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Cuing Prospective Memory With Smartphone-Based Calendars in Alzheimer's Disease

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Abstract

Objectives: We investigated the effect of using smartphone-based calendars (Google and Outlook Calendar) on prospective memory in Alzheimer's disease (AD).
Methods: we recruited two groups of participants with mild AD. In one group, prospective memory was cued by a paper-and-pencil calendar, whereas in the second group prospective memory was cued by a smartphone calendar application. After 2 weeks of training to familiarize the participants with calendar use, we invited participants to perform three prospective events per week (e.g., remembering to go to the grocery store) during a 3-week period. Events were cued either by the paper- or smartphone-based calendar.
Results: we observed fewer omissions of prospective events in the smartphone-based calendar group than in the paper-based calendar group.
Conclusions: our study suggests positive effects of smartphone calendar applications on prospective memory in AD.

Keywords: Alzheimer's Disease; Electronic memory aids; Memory rehabilitation; Prospective memory; Smartphone

Because improving memory in Alzheimer's disease (AD) is a worthwhile endeavor, recent research attempts to identify strategies that may maintain and ultimately improve memory function in AD. One of the promising areas of this booming research field is represented by studies on the use of technological tools that may alleviate memory decline in AD. Along these lines, the present paper investigates the effectiveness of smartphone calendar applications on enhancing prospective memory in AD. Prospective memory refers to the ability to enact intended actions at an appropriate moment in the future (Einstein & McDaniel, 1990). In patients with AD, prospective memory impairment can have a serious impact on patient's safety, autonomy, and quality of life (e.g., forgetting to attend a medical examination, to take medications, or even to turn off the oven or other critical appliances) (El Haj, Coello, Kapogiannis, Gallouj, & Antoine, 2018).

Research has attempted to alleviate prospective memory decline in AD. For example, El Haj, Gallouj, and Antoine (2017) assessed the effectiveness of using smartphone Google calendar applications (which allows events to be entered for a specific time and date) on prospective memory in AD. More specifically, the authors installed the application on a smartphone of a patient with mild AD and this application was synchronized to send the patient SMS text alerts to cue prospective events (e.g., attending the patient's weekly bridge game at the community club). During a 4-week period, the patient performed prospective events that were cued by the calendar application and control events that were not cued by memory aids. Results demonstrated less omission of the events cued by the calendar application. Similar findings were reported in another case study in which a

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Table 1. Demographic and cognitive characteristics of the two groups of patients with Alzheimer's Disease

	Paper-based calendar ($n = 11$)	Smartphone calendar ($n = 11$)	
Women/men	6/5	6/5	X^2 (1, $N = 22$) = .00, $p = 1$
Age in years	74.91 (7.02)	72.36 (6.47)	$t(20) = .88$, $p = .39$
Education in years	9.91 (3.05)	8.09 (2.51)	$t(20) = 1.53$, $p = .14$
General cognitive functioning	23.27 (1.73)	23.11 (1.33)	$t(20) = .14$, $p = .89$
Episodic memory	5.73 (2.76)	6.45 (2.29)	$t(20) = .67$, $p = .51$
Working memory (forward spans)	4.55 (1.04)	4.82 (1.41)	$t(20) = .52$, $p = .61$
Working memory (backward spans)	3.45 (1.13)	3.82 (1.17)	$t(20) = .74$, $p = .47$

Note. In the first group, prospective memory was cued by a paper-based calendar, whereas in the second group, prospective memory was cued by a smartphone calendar application; standard deviations are given between brackets; general cognitive functioning was evaluated with the Mini-Mental State Examination and score referred to correct responses/30; episodic memory was evaluated with the Grober-and-Buschke task and score referred to correct responses/16; performance on the working memory forward and backward spans were number of correctly repeated digits.

patient with mild AD performed both a baseline (i.e., prospective events without using any memory aids) and an intervention condition (e.g., prospective events that were cued by a smartphone calendar application) (El Haj, 2017). Results demonstrated that more prospective tasks were achieved in the intervention condition than in the baseline condition. Although these results are encouraging, they were based on a single case study design and thus have limited generalizability.

The effectiveness of smartphone calendar applications should be tested in a more representative sample and should be also compared with traditional methods. To address this question, we investigated the effects of smartphone calendar applications on prospective memory in two groups of patients with mild AD. In one group, prospective memory was cued by a paper-and-pencil calendar, whereas in the other group, prospective memory was cued by a smartphone calendar application. In light of the encouraging results of our previous case studies (El Haj, 2017; El Haj et al., 2017), we expected better prospective memory performance in the smartphone calendar than in the paper-and-pencil group. Our prediction was also based on the assumption that paper-and-pencil calendars are initially based on self-initiated processes (i.e., patients had to check their calendar), whereas smartphone calendar applications have the advantage to cue prospective events (i.e., to send notifications/reminders to the patients about the to-be-performed events).

Method

Participants

We recruited 22 patients with a clinical diagnosis of probable mild AD. Diagnosis was based on the criteria of the National Institute on Aging and Alzheimer's Association. Participants were recruited by the stuff of local retirement homes in the area of North France between January 2016 and December 2017. They were screened and tested in person. All participants freely consented to participate in this study and were given the opportunity to withdraw whenever they wished. We divided the participants into two groups (i.e., paper-based versus smartphone calendar), and assigned participants to groups based on their own choice. In the paper-based calendar group ($n = 11$ participants), prospective memory was cued by a paper-based calendar, whereas in the smartphone calendar application group ($n = 11$ participants), prospective memory was cued by a smartphone calendar application. As shown in Table 1, there were no significant differences between the two groups regarding demographic characteristics.

For all participants, exclusion criteria were the lack of neurological or psychiatric illness (other than AD), and major visual or auditory acuity difficulties that could prevent adequate assessment. We excluded four AD patients due to lack of informants, two patients who had no smartphones, two patients who were not able to complete the drawing test on the Mini-Mental State Examination, and two patients who had little experience with smartphones. At the end of the baseline phase, one AD patient was excluded as he answered "little bit" on the question "do you feel comfortable with the smartphone-based calendar?" and he did not wish to enroll in the training phase. In the training phase, one patient (from the paper-based group) left the study on the third week due to health problems. We also excluded another patient (from the paper-based group) because, on the second week, her informant did not wish to continue. After applying all these inclusion/exclusion criteria the final sample was 22 participants.

Regarding cognitive characteristics, we evaluated general cognitive functioning, working memory and episodic memory. General cognitive functioning was evaluated using the Mini-Mental State Examination. The working memory phonological loop integrity was assessed using the span tasks, in which participants had to repeat a string of single digits in the same order (i.e., forward spans) or in the inverse order (i.e., backward spans). Verbal episodic memory was assessed using the test of Grober

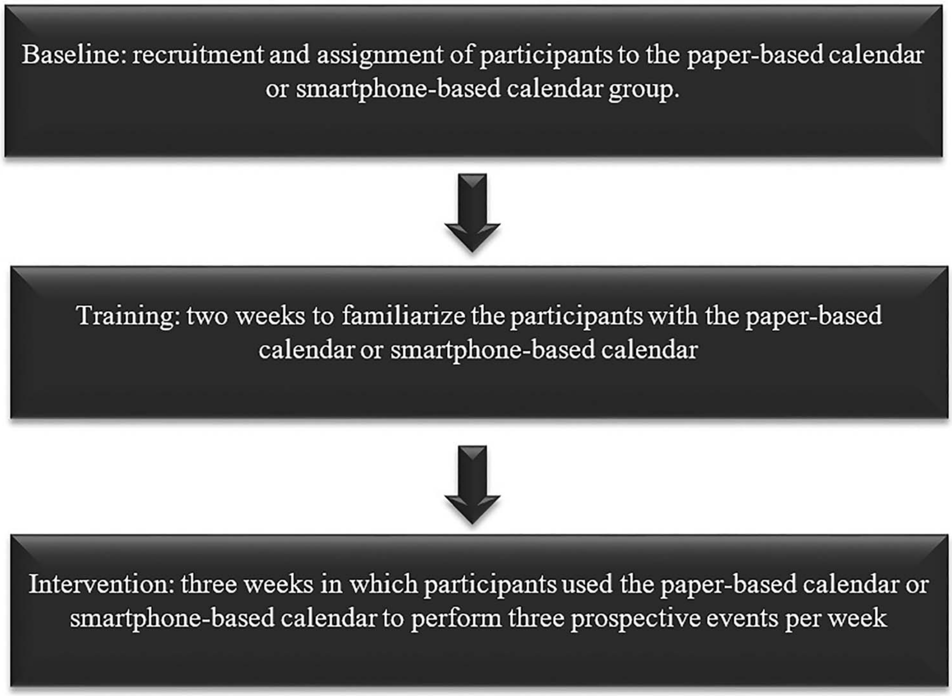

Fig. 1. The study design.

and Buschke, on which participants had to retrieve 16-previously encoded words. As shown in Table 1, there were no significant differences between the two groups on these tests.

Procedures

As illustrated in Fig. 1, the study was divided into three phases: baseline, training, and intervention. The baseline phase was dedicated to the evaluation of cognitive performance, as detailed in the "participants" section, and, critically, to the selection of participants. Because the study required participation of both patients and informants (e.g., caregivers, family members), we excluded four AD patients due to lack of informants. As mentioned in the "participants" section, participants were assigned in the baseline phase to the paper-based or smartphone-based groups following their preference. Two participants wished to integrate only the smartphone group but did not have smartphones. Since the study was not funded and since we were not able to provide smartphones, we excluded these two patients. We also excluded these patients to ensure that the two groups were comparable regarding their baseline smartphone knowledge. To ensure that prospective memory performance would not be influenced by familiarity of patients with paper- or smartphone-based tools, we assessed the familiarity of participants with these tools. Regarding the paper-based group, we included only participants who declared being familiar with paper and pencil tools. To further ensure that these participants are able to deal with paper and pencil tools, we excluded two patients who were not able to complete the drawing test on the Mini-Mental State Examination. Regarding the smartphone-based group, we included only participants who already possess smartphones and who declared using smartphone and apps for more than 1 year; this information was confirmed by the informants. Two participants were excluded as they declared little experience with using smartphones.

To further ensure the familiarity of participants with the paper- and smartphone-based calendars, the baseline phase was followed by a 2-week training phase in which we offered participants of the paper-based group a standard paper-and-pencil calendar. We invited participants to note prospective events, and to try, as much as possible, to check agenda to perform these events. Regarding the smartphone-based group, we informed participants about calendar applications that may answer their needs or any technological constraints (e.g., some applications are more suitable for Android than for IOS phones). Four participants were already users of Gmail addresses and, therefore, they preferred Google Calendar, whereas four other participants were already users of Hotmail/Outlook addresses and they preferred Outlook calendar. Among those who were users of other email addresses, two participants have chosen Google Calendar and one has chosen Outlook Calendar (n total = six participants used Google Calendar and five used Outlook Calendar). Note that we used these calendars as they were free.

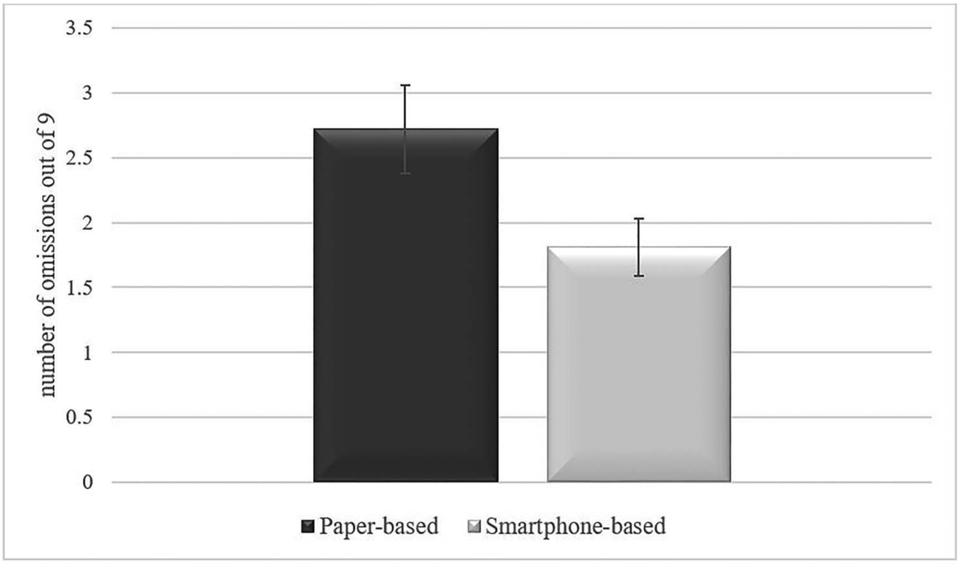

Fig. 2. The Number of omissions in the paper- and smartphone-based calendar. Error bars are 95% within-subject confidence intervals.

We installed the chosen application on the participants' smartphones and trained them to use the applications. For each participant, we defined three time-based prospective events that the informant feels important for the patient's daily life activities and/or events that participants were already trying to do (but sometimes failing to do) in their daily life (e.g., go to the grocery store, call a friend, buy the weekly magazine, attend the bridge club, and so forth). The same three events were repeated each week for each participant. For all events, participants in the smartphone-based group received alerts (i.e., notifications on the home screen) 1 hr, 45 min, and 30 min before the event. All participants in the two groups were encouraged to rely on the respective tool (i.e., paper- or smartphone-based calendar) when performing the prospective events. At the end to the 2-week training phase, participants were invited to rate, by phone, on a five-point Likert scale ranging from "not at all" (one point) to "extremely" (five points), the following question: "do you feel comfortable with the paper-based/smartphone-based calendar?". No significant differences were observed between the paper-based group ($M = 4.42$, $SD = .41$) and smartphone-based group ($M = 4.21$, $SD = .48$) on this question ($Z = .42$, $p = .67$). By doing this, we ensured that both groups were ready for the intervention phase and, critically, sufficiently familiar with the material so any differences on the intervention phase would not be attributed to familiarity with the material. Note that, during each of the two training weeks, we programmed a meeting with patients and, as far as possible, with their informants. During these two meetings, participants were invited to provide feedback to adjust the procedures. Technical assistance, especially for the smartphone-based calendar group (e.g., adjusting the font size/color of applications), was also provided during these meetings. This technical assistance did not include training the smartphone-based calendar group adding the events in the calendar as this task was complicated for patients.

The intervention phase lasted 3 weeks during which participants were invited to weekly perform the three previously defined prospective events. During this phase, informants noted the number of prospective events that were omitted by the patients, that is, whether participants had, or had not, performed the events. The omissions were used as the dependent variable in our statistical analyses. The intervention phase was succeeded by a debriefing session in which informants reported completion of the study and variables were collected. During this debriefing session, both patients and informants were invited to provide general feedback about the study.

Results

We compared the number of omitted prospective events between the paper- and smartphone-based calendar groups. We used Mann–Whitney U test due to the non-normal distribution of data observed with Shapiro Wilk. We provided effect sizes by using Cohen's d criterion. The maximum omission score for each participant was nine points (three events per week $\times$ 3 weeks).

As illustrated in Fig. 2, results demonstrated more omissions in the paper-based calendar group (mean = 2.72, median = 3.00, $SD = 1.27$, $IQR = 2.00$) than in the smartphone-based calendar group (mean = 1.18, median = 1.00, $SD = 1.98$, $IQR = 2.00$) ($Z = -2.69$, $p = .007$, Cohen's $d = 1.40$).

Discussion

In this study, we compared the effects of paper-and-pencil versus smartphone calendar applications on prospective memory in AD. Results demonstrated less omission of prospective events in the smartphone-based calendar group than in the paper-based calendar group, suggesting beneficial effects of using smartphone calendar applications on prospective memory in AD. Overall, both groups showed good performance with remembering to do their prospective memory tasks as the smartphone-based calendar group on average forgot one out of nine tasks and the paper-based calendar group forgot 2.7 out of nine tasks. The superior effect of smartphone calendar applications on prospective memory, as observed in our study, can be attributed to the fact that, unlike paper-based calendars, smartphone calendar applications have the advantage to send notifications to cue the prospective event. More specifically, compared with paper-based calendars, smartphone-based calendars require less self-initiated processes as these calendars typically require remembering to carry out the intended action, whereas paper-based calendars require remembering to check for the calendar and carry out the intended action. In other words, although both types of calendars require not only monitoring the environment for the appropriate time to carry out the action, paper-based calendars require monitoring the storage support (e.g., to check the paper-based calendar and the notifications). Paper-based calendars thus require more cognitive resources (e.g., self-initiation processes) than smartphone-based calendars, which may explain why more omissions were observed in the paper-based calendar-group than in the smartphone-based calendar-group. The superior effect of smartphone calendar applications on prospective memory, as observed on our study, can be also attributed to the fact that participants were free to choose between the paper-based group and the smartphone calendar application group. In other words, the higher performance of the smartphone calendar application group can be attributed to their familiarity, experience, or even enthusiasm for smartphone based applications.

The surge of research on electronic memory aids in AD can be viewed as an extension of the current interest in the use of electronic aids in the field on cognitive training and health in AD. For instance, currently there is an interest in using computerized cognitive training as an intervention to slow down cognitive decline in AD (Hill et al., 2017). Electronic aids have been also studied in the fields of wandering and wayfinding in AD. Research suggests that navigation systems may provide assistance in locating patients, and could also help dementia patients find their way back home (Lanza, Knorzer, Weber, & Riepe, 2014; Teipel et al., 2016). These technologies come with both promises and limitations. For instance, the effects of smartphone-based calendars, as observed in our study, cannot be generalized to patients with AD who do not have access to technology or even to internet coverage. Further, the benefits of this technology may not be applicable to low-income patients who cannot afford paying for such devices, which may be considered as a current limitation on the benefits of electronic aids in AD.

One limitation of our study may be the relatively small sample. It is worth noting, however, that as described throughout the "procedures" section, our study underwent strict inclusion/exclusion criteria, resulting in the limited, but representative, sample. Another limitation may be that participants were assigned to groups according to their preference for paper versus electronic calendar. This makes it challenging to know whether those who prefer the electronic calendar have better cognitive abilities or other characteristics that offer memory advantage.

To summarize, the revolution in mobile technologies, cloud-based platforms, and deep learning-driven software algorithms as well as automated physiological sensors will most likely influence cognitive, and especially memory, rehabilitation, in AD. Our paper can thus be viewed as an attempt to bridge the gap between the current paper-and-pencil and the upcoming mobile-based rehabilitation of prospective memory in AD. In our view, and in the current practice, mobile-based cognitive rehabilitation tools may offer advantages for AD patients, especially those who use mobile-based technology prior to the onset of disease symptoms.

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Conflict of interest

The authors declare no conflict of interest.

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