes, mainly through the medial temporal lobe, and introspection about mental states, mainly through the dorsal medial prefrontal cortex (Andrews-Hanna et al., 2010). Strong resting state functional connectivity within the default network has been associated with high occurrence of spontaneous thought and engagement in mind wandering (Yang, Bossmann, Schiffhauer, Jordan, & Immordino-Yang, 2012). In normal aging, the frequency of mind wandering was found to be associated with a reduced connectivity between medial temporal lobe regions and core/midline default network hubs (O'Callaghan, Shine, Lewis, Andrews-Hanna, & Irish, 2015). According to O'Callaghan et al. (2015), this reduced connectivity may result in a state where internally generated thought, underpinned by medial temporal lobe regions, are disengaged from the control of other default network regions, and are thus subject to less external influence from those regions. This assumption is interesting because medial temporal lobe regions are

preferentially targeted by the neuropathology of AD, decreasing their connectivity with other regions the default network (Pennanen et al., 2004) which may result in a disengagement of internally guided thoughts from influences of these regions and, consequently, mind wandering.

One shortcoming of our paper may be that participants had only the choice between past, present, and future orientation without other options. These options are important because mind wandering may not be solely oriented toward a specific time-perspective (e.g., past) but also toward a combination of time perspectives (e.g., past and present). Future research should address this issue by offering a variety of time-perspective options, even an "atemporal" one. Another shortcoming of our paper may be that frequency and characteristics of mind wandering were not measured in our study via in-the-moment probes but via questionnaire that required participants to give a retrospective estimate of their usual level of mind wandering based on their memory. Regarding our correlation analyses, and although no significant correlations were observed between mind wandering and general cognitive function, this lack of significant effects should be considered with some caution as the severity of cognitive impairment may contribute to mind wandering in AD, especially that cognitive changes can distrust spontaneous, self-generated though in dementia (O'Callaghan & Irish, 2018). To better understand the relationship between mind wandering and cognitive dysfunction in AD, future research can compare mind wandering between patients in mild vs. moderate or severe AD. Future research may also consider the potential role of memory difficulties, or even patients' insight into their own mental processes. While lack of insight is a key challenge for any study on the subjective experience in general, one should consider potential effects of lack of insight on patients' responses, especially that AD is characterized by anosognosia (i.e., lack of insight) (Agnew & Morris, 1998; Morris & Mograbi, 2013).

To summarize, by assessing phenomenology of mind wandering in AD, our study highlights how mind wandering is more than simple attentional lapses or distraction but rather a redirection of attention away from the ongoing task towards the processing of a complex set of subjective experiences, concerns, and goals processing in AD. By doing this, our study offers an original window into the richness of the subjective experience of mind wandering in AD. By emphasizing this experience, we hope that our study will contribute to a shift of attention from the solely study of how mental processing is diminished in AD towards the study of the way patients experience their internal world.

Acknowledgments

The study was supported by the LABEX (excellence laboratory, program investment for the future) DISTALZ (Development of Innovative Strategies for a Transdisciplinary Approach to Alzheimer Disease) and the EU Interreg 2 Seas Programme 2014-2020 (co-funded by the European Regional Development Fund).

References

Addis, D. R., Sacchetti, D. C., Ally, B. A., Budson, A. E., & Schacter, D. L. (2009). Episodic simulation of future events is impaired in mild Alzheimer's disease. *Neuropsychologia, 47*(12), 2660-2671.

Agnew, S. K., & Morris, R. G. (1998). The heterogeneity of anosognosia for memory impairment in Alzheimer's disease: A review of the literature and a proposed model. *Aging Ment Health, 2*(1), 7-19. doi: 10.1080/13607869856876

Amieva, H., Phillips, L. H., Della Sala, S., & Henry, J. D. (2004). Inhibitory functioning in Alzheimer's disease. *Brain, 127*(Pt 5), 949-964. doi: 10.1093/brain/awh045

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron, 65*(4), 550-562. doi: 10.1016/j.neuron.2010.02.005

Barbey, A. K., Krueger, F., & Grafman, J. (2009). Structured event complexes in the medial prefrontal cortex support counterfactual representations for future planning. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 364*(1521), 1291-1300. doi: 10.1098/rstb.2008.0315

Carriere, J. S., Cheyne, J. A., & Smilek, D. (2008). Everyday attention lapses and memory failures: the affective consequences of mindlessness. *Consciousness and Cognition, 17*(3), 835-847. doi: 10.1016/j.concog.2007.04.008

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously. A theory of socioemotional selectivity. *American Psychologist, 54*(3), 165-181.

Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H., Samanez-Larkin, G. R., . . . Nesselroade, J. R. (2011). Emotional experience improves with age: evidence

based on over 10 years of experience sampling. *Psychology and Aging, 26*(1), 21-33. doi: 10.1037/a0021285

Chi, S., Yu, J. T., Tan, M. S., & Tan, L. (2014). Depression in Alzheimer's disease: epidemiology, mechanisms, and management. *Journal of Alzheimer's Disease, 42*(3), 739-755. doi: 10.3233/JAD-140324

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proceedings of the National Academy of Sciences of the United States of America, 106*(21), 8719-8724. doi: 10.1073/pnas.0900234106

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum Associates.

Collette, F., Germain, S., Hogge, M., & Van der Linden, M. (2009). Inhibitory control of memory in normal ageing: dissociation between impaired intentional and preserved unintentional processes. *Memory, 17*(1), 104-122. doi: 10.1080/09658210802574146

El Haj, M. (2016). Memory suppression in Alzheimer's disease. *Neurological Sciences, 37*(3), 337-343. doi: 10.1007/s10072-015-2441-5

El Haj, M., & Antoine, P. (2017). Discrepancy between subjective autobiographical reliving and objective recall: The past as seen by Alzheimer’s disease patients. *Consciousness and Cognition, 49*, 110-116. doi: http://dx.doi.org/10.1016/j.concog.2017.01.009

El Haj, M., Antoine, P., & Kapogiannis, D. (2015a). Flexibility decline contributes to similarity of past and future thinking in Alzheimer's disease. *Hippocampus, 25*(11), 1447-1455. doi: 10.1002/hipo.22465

El Haj, M., Antoine, P., & Kapogiannis, D. (2015b). Similarity between remembering the past and imagining the future in Alzheimer's disease: Implication of episodic memory. *Neuropsychologia, 66*(0), 119-125. doi: 10.1016/j.neuropsychologia.2014.11.015

El Haj, M., Antoine, P., Moustafa, A. A., Roche, J., Quaglino, V., & Gallouj, K. (2019). Off-track thoughts: Intentional and unintentional mind wandering in Alzheimer's disease. *Geriatr Gerontol Int*. doi: 10.1111/ggi.13613

El Haj, M., Antoine, P., Nandrino, J. L., & Kapogiannis, D. (2015). Autobiographical memory decline in Alzheimer's disease, a theoretical and clinical overview. *Ageing Res Rev, 23*(Pt B), 183-192. doi: 10.1016/j.arr.2015.07.001

El Haj, M., Fasotti, L., & Allain, P. (2015). Directed forgetting of source memory in normal aging and Alzheimer's disease. *Aging Clinical and Experimental Research, 27*(3), 329-336. doi: 10.1007/s40520-014-0276-1

El Haj, M., Gallouj, K., & Antoine, P. (2019). Mental imagery and autobiographical memory in Alzheimer’s disease. *Neuropsychology*.

El Haj, M., Jardri, R., Laroi, F., & Antoine, P. (2016). Hallucinations, loneliness, and social isolation in Alzheimer's disease. *Cognitive Neuropsychiatry, 21*(1), 1-13. doi: 10.1080/13546805.2015.1121139

El Haj, M., Kapogiannis, D., & Antoine, P. (2016). Phenomenological Reliving and Visual Imagery During Autobiographical Recall in Alzheimer's Disease. *Journal of Alzheimer's Disease, 52*(2), 421-431. doi: 10.3233/JAD-151122

El Haj, M., Moustafa, A. A., Gallouj, K., & Robin, F. (2019). Visual imagery: The past and future as seen by patients with Alzheimer’s disease. *Consciousness and Cognition, 68*, 12-22. doi: https://doi.org/10.1016/j.concog.2018.12.003

El Haj, M., Roche, J., Gallouj, K., & Gandolphe, M. C. (2017). Autobiographical memory compromise in Alzheimer's disease: a cognitive and clinical overview. *Gériatrie et Psychologie Neuropsychiatrie du Vieillissement, 15*(4), 443-451. doi: 10.1684/pnv.2017.0704

Ellis, P. D. (2010). *The Essential Guide to Effect Sizes: Statistical Power, Meta-Analysis, and the Interpretation of Research Results.* New York, NY: Cambridge University Press.

Epstude, K., & Roese, N. J. (2008). The functional theory of counterfactual thinking. *Personality and Social Psychology Review, 12*(2), 168-192. doi: 10.1177/1088868308316091

Giambra, L. M. (1993). The influence of aging on spontaneous shifts of attention from external stimuli to the contents of consciousness. *Experimental Gerontology, 28*(4-5), 485-492.

Grilli, M. D., Wank, A. A., Bercel, J. J., & Ryan, L. (2018). Evidence for Reduced Autobiographical Memory Episodic Specificity in Cognitively Normal Middle-Aged and Older Individuals at Increased Risk for Alzheimer's Disease Dementia. *Journal of the International Neuropsychological Society*, 1-11. doi: 10.1017/S1355617718000577

Grober, E., & Buschke, H. (1987). Genuine memory deficits in dementia. *Developmental Neuropsychology, 3*(1), 13-36.

Gyurkovics, M., Balota, D. A., & Jackson, J. D. (2018). Mind-wandering in healthy aging and early stage Alzheimer's disease. *Neuropsychology, 32*(1), 89-101. doi: 10.1037/neu0000385

Hasher, L., Lustig, C., & Zacks, R. (2007). Inhibitory mechanisms and the control of attention. *Variation in working memory*, 227-249.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension and aging: A review and a new view. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation* (pp. 193-225). New York: Academic Press.

Irish, M., & Piolino, P. (2016). Impaired capacity for prospection in the dementias--Theoretical and clinical implications. *British Journal of Clinical Psychology*, *55*(1), 49-68. doi: 10.1111/bjc.12090

Kalenzaga, S., Bugaiska, A., & Clarys, D. (2013). Self-reference effect and autonoetic consciousness in Alzheimer disease: evidence for a persistent affective self in dementia patients. *Alzheimer Disease and Associated Disorders, 27*(2), 116-122. doi: 10.1097/WAD.0b013e318257dc31

Kalenzaga, S., & Clarys, D. (2013). Self-referential processing in Alzheimer's disease: two different ways of processing self-knowledge? *Journal of Clinical and Experimental Neuropsychology, 35*(5), 455-471. doi: 10.1080/13803395.2013.789485

Killingsworth, M. A., & Gilbert, D. T. (2010). A Wandering Mind Is an Unhappy Mind. *Science, 330*(6006), 932-932. doi: 10.1126/science.1192439

Kosslyn, S. M., Ganis, G., & Thompson, W. L. (2001). Neural foundations of imagery. *Nature Reviews Neuroscience, 2,* 635. doi: 10.1038/35090055

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Jr., Kawas, C. H., . . . Phelps, C. H. (2011). The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers Dement, 7*(3), 263-269. doi: 10.1016/j.jalz.2011.03.005

McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(1), 196-204. doi: 10.1037/a0014104

Morris, R. G., & Mograbi, D. C. (2013). Anosognosia, autobiographical memory and self knowledge in Alzheimer's disease. *Cortex, 49*(6), 1553-1565. doi: 10.1016/j.cortex.2012.09.006

Moustafa, A. A., & El Haj, M. (2018). Phenomenological Characteristics of Future Thinking in Alzheimer's Disease. *Journal of Alzheimer's Disease, 63*(4), 1279-1287. doi: 10.3233/jad-180182

O'Callaghan, C., & Irish, M. (2018). Candidate Mechanisms of Spontaneous Cognition as Revealed by Dementia Syndromes. In K. Christoff & K. C. R. Fox (Eds.), *The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, and Dreaming*. Oxford: Oxford University Press.

O'Callaghan, C., Shine, J. M., Hodges, J. R., Andrews-Hanna, J. R., & Irish, M. (2019). Hippocampal atrophy and intrinsic brain network dysfunction relate to alterations in mind wandering in neurodegeneration. *Proceedings of the National Academy of Sciences of the United States of America, 116*(8), 3316-3321. doi: 10.1073/pnas.1818523116

O'Callaghan, C., Shine, J. M., Lewis, S. J., Andrews-Hanna, J. R., & Irish, M. (2015). Shaped by our thoughts--a new task to assess spontaneous cognition and its associated neural correlates in the default network. *Brain and Cognition, 93*, 1-10. doi: 10.1016/j.bandc.2014.11.001

Pennanen, C., Kivipelto, M., Tuomainen, S., Hartikainen, P., Hanninen, T., Laakso, M. P., . . . Soininen, H. (2004). Hippocampus and entorhinal cortex in mild cognitive impairment

and early AD. *Neurobiology of Aging, 25*(3), 303-310. doi: 10.1016/S0197-4580(03)00084-8

Preacher, K. J. (2001). Calculation for the chi-square test: An interactive calculation tool for chi-square tests of goodness of fit and independence.

Rosenthal, R., & DiMatteo, M. R. (2001). Meta-analysis: recent developments in quantitative methods for literature reviews. *Annual Review of Psychology, 52*, 59-82. doi: 10.1146/annurev.psych.52.1.59

Seli, P., Maillet, D., Smilek, D., Oakman, J. M., & Schacter, D. L. (2017). Cognitive aging and the distinction between intentional and unintentional mind wandering. *Psychology and Aging, 32*(4), 315-324. doi: 10.1037/pag0000172

Singer, J. A., & Blagov, P. (2002). *Classification System & ScoringManual for Self-Defining Memories*. New London, CT: Connecticut College.

Smallwood, J., Fitzgerald, A., Miles, L. K., & Phillips, L. H. (2009). Shifting moods, wandering minds: negative moods lead the mind to wander. *Emotion, 9*(2), 271-276. doi: 10.1037/a0014855

Smallwood, J., Nind, L., & O'Connor, R. C. (2009). When is your head at? An exploration of the factors associated with the temporal focus of the wandering mind. *Consciousness and Cognition, 18*(1), 118-125. doi: 10.1016/j.concog.2008.11.004

Smallwood, J., & O'Connor, R. C. (2011). Imprisoned by the past: Unhappy moods lead to a retrospective bias to mind wandering. *Cognition & emotion*, 1-10. doi: 10.1080/02699931.2010.545263

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: empirically navigating the stream of consciousness. *Annual Review of Psychology, 66,* 487-518. doi: 10.1146/annurev-psych-010814-015331

Stawarczyk, D., Majerus, S., Maquet, P., & D'Argembeau, A. (2011). Neural Correlates of Ongoing Conscious Experience: Both Task-Unrelatedness and Stimulus-Independence Are Related to Default Network Activity. *PloS One, 6*(2), e16997. doi: 10.1371/journal.pone.0016997

Watts, F. N., MacLeod, A. K., & Morris, L. (1988). Associations between phenomenal and objective aspects of concentration problems in depressed patients. *British Journal of Psychology, 79*(2), 241-250. doi: 10.1111/j.2044-8295.1988.tb02285.x

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin, 132*(2), 249-268. doi: 10.1037/0033-2909.132.2.249

Yang, X. F., Bossmann, J., Schiffhauer, B., Jordan, M., & Immordino-Yang, M. H. (2012). Intrinsic Default Mode Network Connectivity Predicts Spontaneous Verbal Descriptions of Autobiographical Memories during Social Processing. *Frontiers in Psychology, 3,* 592. doi: 10.3389/fpsyg.2012.00592

Zacks, R. T., Radvansky, G., & Hasher, L. (1996). Studies of directed forgetting in older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*(1), 143-156.

Table1.

Characteristics of mind wandering in Alzheimer's disease (AD) patients and control participants

Characteristic	**AD** *n* = 32	**Older adults** *n* = 35	**Mann-Whitney U tests**
Occurrence	3.66 (1.12)	2.43 (1.29)	U = 261.50***
Intentionality	1.84 (1.11)	1.94 (1.14)	U = 525.00$^{n/s}$
Emotionality	2.03 (.93)	3.94 (.99)	U = 107.00***
Visual imagery	2.22 (1.26)	3.64 (1.06)	U = 228.00***
Specificity	1.69 (.93)	3.43 (1.40)	U = 194.00***
Self-relatedness	3.09 (1.15)	3.26 (1.07)	U = 504.50$^{n/s}$

Note. Standard deviations are given between brackets; occurrence was rated from 1 "never" to 5 "frequently"; intentionality was rated from 1 "not at all voluntary" to 5 "totally voluntary"; emotion was rated from 1 "very negative" to 5 "very positive"; visual imagery was rated from 1 "not at all clear" to 5 "totally clear"; specificity was rated from 1 "not at all" to 5 "totally"; self-relatedness was rated from 1 "not at all" to 5 "totally"; $^{n/s}$ the difference with the following group was no-significant; ***the difference with the following group was significant at $p < .001$

Table2.

Number of Alzheimer's disease (AD) patients and control participants who considered their mind wandering as past- present- or future-oriented

Temporality	**AD** *n* = 32	**Older adults** *n* = 35
Past	19**	8
Present	7**	20
Future	6$^{n/s}$	7

Note. $^{n/s}$the difference with the following group was no-significant; the difference with the following group was significant at $^{**}p < .01$, $^{***}p < .001$