



Event-based prospective memory failure in amnesic mild cognitive impairment

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ABSTRACT

Prospective memory (PM) deficits have recently been documented in individuals with amnesic mild cognitive impairment (aMCI). In this paper, we investigated whether these deficits are due to the failure of retrospective memory processes. We also examined the role played by attentional/executive processes in PM functioning.

We enrolled 24 individuals with aMCI and 24 healthy controls (NCs). In the PM procedure, we manipulated both the memory load of the retrospective component of the PM task and the complexity of the ongoing task in a 2 × 2 experimental design. Sequences of four words were presented. Participants had to repeat the sequence in the same order (low attentional demand condition) or in the reverse order (high attentional demand condition). When a target word appeared in the sequence, participants had to press a button on the keyboard (PM task). Target words could be one (low memory load condition) or four (high memory load condition) in different blocks.

MCI participants obtained lower PM scores than NCs in all four experimental conditions. However, they recalled the target words less accurately than NCs only in one four-word condition. Finally, the executive demand of the ongoing task did not significantly affect the PM performance of aMCI individuals.

Our findings confirm that PM is severely impaired in individuals with aMCI. Moreover, a failure of retrospective memory processes does not seem to fully account for the poor PM performance in aMCI individuals. Finally, the finding that in these individuals, a deficit in executive control cannot be claimed as the main responsible for the observed PM impairment could suggest the involvement of automatic-reflexive processes.

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1. Introduction

The term “mild cognitive impairment” (MCI) refers to a heterogeneous, transient condition that might represent the very early phase of a dementia syndrome. According to internationally accepted criteria, MCI can be diagnosed in an otherwise healthy elderly individual if there is evidence of both subjective cognitive complaints and objectively ascertained cognitive deficits not associated with significant functional impairment (Petersen et al., 2001; Petersen, 2004). Research is currently focused on identifying different subtypes of MCI that might represent the prodromal phase of various dementia syndromes depending on the characteristics of the neuropsychological profile at onset. Particular interest has been devoted to the study of amnesic MCI (aMCI), a condition characterized by the presence of an episodic memory disorder, that is, the reduced ability to intentionally recollect previously encountered information (Petersen, 2004). Convergent findings from different

studies indicate that patients with aMCI have a high risk of progressing to Alzheimer's disease (AD; e.g., Petersen, 2004; Perri, Serra, Carlesimo, & Caltagirone, 2007; but see, Ritchie, Artero, & Touchon, 2001; Visser et al., 2000 for partially divergent findings). Indeed, consistent with the idea that reduced episodic memory functioning is the early cognitive marker of AD (Dubois et al., 2007), Perri et al. (2007) documented that aMCI individuals who developed AD during a two-year follow-up period presented a more pervasive memory disorder at the baseline assessment than aMCI individuals who remained stable or even improved their memory performance in the same follow-up period. The very early impairment of episodic memory in typical AD has been generally interpreted as an expression of neuropathological changes precociously affecting mesial temporal areas involved in long-term storage and consolidation of episodic information (Braak, Braak, Bohl, 1993; Whitwell et al., 2007).

Although poor performance on episodic memory tests is the neuropsychological hallmark in individuals with aMCI, recent evidence in the prospective memory (PM) literature suggests that the spectrum of their memory deficits may go beyond their difficulty in remembering previously learned information. PM refers

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to a complex cognitive ability involved in the delayed realization of previously formulated intentions (Einstein & McDaniel, 1990). It is generally accepted that failures to retrieve prospective intentions may lead to significant disability and interfere with individuals' social and occupational activities (Kliegel & Martin, 2003).

In a prototypical PM experiment, participants are engaged in an attention-demanding ongoing activity; then, at the occurrence of the target event (event-based PM) or at the expiration of a pre-defined time (time-based PM), the subject has to perform one or more specified actions. One critical methodological difference between episodic memory and PM tasks is that in the former the recollection of the studied information is explicitly prompted by the examiner, whereas in the latter the decision to activate oneself to perform the intended action at the occurrence of the target event or at the expiration of the established time is self-guided (i.e. no explicit external reminder is given). Indeed, it is generally accepted that two cognitive components are critical for the correct delayed execution of planned actions: (i) a retrospective memory component, which allows effectively encoding and successively recalling the cued event or time and the particular actions to be performed; and (ii) a more typical prospective component, which allows reactivating the intention to perform the planned actions at the appropriate time or when the event occurs without any explicit external prompt (Kvavilashvili, 1987). It is generally acknowledged that the retrospective component of a PM task relies on the same episodic memory system also involved in the encoding and successive retrieval of past events (Burgess & Shallice, 1997; Carlesimo, Casadio, & Caltagirone, 2004; Marsh, Hicks, & Landau, 1998). Conversely, a variety of cognitive and motivational factors (many of which are still underspecified) contribute to the effective functioning of the prospective component. In fact, executive abilities involved in the planning of sequential activities, monitoring the passing of time and shifting at the appropriate time from the ongoing task to the realization of the intended action, seem to play a significant role (Costa, Peppe, Caltagirone, & Carlesimo, 2008; Costa, Peppe, Brusa, et al., 2008; Knight, 1998; McDaniel, Glisky, Rubin, Guynn, & Routhieaux, 1999; Otani et al., 1997).

Kazui et al. (2005) were the first to document a significant PM deficit in a group of individuals with aMCI. Indeed, their patients were similarly impaired in performing the episodic memory and the event-based PM subtests of the Rivermead Behavioural Memory Test. The presence of significant PM deficits in persons with aMCI was subsequently confirmed in studies that used both event-based and time-based PM experimental paradigms (Blanco-Campal, Coen, Lawlor, Walsh, & Burke, 2009; Costa et al., 2010; Karantzoulis, Troyer, & Rich, 2009; Schmitter-Edgecombe, Greeley, & Woo, 2009; Thompson, Henry, Rendell, Withall, & Brodaty, 2010; Troyer & Murphy, 2007).

One emerging question in the literature is whether the PM impairment observed in individuals with aMCI is fully accounted for by the well known failure of episodic memory processes – which interferes with the encoding and successive remembering of the associative link between target time or event and prospective intention and of the specific actions to be performed (i.e., the retrospective component of a PM task) – or whether it is an independent phenomenon, mainly related to difficulty in autonomously reactivating the prospective intention at the expiration of the time or at the occurrence of the target event, despite normal episodic memory for the content of the intention (i.e., the prospective component of the PM task). Indirect support for the hypothesis that episodic memory deficits do not fully account for the PM impairment in individuals with aMCI comes from a study by Blanco-Campal et al. (2009). These authors examined the relative accuracy of prospective and episodic memory tasks in discriminating between healthy controls and MCI individuals with an amnesic neuropsychological profile. For this purpose, they administered two traditional tests of

episodic memory (a Short Paragraph and Word List recall) and an event-based PM procedure to both aMCI and healthy controls. In the PM task, the participants were required to say aloud the word “animal” when they saw the name of a particular animal (specific condition) in a written sentence, or when they saw a word indicating any type of animal (unspecific condition) while performing an ongoing lexical decision task. Consistent with the data from a previous study by Huppert and Beardsall (1993), who demonstrated that tasks tapping PM are more sensitive than traditional episodic memory tests in discriminating between persons in the very early stage of dementia and healthy controls, the results of Blanco-Campal et al.'s study (2009) documented that the performance score on the unspecific condition of the PM task discriminated individuals with aMCI from normal controls more accurately than the score on the episodic memory tests. The issue of the relationship between prospective and retrospective components of PM in individuals with aMCI was more directly investigated in a previous study by our research group (Costa et al., 2010). In this study, we administered two experimental PM procedures that required executing three actions after the ring of a timer (event-based condition) or after 20 min had elapsed (time-based condition) to individuals with both amnesic and non-amnesic (i.e., dysexecutive) MCI. The procedure allowed computing independent scores for the prospective and retrospective components of the PM task; the former were represented by the number of times the experimental subject autonomously retrieved the intention to perform the actions, and the second by the total number of actions correctly recalled after controlling for the possible failure to autonomously retrieve the intention. Results of the study documented that although MCI individuals were impaired on both PM components, they were significantly more impaired on the prospective than the retrospective one. The results of two other studies also support the relative independence of episodic and PM deficits in individuals with aMCI. Schmitter-Edgecombe et al. (2009) reported that a group of aMCI individuals failed to retrieve the intention to act in an event-based PM task, even though they were normally able to recall the PM instructions. Although recalling task instructions could not fully tap the declarative memory requests of a PM task, the reported results at least partially support the independence of episodic and PM deficits in individuals with aMCI. Finally, in line with the above observation, Thompson et al. (2010) demonstrated that participants with both amnesic and non amnesic forms of MCI were impaired on a PM task even when the retrospective component scores were introduced as a covariate in the statistical comparisons.

Congruently with the above view of partial independence of PM disorders from retrospective memory failure in aMCI, some evidence suggests that a reduced efficacy of executive control might be responsible for difficulty in retrieving the prospective intention. In fact, greater involvement of time- than event-based PM was found in these individuals (Costa et al., 2010; Karantzoulis et al., 2009; Troyer & Murphy, 2007; but see Thompson et al., 2010 for partially divergent results). This might have been due to the higher executive demands of the time- than the event-based task, primarily because in the former task the decision to shift from the ongoing activity to execution of the prospective intention is completely self-guided (Troyer & Murphy, 2007). Moreover, we previously showed that the PM scores of individuals with MCI were significantly correlated with their performance on the Modified Card Sorting test, in which set-shifting abilities are particularly stressed (Costa et al., 2010). In this regard, Schmitter-Edgecombe and Sanders (2009) recently found that the switch cost between the execution of two different tasks was significantly higher for MCI participants than for healthy controls, thus documenting poor shifting abilities in these individuals. Other studies have documented the frequent occurrence of dysexecutive disorders (Arnáiz & Almkvist, 2003; Backman, Jones, Berger, Laukka, & Small, 2005), which might be associated with

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