

Original Research Article

Apathy and Prospective Memory in Aging

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Key Words

Apathy · Lack of initiative · Lack of interest · Execution of delayed intentions · Aging

Abstract

Background: Apathy is common in aging, but the processes underlying its different components are still unclear. The aim of this study was to examine the relationships between apathy and prospective memory (PM), a process involved in the execution of delayed intentions. **Methods:** Fifty elderly participants completed a PM task and a working memory task. Close relatives of the participants were given the Apathy Inventory, which assesses three dimensions of apathy (lack of initiative, lack of interest, emotional blunting), and a negative mood scale. **Results:** Correlation analyses showed strong relationships between PM and lack of initiative and interest. These relations remain significant even after controlling for global cognitive functioning, working memory, processing speed and negative mood. **Conclusion:** This study sheds new light on the cognitive mechanisms associated with apathy in aging and opens up interesting prospects for psychological intervention.

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Introduction

Apathy is a common behavioral symptom in elderly people (with or without dementia) [1] and constitutes the main cause of close relatives' suffering [2]. Apathy is linked to poor quality of life [3] and lower instrumental activities in daily life [2], and appears significantly associated with cognitive decline [1]. Defined as diminished goal-directed behaviors (GDB)

[4], apathy is commonly divided into three dimensions: loss or decrease of initiative, loss or decrease of interest, and affective blunting [4, 5]. Lack of initiative corresponds to the incapacity to act or to begin routine and non-routine activities spontaneously (self-initiation) or in response to external stimuli, while lack of interest corresponds to the incapacity to feel or show an attraction for routine activities or new events [4, 5]. In fact, in most clinical situations these two apathy dimensions are probably closely related: loss of interest could contribute to loss of action initiation (e.g. if I am not interested in this book, I will not read it) and initiation difficulties could lead to loss of interest (e.g. if I have difficulties participating in some activities, I will give them up). As for the third dimension, emotional blunting, it corresponds to a decrease in positive and negative emotional reactions [4, 5]. However, its assessment is rather problematic, especially considering how difficult it is for close relatives to understand loss of ‘experienced’ emotion.

Few studies have tried to examine the relationships between the different facets of apathy in aging and specific psychological mechanisms, and the nature of apathy problems in elderly people is still misunderstood. Some studies in healthy elderly people or elderly patients with dementia [e.g. 6, 7] showed that apathy was associated with poor performance on several executive tests, such as the Verbal Fluency test, the Trail Making Test-Part B and the Stroop Color Interference test. Moreover, Robert et al. [8] found a significant link between apathy and performance on the dual-task procedure developed by Baddeley et al. [9]. Finally, another study by Robert et al. [10] highlighted an association between apathy in patients with mild cognitive impairment and episodic memory deficits in tasks that trigger effortful conscious processes (free recall on a selective reminding test).

However, most studies on apathy [e.g. 10] considered only the global apathy score and did not distinguish between the three apathy dimensions mentioned by Robert et al. [4]. In addition, in these studies, the relationships between cognitive mechanisms and apathy were only exploratory and not based on specific hypotheses. Consequently, these studies do not really provide adequate information about the nature of apathy problems.

In the current study, we decided to explore the relationships between apathy dimensions (chiefly lack of initiative and interest) and prospective memory (PM), a process which plays a central role in action execution and is closely related to self-initiated behaviors [11]. More specifically, given that apathy corresponds to an incapacity to translate an intention into action [11], PM problems might constitute a key component of GDB reduction, especially lack of initiative, since PM allows one to remember acting [12].

PM refers to remembering to perform an intended action at some point in the future [13]; for example, ‘I have to go to work, prepare my talk for this afternoon and remember to pick the children up from school.’ It includes several cognitive processes divided into four steps: (1) the formation of an intention; (2) the maintenance of this intention in memory during the execution of another task; (3) the identification of the suitable situation or time to realize the intention; (4) the execution of the intention according to one’s plans [14]. In addition, it should be noted that individual differences in working memory significantly influence PM performance [e.g. 15]. Deficits affecting any one of the four steps proposed by Kliegel et al. [14] may account for apathy (mainly lack of initiative) by hindering the capacity to translate an intention into action. More specifically, PM seems closely related to self-initiated behaviors [13], insofar as PM allows one to connect together the complex sequences of GDB and to execute one’s plans in the correct order and at the appropriate time [16]. In this context, PM deficits, on the one hand, may play a role in the development of apathy (mainly lack of initiative) by affecting adaptation to the constraints of the time/environment, the ability to consider internal signals that act prospectively as triggers for the initiation of behavior, or the ability to switch between the ongoing task and the PM task [e.g. 11]. On the other hand, some aspects of apathy (e.g. lack of interest) may account for PM deficits by hindering the execution of delayed intentions.

However, although both PM impairments and apathy are common in aging, no study to our knowledge has examined the relationships between PM and specific dimensions of apathy. Thus, the aim of this study was to explore the relationships between the facets of apathy and PM in aging. We hypothesized that there would be a strong relationship between lack of initiative, lack of interest and PM, and suggested that this relationship could go in either direction: PM deficits may play a role in the development of some aspects of apathy (such as lack of initiative) over the medium or long term, and the presence of some aspects of apathy (such as lack of interest) may account for PM deficits. In addition, we investigated whether this strong relationship between PM and apathy would remain significant even after controlling for interindividual differences in variables supposed to be related both to PM and apathy (i.e. global cognitive functioning, working memory, processing speed and negative mood). Note that we considered a specific aspect of depression, namely negative mood, which does not overlap with the apathy dimensions. To test these hypotheses, we investigated the links between the three apathy dimensions (initiative, interest and emotion), as assessed with the Apathy Inventory (AI) [17], and an event-based PM task. To assess PM, we used the task developed by Blanco-Campal et al. [18], which consists in remembering to perform an action (such as pressing a particular key on a computer keyboard) when a particular cue event occurs, while also performing an ongoing task. The cognitive processes recruited in PM tasks, and the likelihood of success, are determined by the nature and demands of the ongoing task and the parameters of the PM cue [19]. We chose the most demanding condition (non-specific–non-salient condition; see below), which requires a range of executive processes, including the maintenance of the intention in working memory during the ongoing task, the monitoring of the environment and thus the allocation of greater attentional resources to identify the cue that signals the initiation of the action, the switch from the ongoing task to the PM task once the intention has been recalled, and the interruption of the ongoing task when the intention is to be performed [18, 20]. We assume that PM situations of this kind (especially the initiation and execution of the intention, i.e. steps 3 and 4, which require executive functions) [21] tap particularly well into a specific set of cognitive processes that are essential for GDB [11], such as monitoring for the target cue, inhibition of work on the ongoing task [22] and cognitive flexibility to switch to the PM task set [23].

Finally, in agreement with Walters' [24] study, we chose to adopt a perspective that considers cognitive aging along a continuum. Indeed, Walters' [24] study – conducted on more than 10,000 participants with and without dementia – showed (by using taxometric analysis) that differences in performance on a variety of cognitive tasks (episodic and working memory, executive function, language) are quantitative (continuum) rather than qualitative (distinct entity) [24]. Thus, in the present study, we performed analyses on one group of people presenting with more or fewer cognitive difficulties, without making group comparisons.

Methods

Participants

Fifty elderly individuals (31 women and 19 men) participated in this study. Most of the sample (34 non-consecutive participants) was recruited from the Geneva Memory Clinic (University Hospital of Geneva, Switzerland) and a smaller number (16 participants) were recruited in the general population. The inclusion criteria included scores ≥ 20 on the Mini-Mental State Examination (MMSE) [25]. All participants were in retirement and occupied independent living accommodations. Participants with schizophrenia, motor impairment, or uncorrected visual or hearing difficulties were excluded. Only participants for whom a close relative could complete the hetero-evaluation apathy questionnaire were included in

the study (among people who completed this questionnaire, 29 were spouses, 11 were adult children, and 10 were either siblings or sons-/daughters-in-law). The age range for the sample was from 64 to 88 years (mean \pm SD: 77.54 \pm 6.39 years), the educational level from 6 to 18 years (12.50 \pm 2.23 years) and the MMSE score from 20 to 30 (25.04 \pm 2.84). Among the participants recruited in the Geneva Memory Clinic, 10 had a mixed form of dementia, 9 mild cognitive impairment, 5 probable Alzheimer dementia, 3 vascular dementia, 2 Parkinson dementia, 1 frontotemporal dementia, and 4 deferred diagnosis.

Measures

The Apathy Inventory [17]

The AI is a semi-structured interview including three dimensions: emotional blunting (e.g. ‘Is he/she as affectionate and does he/she express emotion as usual?’), lack of initiative (e.g. ‘Does he/she initiate a conversation and make decisions?’), and lack of interest (e.g. ‘Does he/she seem interested in the activities and plans of others?’). The questions deal with behavioral changes that have occurred since the beginning of the disease. However, as our sample contains ‘healthy’ individuals, the notion of change was not specified. In fact, we were not interested in apathy in terms of change, but in its current level. We used the hetero-evaluation form in which yes/no questions are asked to determine whether apathy is present or absent. If the response is negative, the close relative assigns the score of 0 and proceeds to the next item. If the response is positive, the close relative explores the frequency and gravity of the item with simple questions (‘How frequently do these problems arise?’ and ‘How severe are these problems? To what extent do they disturb or handicap the patient?’). For each of the three dimensions, the maximum score (frequency of 1 to 4 multiplied by gravity of 1 to 3) is 12, giving a maximum total score of 36. The AI has good internal consistency and test-retest reliability [17].

The Silly Sentences Prospective Memory Task (adapted from 18)

The Blanco-Campal task is an event-based PM task using a dual-task paradigm in which an intention is embedded in an ongoing task. In this PM task, participants are instructed to perform a particular action (to say ‘animal’) whenever they encounter a particular target event (the name of any type of animal) during an ongoing activity. The major challenge for participants is remembering the intended action at the appropriate time, namely when the target event appears. We used only the non-specific–non-salient condition (‘when you see the name of any type of animal remember to say “animal”’), which requires monitoring processes (contrary to the specific – salient condition: ‘when you see the word *lion* written in any of the sentences, remember to say “animal”’; the word *lion* is salient, for it is presented in italics).

The *ongoing task* consisted of a lexical decision task, preventing continuous rehearsal of the intention in PM. Participants had to judge the truthfulness of 128 short sentences (e.g. ‘Spoons have sharp teeth’) individually presented in the middle of a computer screen, with a choice of answers (True/False) appearing below every sentence. Participants had to read each sentence and click on V if they considered it true or F if they considered it false. They were told that this task aimed to determine their ability to verify the truthfulness of a series of sentences in a limited time. Before beginning the task, an example was given to each participant (e.g. ‘Lettuce can be eaten’). Sentences were inspired by the Silly Sentences Test, which measures language comprehension speed [see 26]. The rate of presentation was set at 8 s per sentence [see 18].

The *PM task* consisted in remembering to say the word ‘animal’ aloud, when a word belonging to the category of animals appeared in the sentence to assess (e.g. ‘Africa is home to tigers’, True or False?). Of the 128 sentences to be assessed, 15 contained the prospective cue

(target word). Note that the location of the target words in the sentences was counterbalanced, as was the truthfulness of the sentences containing the target word. Participants did not know how many times the prospective cue would appear. They were simply told to remember the task instructions, because they would not be reminded of them during the task. The variable assessing PM performance corresponded to the number of times participants remembered to say ‘animal’ when they saw the target word. Data from participants who did not demonstrate any memory of the PM task (memory for the target item and the instructed response) at the conclusion of the experiment were excluded. The variables retained are (1) the memory for the target item (PM index), (2) the reaction time on the ongoing task (processing speed), and (3) the number of errors on the ongoing task.

This task captures the parameters that define a PM task: the action cannot be performed immediately, but there is an intention to perform this action in a particular situation; the period between creating the intention and the occurrence of the appropriate time to act is filled with a concurrent activity; and the retrieval context does not interfere with the execution of the ongoing task. Intention enactment is therefore self-initiated.

Letter-Number Sequencing Subtest of the Wechsler Adult Intelligence Scale-III [27]

The Letter-Number Sequencing task is a measure of verbal working memory (both retention and manipulation of information). Mixed lists of digits and letters were read aloud to the participants and they were asked to recall each list in the correct numerical and alphabetical order. The total number of correct trials was summed to create a Letter-Number Sequencing score. This task correlates strongly with laboratory working memory measures (e.g. operation span) and is a good predictor of fluid intelligence [28].

Negative Mood Scale (Hetero-Evaluation Adaptation of the Short Depression-Happiness Scale) [29]

This hetero-evaluation scale, adapted from the Joseph et al. [29] scale, assesses negative mood (sadness and hopelessness), a characteristic of depression which does not overlap with the dimensions of apathy. This scale is composed of six items; three items assess positive mood (e.g. ‘I see him as somebody who is optimistic’) and three other items assess negative mood (e.g. ‘I see her as somebody who is sad’). Items are assessed on a 4-point Likert scale (‘never’, ‘rarely’, ‘sometimes’, and ‘often’). The total score was computed by summing the responses obtained on the six items. We reversed happiness items such that a high score reflects a tendency to experience depressive thoughts and feelings, whereas a low score reveals a general tendency to happiness.

Procedure

Participants were tested individually in a quiet environment. After written informed consent was obtained, participants completed the tasks and scales. All participants performed the MMSE [25], the Silly Sentences PM task, and the Letter-Number Sequencing task. Simultaneously, close relatives completed the Negative Mood Scale and the AI. All participants gave their written consent to participate, and the study was approved by the ethics committees of the University Hospital of Geneva and the University of Geneva.

Statistical Analyses

First, exploratory analyses of the data revealed that most of the variables were normally distributed; therefore, parametric tests were performed. Second, Pearson’s parametric correlations were used to explore (1) the relationships between the three apathy dimensions and the demographic and clinical data (neuropsychological tests and scales), and (2) the links between PM performance, reaction time and number of errors on our PM task. Taking the

Table 1. Means and standard deviations of the clinical data

Measures	Elderly participants (n = 50)		
	mean ± SD	Min.	Max.
MMSE	25.04 ± 2.84	20	30
Letter-Number Sequencing	6.72 ± 2.09	3	12
Memory for the target item (PM index)	7.44 ± 3.27	2	12
Reaction time (ongoing task of the PM task)	7.99 ± 0.41	7.28	10.16
Number of errors (ongoing task of the PM task)	7.66 ± 3.27	2	18
AI (total)	10.16 ± 8.14	0	36
Lack of initiative	5.48 ± 4.07	0	12
Lack of interest	3.50 ± 3.40	0	12
Emotional blunting	1.18 ± 2.42	0	12
Negative Mood Scale	13.82 ± 4.01	8	22

multiple correlations into account, we decided to use an $\alpha = 0.01$ to reduce type I errors due to multiple tests or comparisons. We did not use the Bonferroni correction, usually employed to correct type I errors, as it is considered to be particularly conservative and to dramatically increase the risk of rejection of true correlations (type II errors) [30]. Finally, partial correlation analyses were also computed to assess the relationships between PM and apathy (lack of initiative and interest) after partialing out the effect of global cognitive functioning, working memory, processing speed and negative mood.

Results

Exploratory Analyses

Exploratory analyses of the skewness and kurtosis of each test and scale revealed that most of the data were normally distributed, considering that absolute values for skewness and kurtosis greater than 3 and 20, respectively, are judged to be extreme [31]. Only the reaction time on the ongoing task of the PM task, for which the skewness was 6.55 and the kurtosis 45.00, was not normally distributed. A logarithmic transformation was then carried out for reaction time. Except for this variable, the results showed that skewness ranged from -0.41 to 2.95 and kurtosis from -1.24 to 9.36 . Thus, there was no indication of a strong deviation from normality.

Demographic and Clinical Data

The means and standard deviations for the apathy dimensions and the neuropsychological assessment are shown in table 1.

Note that the AI is sensitive enough to assess apathy in our sample. Indeed, the 99% confidence intervals (CI) for the AI dimensions are 99% CI 3.21–5.45 for lack of initiative 99% CI 2.69–4.56 for lack of interest, and 99% CI 1.92–3.25 for emotional blunting, meaning that apathy differs significantly from 0. As for the Negative Mood Scale, Cronbach's α is high ($\alpha = 0.83$).

Correlation Analyses

In order to examine the relationships between the three dimensions of apathy and the clinical test data, Pearson's correlations were computed between the AI dimensions (initia-

Table 2. Correlations between apathy dimensions and cognitive and demographic data

	Age	Years of education	MMSE	Letter-Number Sequencing	Memory for the target item ¹	Reaction time ²	Number of errors ²	Negative Mood Scale	Lack of initiative	Lack of interest
Age	–	–	–	–	–	–	–	–	–	–
Years of education	–0.08 (–0.43 to 0.29)	–	–	–	–	–	–	–	–	–
MMSE	–0.16 (–0.49 to 0.21)	–0.02 (–0.38 to 0.34)	–	–	–	–	–	–	–	–
Letter-Number Sequencing	–0.30 (–0.60 to 0.07)	–0.07 (–0.41 to 0.30)	0.36 (0.01 to 0.64)*,†	–	–	–	–	–	–	–
Memory for the target item ¹	–0.24 (–0.55 to 0.13)	0.01 (–0.35 to 0.37)	0.42 (0.07 to 0.68)*,†	0.39 (0.04 to 0.66)*,†	–	–	–	–	–	–
Reaction time ²	0.05 (–0.32 to 0.40)	–0.15 (–0.48 to 0.22)	–0.11 (–0.45 to 0.26)	–0.14 (–0.48 to 0.23)	–0.40 (–0.66 to –0.05)*,†	–	–	–	–	–
Number of errors ²	0.18 (–0.19 to 0.51)	0.04 (–0.32 to 0.39)	–0.15 (–0.48 to 0.22)	–0.34 (–0.62 to 0.02)	–0.26 (–0.57 to 0.11)	0.10 (–0.27 to 0.44)	–	–	–	–
Negative Mood Scale	–0.13 (–0.47 to 0.24)	–0.24 (–0.55 to 0.13)	0.22 (–0.15 to 0.54)	0.03 (–0.33 to 0.39)	–0.32 (–0.61 to 0.04)	0.12 (–0.25 to 0.50)	0.19 (–0.18 to 0.51)	–	–	–
Lack of initiative	0.27 (–0.10 to 0.57)	0.01 (–0.35 to 0.37)	–0.26 (–0.57 to 0.11)	–0.48 (–0.72 to –0.15)**,†	–0.75 (–0.87 to –0.53)**,†	0.40 (0.05 to 0.66)*,†	0.20 (–0.17 to 0.52)	0.33 (–0.03 to 0.62)	–	–
Lack of interest	0.18 (–0.19 to 0.51)	0.01 (–0.35 to 0.37)	–0.13 (–0.47 to 0.24)	–0.44 (–0.69 to –0.10)**,†	–0.58 (–0.78 to –0.28)**,†	0.42 (0.07 to 0.68)*,†	0.29 (–0.08 to 0.59)	0.37 (0.01 to 0.64)*,†	0.65 (0.38 to 0.82)**,†	–
Emotional blunting	–0.01 (–0.37 to 0.35)	–0.04 (–0.39 to 0.32)	0.20 (–0.17 to 0.52)	–0.09 (–0.44 to 0.28)	–0.26 (–0.57 to 0.11)	0.16 (–0.21 to 0.49)	0.01 (–0.35 to 0.37)	0.39 (0.03 to 0.66)*,†	0.38 (0.02 to 0.65)*,†	0.42 (0.07 to 0.68)*,†

¹ PM index; ² ongoing task of the PM task. * p < 0.01; ** p < 0.001. Effect sizes were reported within their 99% CI. † 0 not included in the 99% CI.

tive, interest, emotion), age, number of years of education, MMSE, Letter-Number Sequencing, PM task, and Negative Mood Scale (see table 2).

Correlation analyses revealed a strong correlation between the PM index (i.e. the memory for the target item) and lack of initiative and interest: the greater the lack of initiative and interest, the poorer the PM performance. Moreover, we found that reaction time on the ongoing task and Letter-Number Sequencing also correlated significantly with these two dimensions of apathy. The correlation between the Negative Mood Scale and lack of interest was also significant, as was the case for emotional blunting. As for the relations between the apathy dimensions, the correlation between lack of initiative and lack of interest proved to be very strong.

Regarding the characteristics of performance on our PM task, correlation analyses between the PM index, reaction time and number of errors on the ongoing task revealed a significant negative association between reaction time on the ongoing task and PM performance (PM index): the better the PM performance, the faster the reaction time on the ongoing task. Thus, in this task, good PM performance does not involve a slowing-down of the ongoing task. This suggests that participants did not favor memory for the target item to the detriment of the ongoing task. As for the number of errors on the ongoing task, there was no significant correlation. Note that participants did not make many mistakes: they had to judge the truthfulness of 128 sentences and the average error rate was 7.66 (SD = 3.27), with a maximum of 18 and a minimum of 2 (see table 1). Finally, in line with data from the literature, PM performance was significantly related to working memory performance, and both correlated significantly with the MMSE.

Partial Correlation Analyses

Partial correlation allows one to look at the relationship between two variables when the effects of other variables are held constant. Given that global cognitive functioning (MMSE), working memory (Letter-Number Sequencing), processing speed (reaction time on the ongoing task of the PM task) and negative mood correlated significantly with lack of initiative, lack of interest and/or the PM index, we computed partial correlation analyses to partial out the effect of these variables on the link between PM and apathy dimensions.

The results revealed that even after controlling for global cognitive functioning, working memory, processing speed and negative mood, the link between lack of initiative and PM remains highly significant ($r = -0.58$, $p < 0.001$, 99% CI -0.78 to -0.28), as does the link between lack of interest and PM ($r = -0.37$, $p < 0.01$, 99% CI -0.64 to -0.01).

Discussion

The aim of this study was to examine the relationships between the dimensions of apathy and PM in aging. To our knowledge, this is the first study to consider the apathy dimensions separately and explore their links with a process which plays a central function in the execution of delayed intentions. We hypothesized that there would be a strong relationship between PM and apathy dimensions (lack of initiative and lack of interest). In line with this assumption, the results showed a strong relationship between lack of initiative, lack of interest and PM, and are compatible with data showing that PM constitutes a key component of GDB. More importantly, this relationship remained significant even after we controlled for global cognitive functioning, working memory, processing speed and negative mood, aspects that are closely related to PM performance and apathy dimensions. This means that global cognitive functioning, working memory, processing speed and negative mood, although correlated with PM and/or apathy, did not significantly account for the relation between those two variables. These results suggest that the relationship between lack of initiative, lack of interest and PM performance is relatively specific. Moreover, unlike the MMSE (considered as a measure of global cognitive functioning) and the Letter-Number Sequencing task (which measures working memory), the PM task used in this study measures processes specific to situations often encountered in everyday life, and requires participants to maintain and activate delayed intentions [14], and thus to self-initiate behaviors. However, these results are based on correlation analyses, which do not indicate causality. In fact, the links between apathy and PM are presumably bi-directional.

On one hand, PM deficits may contribute to the various manifestations of apathy, mainly lack of initiative. Indeed, such deficits may reflect problems executing one's plans in the correct order and at the appropriate time, inability to consider internal signals as triggers for action initiation, inability to translate an intention into action, problems switching between the ongoing task and the PM task, and multitasking difficulties [32, 33]. As for lack of initiative, recall that, according to Robert et al. [4], it refers to self-initiated and environment-stimulated GDB. We assume that PM is specifically linked to self-initiated behaviors, insofar as it requires the occurrence of the appropriate event or time to activate the memory of the intention without external solicitations and prompts the subject to initiate an action [13]. Indeed, a non-specific and non-salient condition, like our PM task, requires self-initiated cue monitoring. It is likely that apathy depends on the degree to which external support is present and the cognitive tasks require self-initiated, controlled processes. Interestingly, Eusop-Roussel and Ergis [34] showed that PM deficits in aging are greater when self-initiated processes (i.e. non-specific–non-salient condition) are very much involved. Further studies

should clarify the links between PM and lack of initiative, by exploring the executive components of PM, such as flexibility and inhibition.

On the other hand, some manifestations of apathy, such as lack of interest, may contribute to PM deficits. Interestingly, several studies have found strong associations between interest and attentional and executive capacities [e.g. 35]. In addition, Silvia and Kashdan [36] suggested that people interested in something allocated more attention to the events around them, engaged in in-depth information processing and had a better memory of the information, persevered more on a task until the goal was achieved, and mobilized more effort [see also 37]. Thus, lack of interest can have a negative impact on PM: (1) by making the formation of the intention not specific enough; (2) by hampering the maintenance of the intention in memory because of poor encoding; (3) by decreasing attentional and executive capacities to identify the proper situation/moment to carry out the intention, and (4) by making it difficult to execute the intention because of the lack of a structured plan. Conversely, high interest (e.g. being motivated by important intentions) may lead individuals to strategically focus their available resources on relevant aspects of a task [21]. In this context, elderly people's better performance on ecological PM tasks (*'naturalistic settings'*, e.g. phone a friend at the appropriate time) versus laboratory tasks [38] might be explained by their higher motivation (high interest) to complete the task [e.g. 39]. Indeed, in naturalistic settings, elderly people seem to use more external aids, to have a better knowledge of their memory capacities, and to be more motivated (high interest) in performing the task than young people [39]. In future studies, it would therefore be relevant to examine whether a link between apathy and PM is found in a naturalistic PM task. Finally, it could be argued that the link between PM and apathy is due to the participants' low degree of motivation to perform the PM task properly. Nevertheless, this does not seem to be the case, if we consider the small number of errors on the ongoing task (mean: 7.66), which consisted in judging the truthfulness of 128 sentences. Indeed, despite their poor performance on the PM task, participants seemed motivated and made real efforts to avoid making mistakes on the ongoing task. However, as in most studies on apathy, we explored apathy through a hetero-evaluation and the participants' motivation was not directly assessed. In future studies, it would be interesting to evaluate the participants' motivation to perform the task, by asking them if they were motivated by the task or by measuring changes in the activity of their cardiovascular system (a reliable and valid measure of motivational intensity) [40] during task performance, given that motivation is related to the mobilization of effort to perform a task [e.g. 40].

Lastly, regarding the relationship between apathy and depression, it should be remembered that the depression scale used in this study specifically assesses negative mood, a key aspect of depression which does not overlap with the dimensions of apathy assessed with the AI. In addition, negative mood, although correlated with apathy components, did not significantly account for the relation between apathy and PM. In fact, we consider that it is pointless to try to distinguish 'apathy' from 'depression' as separable categories, considering the overlap between their symptoms. Indeed, some of the symptoms considered characteristic of depression, such as lack of interest or absence of pleasure, are similar to apathy components [41, for a critical review, see 42]. Moreover, specific symptoms of depression such as negative mood [43] could contribute to the presence of apathetic manifestations. For instance, people who face a challenge judge the task to be more difficult when they are in a negative mood state than when they are in a positive mood state, which might result in disengagement when the task is objectively difficult [e.g. 44].

To conclude, it is likely that the relationships between PM, lack of initiative and lack of interest are dynamic: these relationships can change over time and differ between individuals. Longitudinal studies are needed to examine the dynamic interactions between PM and apathy, that is, to better clarify the predictive role of PM impairments, at one point, in the

development of certain apathy manifestations and the contribution of some aspects of apathy to PM deficits. Of course, the different manifestations of apathy are associated with other psychological factors than PM, such as poor self-esteem, inability to mobilize effort, deficits affecting anticipatory pleasure, etc. Further studies should adopt a multifactorial approach in order to determine the respective contributions of these different factors.

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Disclosure Statement

The authors have no conflicts of interest to disclose.

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