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Effects of Age on Performance of Prospective Memory Tasks Differing According to Task Type, Difficulty and Degree of Interference

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Abstract

In this study we compare the performance of older and younger adults in prospective memory tasks. Our aim is to understand the differences between the performances of cognitively unimpaired older individuals and young people in prospective memory tasks using both events based and time based tasks, as well as to determine whether the prospective memory interference effect in the ongoing task differs according to the age samples. A further objective is to analyze whether the difficulty of the PM task (event-based versus time-based) affects the degree of interference in the ongoing task. Using four different event based prospective memory tasks, we found no differences between the young people and the cognitively unimpaired older individuals (even when increasing the difficulty of the ongoing task), neither in the time-based tasks or the PM interference effect. It was concluded that deterioration in performance on tasks involving the recall of pending intentions is not a problem associated with age but rather with another series of deficits in the cognitive processes.

Keywords: Aging; Prospective memory; Interference

Introduction

The term prospective memory (PM) refers to remembering to carry out a delayed intention at the correct time in the future [1]. PM involves having to remember to do a pending task without any explicit request for it while immersed in other tasks of daily life (ongoing task), to interrupt those ongoing tasks and to perform the prospective task [2]. This self-initiated recall of the task and interruption of the ongoing tasks is not present in retrospective memory tasks. This is why prospective memory is particularly susceptible to the attentional demands of the tasks we are involved in. In fact, more than half of the memory failures that occur in daily life have to do with forgetting to carry out pending tasks [3-5]. Prospective memory tasks are classified into two types [6]: (a) event-based prospective memory tasks (those in which the intended action must be performed when a certain external target event occurs, for example, remembering to give a message to a colleague when we see her, or remembering to buy aspirin when we go by the pharmacy); (b) time-based prospective memory tasks (those in which the intended action must be carried out at a certain time or after a certain amount of time has elapsed, for example, remembering to go to an appointment at 12:00 or remembering to turn off the oven after 15 minutes).

An important line of research in this field is the study of changes in PM during the aging process. One of the most widespread complaints among the elderly and those around them is forgetting to perform necessary tasks or actions at the right moment [7,8]. It is generally assumed that PM tasks involve a larger component of self-initiation than retrospective memory tasks, and that this should make them particularly difficult for older individuals [9]; further, some authors have suggested that time-based PM tasks should show an even greater age effect given their higher degree of self-initiation and the greater demand on controlled cognitive processes involved in these tasks as compared to most event-based PM tasks [10,11]. In their meta-analytic review, Henry et al. [12] concluded that in general older individuals perform more poorly than young people in both time-based and event-based laboratory PM tasks. Nonetheless, this seems to depend on many factors, among others, the type of experiment (laboratory tasks/real life; artificial/natural), the type of task (event-based/time-based), the cognitive load demanded by the ongoing task, the retention interval, the scoring criteria [13], and the preservation of an individual's different neuropsychological and cognitive factors [14].

Whereas some studies show that older persons perform more poorly than young people on PM tasks in the laboratory [15-18], others have not found these differences when it comes to natural tasks [19] and even several event-based PM studies carried out in a laboratory failed to find age-related differences or found only small differences [6,10,20-25]. Other studies [23,26] found that older individuals performed more poorly on non-focal event-based tasks (PM events that are presented in the context of the ongoing task, but do not form part of the information that has to be taken into account in order to carry out the ongoing task). Moreover, the age effect found is usually greater in the retrospective component of the intention (remembering what task has to be done), than in the prospective component (remembering that something has to be done [27]). In short, the results are divergent and usually justified by the characteristics of the tasks rather than by characteristics associated with age.

Smith [28] posited that successful prospective retrieval requires the intervention of resource-demanding attentional monitoring processes. According to this perspective, the ongoing task and the PM task would be competing for limited resources, and therefore the deficits associated with aging in PM should generally appear given that older adults will presumably try to maintain performance of the ongoing task to a reasonable extent, and thus their prospective remembering will be compromised [29]. This is how the absence of age-related PM deficits can be explained: by adducing that participants try to maintain

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a relatively high level of prospective remembering, exacting a high cost to the ongoing task. This effect in which the presence of a PM task leads to a decrease in the performance of the ongoing task (affecting response latencies, the rate of correct answers, or both) is known as the PM interference effect [28,30,31] and would be the result of the resource-demanding preparatory attentional process involved in monitoring the environment in search of potential PM events [30,32].

This is the main objective of our study: to learn whether the interference effect caused by PM varies according to age, since this could tell us whether older adults exact high costs to the ongoing task in order to be able to attain a performance similar to that of young adults in the PM task. The few studies that have addressed this issue have obtained inconsistent results [33,34]. Some studies [10,35] did not find age-related differences in the PM interference effect on the rate of correct answers in the ongoing task (hereafter, accuracy rate). In contrast, d'Ydewalle et al. [36] found that older adults showed a greater interference effect when they had to perform a time-based PM task, but not when they had to do an event-based PM task. Logie et al. [37] even suggested that the younger adults may show a greater interference effect than the older adults. When the measure used was response latency in the ongoing task, McDaniel and Einstein [38] found that with events the older adults showed a greater interference effect, whereas Jäger and Kliegel [23] did not find any evidence that the interference effect was related to age either in time-based or event-based tasks.

Our second objective is to learn whether event-based tasks and time-based tasks produce PM interference effects in the same way or to different degrees in older and younger individuals. Since time-based tasks require a series of controlled cognitive processes that involve greater self-initiation, as they require that an individual actively monitor the passing of time [2,39,40] have posited the hypothesis that the interference effect should be greater in time-based tasks than in event-based tasks. Although the findings of d'Ydewalle et al. [36] seem to support this hypothesis, other studies have not found evidence that the interference effect varies as a function of the type of task, whether in affecting the accuracy rate in the ongoing task [10,37,41,42] or the response latency [40]. In contrast, Park et al. [35] found that the event-based tasks exact higher costs to the accuracy rate in the ongoing task than time-based tasks, and Jäger and Kliegel [23] found the same result using the response latency in the ongoing task as a variable. Park et al. speculated that the PM interference effect can be greater in event-based tasks because the participants must pay constant attention to the possible appearance of a PM event, whereas in the time-based tasks the participants only direct their attention sporadically to the PM task to monitor the time. Further, this allocation of attentional resources may cease for a time after the participant has made a PM response.

All these studies seem to indicate that age may not have effect on PM performance; rather, the characteristics of the task and the cognitive resources of the participants may be more determinant. Thus, in order to broach the issues described above, we carried out a study in which we applied four PM laboratory tasks to samples of young adults and older adults. Three of the tasks were event-based (all of them non-focal) and one was time-based, the latter with the same ongoing task as the first event-based task in order to make the characteristics and demand of both PM tasks the same. With this procedure we obtained two variables in each task: (a) prospective remembering or performance on the PM task, and (b) the PM interference effect on the ongoing task. Based on these variables obtained from each of the tasks we hoped to address two issues: first, the existence of age-related differences in prospective memory and the interference effect in the event-based tasks. Our hypothesis in this respect is that no age-related differences should appear either in prospective memory or in the interference effect, as we believe that age is not a significant predictor of PM performance, this being rather the individual's attentional resources capability. Young people and cognitively and neurologically intact older individuals should be affected by the inference effect to the same degree and perform the PM tasks without significant differences. When older persons maintain adequate cognitive functions, there is no deterioration in PM performance and they are capable of maintaining cognitive resources for both tasks (ongoing and PM). Our second research objective has to do with the differences between the time-based and event-based PM tasks. As regards the differences in PM, our hypothesis is that time-based tasks will give rise to poorer performance in PM, since they are thought to demand a greater component of self-initiation. As a result, when considering the effect of PM interference, the event-based tasks should have a lower interference effect than the time-based ones.

Method

Participants

We selected a sample of 34 participants: 22 young people (Age: *M*=23.86, *SD*=4.086, range=19-34; 17 women), all undergraduate students majoring in Psychology, and 12 older adults (Age: *M*=62.08, *SD*=3.288, range=55-68; 7 women) who are participants in the University of Experience Program (Unofficial university studies for older people of 55 years). In order to exclude participants with any kind of cognitive deterioration, before the experimental procedure we interviewed the participants using a questionnaire about their general state of health and the presence of any psychiatric or neurological disorders, and assessed the older adults with the *Mini-Examen Cognoscitivo de Lobo (MEC)* [41], the Spanish adaptation of the Mini-mental State Examination (MMSE) [43]. The results of the screening test showed that none of the participants showed indications of cognitive deterioration (MMSE: *M*=29.17, *SD*=0.835, range=28-30).

Materials

The participants carried out four experimental PM tasks (Figure 1), each of which was comprised of an ongoing task and a prospective memory task. Tasks 1, 2 and 3 were event-based prospective memory tasks (adaptated from Burgess et al.) [44]. Task 4 consisted of a time-

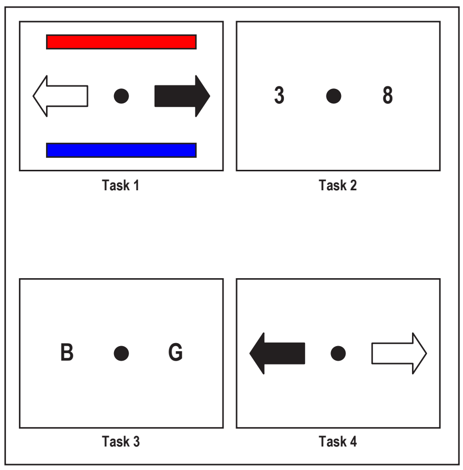

Figure 1: Description of the experimental tasks.

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based prospective memory task but parallel to Task 1. In Task 1, in each trial an arrow appears on each side of the fixation point, one of them black and the other white. The participants had to respond according to which side of the fixation point the black arrow appeared (ongoing task) by pressing the number keys 1 or 2 on the number pad (labeled with an arrow pointing left and an arrow pointing right, respectively). The prospective memory task involved paying attention to two horizontal bars of color located at the top and bottom of the screen. When both bars were the same color the participants had to press the space bar. In Task 2, the participants were shown two different numbers on the screen, one on each side of the fixation point. The ongoing task consisted of saying which number was higher, the one on the right or the one on the left of the fixation point, by pressing keys 1 or 2 on the number pad. For the prospective memory task the participants were asked to press the space bar whenever the two numbers were even numbers. In Task 3, the participants were shown two different capital letters. The ongoing task consisted of deciding which of the letters came first in the alphabet, using the keys with the corresponding arrow in order to answer. For the prospective task the participants had to press the space bar when both letters were vowels. In Task 4, the ongoing task was similar to that of Task 1: the participants were asked to say on which side of the fixation point the black arrow appeared, but the prospective task involved pressing the space bar every 30 seconds. Each prospective response that took place within an interval of ± 10 s of the target time was recorded as a correct prospective response. We used the 10-second interval because unlike in other studies, the participants had no means or event to help them verify the passing of time.

In the four ongoing tasks we calculated the accuracy rate as the sum of correct responses. Response latency was expressed in mean reaction times for correct answers after excluding trials in which a PM event appeared [28]. The PM interference effect was calculated as the difference between the accuracy rate of the trials with correct answers in the ongoing task when the PM task was present and a previous baseline measure of the accuracy rate in the ongoing task without the presence of the PM task [29]. The interference effect on the main latency response was calculated according to the same procedure. Trials in which a PM event appeared were excluded in order to avoid finding artificial PM interference effects.

Procedure

Participants were assessed in individual 30-minute sessions. Tasks 1, 2 and 3 (event-based) were conducted as follows: (1) Instructions for completing the ongoing task; (2) Practice block for the ongoing task: 10 trials with a reminder of the ongoing task (e.g., "What side does the black arrow appear on? On the left, so you must press the key with the arrow pointing left "); (3) Training block: 50 trials of the ongoing task; (4) Baseline block: 100 trials of the ongoing task; (5) Instructions for the PM task; (6) Training block for the PM task: 10 trials of the ongoing task, 2 of which included prospective events with a reminder of the ongoing task and the prospective task, respectively (e.g., "Since the two bars are the same color, press the space bar"); and (7) Prospective block: 100 trials of the ongoing task with 10 PM trials pseudo-randomly distributed so that two PM trials would not appear consecutively. For Task 4 (time-based), given that the ongoing task was the same as in Task 1, the baseline and ongoing task training blocks were left out. The prospective block consisted of 300 experimental trials (10 possible prospective responses every 30 seconds). The trial sequence was the same in all the tasks: (1) the fixation point appears on the screen for 300 ms; (2) the experimental stimuli appear on the screen and remain there until the participant responds; and (3) a blank screen comes on for 300 ms to separate each trial from the next. The experimental stimuli for each task varied randomly in each trial. In each task, the participants had to respond by pressing keys 1 or 2 of the number pad, labeled with a sticker with an arrow pointing left and pointing right, respectively. The PM response always involved pressing the space bar. Once the four tasks were completed, the experiment was considered to be over. The participants were then debriefed and thanked for their participation.

Results

To analyze the results of participants' performance in the ongoing task, the PM task and the PM interference effect, a series of repeated measures ANOVA were conducted. We used a mixed factor design with the age group (young adults versus older adults) as the between-subjects factor. We used the Greenhouse-Geiser correction for p values when necessary and the Bonferroni correction for multiple comparisons. Table 1 shows the means of the accuracy rates, response latencies and PM interference effects of the ongoing task for the younger and older participants.

Performance on the ongoing task

First we analyze the participants' performance on the ongoing

		Younger adults		Older adults	
Experimental block	**Variable**	**M**	**SD**	**M**	**SD**
	Task 1 (EB)				
Base Line	Proportion of correct responses	.998	.004	.998	.005
	Latency (ms)	449	86	695	200
Ongoing + MP	Proportion of correct responses	.994	.009	.996	.007
	Latency (ms)	608	101	919	253
	Event-based PM Hits	7.91	1,23	8	2.80
	PM interference effect (ms)	158	81	223	198
	Task 2 (EB)				
Base Line	Proportion of correct responses	.978	.017	.992	.010
	Latency (ms)	646	119	808	133
Ongoing + MP	Proportion of correct responses	.966	.032	.985	.011
	Latency (ms)	934	208	1164	292
	Event-based PM Hits	8.27	2.07	8.42	1.88
	PM interference effect (ms)	288	126	355	226
	Task 3 (EB)				
Base Line	Proportion of correct responses	.928	.038	.956	.037
	Latency (ms)	1368	358	2005	704
Ongoing + MP	Proportion of correct responses	.923	.043	.943	.055
	Latency (ms)	1612	493	2272	610
	Event-based PM Hits	8.68	2.08	7.58	2.15
	PM interference effect (ms)	244	209	267	318
	Task 4 (TB)				
Ongoing + MP	Proportion of correct responses	.979	.024	.992	.007
	Latency (ms)	421	70	856	637
	Time-based PM Hits	5.59	3.46	6.17	3.54
	PM interference effect (ms)	-28	61	160	552

Table 1: Ongoing task performance, prospective memory interference effect and prospective memory performance.

task in its baseline measurement (when the ongoing task is presented without any additional task) and in its measurement in the presence of a PM task. To analyze performance on the ongoing task, we conducted two repeated measures 2 (age group) × 3 (event-based tasks 1, 2, and 3) ANOVA. For the accuracy rate, the interaction between Age group × Task was significant, $F_{(1.183,\ 37.86)}$=3.889, p<0.05. Age group also yielded a significant effect, $F_{(1,\ 32)}$=5.021, p<0.05, the accuracy rates of the older adults being higher (a mean of 0.982) than those of the younger individuals (a mean of 0.968 ms). This higher accuracy rate is significantly different in Tasks 2 ($F_{(1,\ 32)}$=6.928, p<0.05) and 3 ($F_{(1,32)}$=4.165, p<0.05), but not in Task 1 ($F_{(1,\ 32)}$=0.021). The task effect was also significant, $F_{(1.183,\ 37.86)=}$68.288, p<0.01, the pairwise comparisons showing significant differences between all the tasks: Tasks 1 and 2 (Bonferroni C, p<0.01), Tasks 1 and 3 (Bonferroni C, p<0.01) and between Tasks 2 and 3 (Bonferroni C., p<0.01). The task with the highest accuracy rates was Task 1 (.998), followed by Task 2 (.985) and finally by Task 3 (.942). For response latency, the Age group × Task interaction was significant, $F_{(1.062,\ 33.99)}$=7.233, p<0.05. Again we found a significant effect of age group, $F_{(1,\ 32)}$=18.633, p<0.01, the response latencies of the older adults being longer (mean=1170 ms) than those of the younger individuals (mean=822 ms). The longer response latencies of the older age group occurred in Task 1 ($F_{(1,\ 32)}$=25.046, p<.01), Task 2 ($F_{(1,\ 32)}$=13.187, p<0.01) and Task 3 ($F_{(1,32)}$=12.341, p<0.01). The task effect was significant, $F_{(1.062,\ 33.99)}$=164.216, p<0.01, and pairwise comparisons again yielded significant differences between all the tasks: between Tasks 1 and 2 (Bonferroni C, p<0.01), Tasks 1 and 3 (Bonferroni C, p<0.01) and Tasks 2 and 3 (Bonferroni C, p<0.01). The task showing the shortest latencies was Task 1 (573 ms), followed by Task 2 (728 ms) and finally by Task 3 (1687 ms). The fact that the task effect was significant both in the accuracy rate and the response latency allows us to establish that the tasks, as expected, differed in their level of difficulty, Task 3 being more difficult than Task 2 and this in turn being more difficult than Task 1.

Next, we analyzed the ongoing task with the performance of the PM tasks in the same way. As regards the accuracy rate, there was no Age group × Task type interaction, $F_{(1.378,\ 44.111)}$=0.956. Neither did we find a significant effect for Age group ($F_{(1,\ 32)}$=2.945), which reflects a lack of differences between the group of older adults (.974) and the group of younger adults (.961). In contrast, we found a significant effect of task type, $F_{(1.378,\ 44.111)}$= 40.022, p<0.01, with pairwise comparisons showing significant differences between Task 1 and Task 2 (Bonferroni C, p<0.01), Task 1 and Task 3 (Bonferroni C, p<0.01), and Task 2 and Task 3 (Bonferroni C, p<0.01). The task with the highest accuracy rate was Task 1 (.995), followed by Task 2 (.976) and finally by Task 3 (.933). For response latency, the Age group × Task interaction was significant, $F_{(1.203,\ 33.499)=}$4.794, p<0.05. It also showed a significant effect of the Age group, $F_{(1,\ 32)}$= 18.211, p<0.01, the older adults having longer response latencies (1452 ms) than the younger ones (1052 ms). These longer response latencies in the older adults occurred in Task 1 ($F_{(1,\ 32)}$=25.997, p<0.01), Task 2 ($F_{(1,\ 32)}$=7.091, p<0.05) and Task 3 ($F_{(1,32)}$=11.762, p<0.01). The task effect was significant, $F_{(1.203,\ 38.499)}$=138.626, p<0.01, the pairwise comparisons showing significant differences between Task 1 and Task 2 (Bonferroni C., p<0.01), Task 1 and Task 3 (Bonferroni C., p<0.01) and between Task 2 and Task 3 (Bonferroni C., p<0.01). The task with the shortest latencies was Task 1 (764 ms), followed by Task 2 (1050 ms) and finally, Task 3 (1943 ms). Analysis of performance on the ongoing task (both the baseline ongoing task and the ongoing + PM task) confirmed that the ongoing tasks differed in their level of difficulty depending on the type of PM task. Task 1 has the highest accuracy rate and the shortest response latencies, whereas Task 3 has the lowest accuracy rate and the longest latencies. The results also show that in the baseline of the ongoing tasks the older adults had a higher accuracy rate, but to achieve this they invested more time in their responses than the younger adults. However, no differences were found between the age groups as regards accuracy rate when the participants had to do the ongoing tasks together with the PM task.

Finally, we analyzed the differences found in performance of the baseline ongoing task when each one of the PM tasks is present. As regards the accuracy rate, differences in the performance of the ongoing task were found in ongoing Task 1 (t_{33}=2.149, p<0.05) and in ongoing Task 2 (t_{33}=2.701, p<0.05), but not in ongoing Task 3 (t_{33}=1.595), the accuracy rate always being higher in the baseline performance. As regards the response latencies, we found differences in ongoing Task 1 (t_{33}=-7.820, p<0.01), ongoing Task 2 (t_{33}=-10.804, p<0.01), and ongoing Task 3 (t_{33}=-5.918, p<0.01), the response latencies being shortest in the baseline performance.

Event-based PM Tasks

To determine the effect of age and task difficulty on prospective recall and the interference effect of the three event-based PM tasks, we conducted a series of repeated measures 2 (Age group) × 3 (event-based tasks 1, 2, and 3) ANOVA. Analysis of the accuracy rate in prospective recall did not yield a significant effect either of the Age group × Task interaction, $F_{(2,\ 64)}$=1.353, the Age group, $F_{(1,\ 32)}$=0.298, or the Task type, $F_{(2,\ 64)}$=0.418. To compare the interference effects of the PM task, we ran two ANOVA using the values of the difference of the accuracy rates and the response latencies in performance of the baseline ongoing task minus performance in the experimental task. ANOVA carried out on the interference effect in regard to the accuracy rate did not show significant differences either in the Task type × Age group interaction, $F_{(1.323,\ 42.326)}$= .681; or differences owing to Age group, $F_{(1,\ 32)}$=0.006, or Task type, $F_{(1.323,\ 42.326)}$=0.933. With respect to the interference measured by response latencies, the ANOVA did not yield either interaction effects $F_{(1.633,\ 52.265)}$=0.157, or differences due to Age group ($F_{(1,\ 32)}$=1.267). However, it did show differences depending on the Task type, $F_{(1.633,\ 52.265)=}$4.372, p<0.05. Pairwise comparisons showed significant differences between Tasks 1 and 2 (Bonferroni C, p <0.01), the interference being greater in Task 2. We thus conclude that there are no differences in the PM performance between younger and older adults regardless of the difficulty of the event-based PM task. Neither was any differences found between the age groups in the degree of interference caused by the PM tasks.

Event-based PM Task vs. Time-based PM Task

In order to analyze participants' performance on ongoing task 1 in the presence of the event-based PM parallel tasks (Task 1) as compared to the presence of the time-based PM task (Task 4), we conducted two repeated measures 2 (Age group) × 2 (Task 1 and Task 4) ANOVA on the accuracy rate and response latencies. As regards the accuracy rate, no Age group × Task interaction was found, $F_{(1,\ 32)}$=2.085. Neither was a significant effect found for Age group, $F_{(1,\ 32)}$=3.036, reflecting the lack of differences between the group of older (.994) and younger adults (.986). In contrast, the Task effect was significant, $F_{(1,\ 32)}$=6.777, p<0.05. Pairwise comparisons showed significant differences between the event-based task and the time-based task, (Bonferroni C, p<0.05), the event-based task having a higher accuracy rate (a mean of .995) than the time-based task (.985). In the case of response latency, the repeated measures ANOVA did not yield an effect of Age group × Task interaction, $F_{(1,32)}$=0.829, although it did show a significant effect of Age group, $F_{(1,32)}$=21.891, p<0.01, the response latencies being longer for the older adult participants. These longer response latencies in the older adult group occurred in event-based Task 1 ($F_{(1, 32)=}$25.997, $p<0.01$), and in time-based Task 4 ($F_{(1, 32)}$=10.305, $p<0.01$). The task effect was not significant, $F_{(1, 32)}$=3.325. Again we confirm the lack of differences according to age between performance of the ongoing task in an event-based task and a time-based task, although the time-based task turned out to be more difficult, as expected.

To find out whether there were differences in PM performance between the event-based task and the time-based task in the interference effect they can have on the ongoing task, we decided to conduct 2 × 2 repeated measures ANOVA with the Age group factor and the PM task type factor (Event-based task 1 vs. Time-based task 4). As regards PM performance, the test did not show either a significant effect of Age group × Task interaction, $F_{(1, 32)}$=0.107, or an Age group effect, $F_{(1, 32)}$=0.236. However, the task effect was significant, $F_{(1, 32)}$=7.837, $p<0.01$, since the event-based task led to greater prospective recall (mean=0.794) than the time-based task (mean=0.579). Once again, no differences were found between performance on an event-based PM task and a time-based PM task according to age.

With respect to the difference in the interference effect on the accuracy rate according to whether the PM task was event-based or time-based, the effect of the Task × Age group interaction as not significant, $F_{(1, 32)}$=2.085. Nonetheless, the effect of Age group was seen to be significant, $F_{(1, 32)}$=4.480, $p<0.05$, reflecting a greater interference effect on the accuracy rate of the young adults in both tasks. As regards Task type, the ANOVA showed a significant effect, $F_{(1, 32)}$=6.777, $p<0.05$ since the interference effect was greater in the time-based (1.4%) than in the event-based task (0.3%). With respect to the interference effect measured by response latencies, the Task × Age group interaction was not significant, $F_{(1, 32)}$=0.829. The ANOVA did point to differences according to Age group, $F_{(1, 32)=}$4.807, p<0.05, reflecting a greater interference effect of the PM task on the older adults. No significant effect was found for Task type, $F_{(1, 32)}$=3.325, which shows that the interference effect was similar in magnitude for both types of PM tasks. Once again we found no differences between the younger and older groups owing to the PM task to be carried out, and the interference effect on the accuracy rate was greater for the younger adults than for the older ones, whereas in the case of the response latencies it was greater on the older adults. However, the PM interference effect was significantly greater than 0 in the event-based task, $t_{(33)}$=7.820, p=0.000, but not significantly greater than 0 in the time-based task, $t_{(33)}$=0.664, p=0.511. The effect of the Task × Age group interaction was not significant, $F_{(1, 32)}$)=0.829.

Discussion and Conclusions

The aim of this study was to verify the effect of age and type of PM task (event-based or time-based) on prospective memory and its interference effect. In general, we found that older adults have the same rate of recall of delayed intentions as young adults in a series of prospective memory tasks using both event-based tasks and time-based tasks. No significant differences were found between the two groups in prospective remembering in any of the three event-based tasks or in the time-based task, which contradicts the hypothesis that older adults should show deficits in their skills for monitoring time, which are essential in these kinds of tasks [39]. This result of finding of no differences as a function of age, although coinciding with results obtained in previous studies [6,10,20,21,23-25], was nonetheless contradictory with the results of the meta-analytical review by Kliegel et al. [45], since the tasks employed in the study were artificial laboratory non-focal event-based PM tasks, which, according to these authors, should produce greater age-related deficits in PM tasks.

These recall rates were not affected by the difficulty of the PM task. However, we did find that prospective remembering was higher in the event-based task than in time-based task for both groups of participants. This finding is consistent with the idea that time-based prospective tasks should be more difficult owing to their higher degree of self-initiation and the higher demand on controlled cognitive processes as compared to event-based tasks [10].

As regards the difficulty of the ongoing task interfering with the PM task, we found that it did not seem to affect prospective remembering. No differences were found as a function of the ongoing task used, even though they were found to have different degrees of difficulty. These findings once again throw doubt on those studies that compare younger adults (generally university students) with older persons who are the product of previous educational and technological models [46]. As mentioned earlier, when the sample is comprised of older individuals with broad cognitive reserve and without any explicit deterioration in cognitive or neurological structures, as is the case with our sample, these differences may not appear because age is not a significant predictor of PM performance, whereas a person's cognitive resource capacity is. We can thus conclude that controlling for inter-individual differences regarding different cognitive factors eliminates or reduces to a great extent the deterioration shown by older adults in memory [47,48]. What we did find was that older adults slow down their ongoing task performance in order to maintain their performance rate in the PM task. This seems to agree with the studies by [28] regarding the intervention of attentional monitoring processes that demand cognitive resources, resources that would be limited. Older adults who have these resources try to distribute them to attain an efficient performance. When older adults possess these resources, as occurs in our study, their performance does not differ from that of younger adults. In an attempt to verify this idea we analyzed the interference effect of the PM task and its relation to the aging process. To do so, we analyzed whether the older adults exacted a high cost to the ongoing task in order to be able to reach a performance level similar to that of the younger adults on the PM task. This would be confirmed if the older adults were to show a greater PM interference effect than the younger adults on the event-based tasks. Despite its potential importance, this topic has received scarce attention until now and the few studies that have addressed the issue have shown inconsistent results. Although most of the literature refers to the idea that older adults should show a greater PM interference effect than young adults, our findings do not show significant differences between older and younger adults. In our study the mean interference was equivalent to a decrease of 0.7% in the accuracy rate and a 25% increase in the response latencies in both groups. Therefore, we did not find evidence that older individuals undergo a greater interference effect than younger individuals due to the presence of PM tasks. This lack of differences remains regardless of the level of difficulty of the ongoing task.

In relation to the interference effect caused by the event-based and time-based tasks, we found that at the level of response latencies the time-based task and the event-based task gave rise to an interference effect of similar magnitude; however, the interference effect was only different from zero in the event-based task. Several researchers have argued that time-based tasks should exact greater cost to the ongoing task because they require a higher degree of self-initiation and controlled processes than the event-based tasks [40]; nonetheless, according to our findings the time-based task did not give rise to a significant interference effect. These results are consistent with those of Jäger and Kliegel [23] and

Park et al. [35] and could be a result of the fact that in the time-based tasks the participants do not have to be constantly monitoring for the prospective events as they do in the event-based tasks, and this would thus cause the interference effect to be greater in the event-based tasks. Another possibility is that the time-based task may have given rise to a smaller interference effect because in all the cases it was administered after the event-based task and the participants may have improved their performance of the ongoing task as a result of training. Nevertheless, the results show that, in fact, the accuracy rate was lower in the time-based task, which suggests that we can rule out this explanation. Thus, these findings suggest that the interference effect may be greater in the event-based PM tasks than in the time-based tasks. As to whether the interference effect caused by the event-based and time-based tasks differs according to age, we found that in relation to the accuracy rate the younger adults experienced greater interference in the time-based task, whereas the performance of the older adults was more affected at the level of response latencies.

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