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Age-related declines in prospective memory: behavioral and electrophysiological evidence

Robert West*, Kristin Jakubek, Nicholas Wymbs

University of Notre Dame, 118 Haggar Hall, Notre Dame, IN 46556, USA

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Abstract

Prospective remembering reflects the ability of an individual to form and later realize intentions that must be delayed over minutes, hours, or days. A substantial body of literature, primarily based upon the findings of behavioral studies, indicates that there are robust declines in the efficiency of prospective remembering in later adulthood. However, the cognitive and neural mechanisms mediating age-related deficits in prospective remembering are not well understood. In this review we consider evidence from recent behavioral and electrophysiological studies indicating that decreases in the efficiency of prospective memory in older adults results from age-related differences in those neural mechanisms supporting the encoding of intentions into memory and the detection of prospective memory cues in the environment.

Keywords: Prospective memory; Event-related brain potentials; Aging; Memory; Intentions

Prospective memory reflects the ability of an individual to form and later realize intentions that must be delayed over minutes, hours, or days [22]. For instance, suppose that one evening I decide to deliver my laundry to the dry cleaners on the way to work the next morning. Knowing that I am often absentminded in the morning, I place the laundry in the car that evening. Entering the car the next morning the laundry serves as a reminder to stop at the cleaners on the way to work. As I drive past the cleaners, seeing the sign again reminds me of my task, and I pull into the parking lot and drop off my package. I have successfully realized my intention. Alternatively, I could just as easily have driven past the cleaners, proceeded directly to work, and on returning to my car that evening, realized that I have failed to complete my intention. This example is representative of many of the intentions that we either realize or fail to realize over the course of an average day.

Over the past decade a number of investigators have become keenly interested in the effects of aging on those cognitive processes and neural mechanisms that support prospective remembering. Early naturalistic [29] and laboratory-based [11] studies produced data revealing preserved prospective memory in older adults. These findings were counterintuitive within the context of Craik's [4] conceptual work proposing that age-related differences in prospective memory should be rather pronounced given the high demand that prospective remembering places upon self-initiated processes. Consistent with this proposal, more recent data clearly indicate that there are age-related declines in prospective memory in laboratory settings [19], and that older adults report that failures of prospective memory are at least as common as failures of retrospective memory in daily life [27]. There were three goals for the present review: (1) to review behavioral evidence revealing age-related differences in both the prospective and retrospective components of prospective memory; (2) to examine the neural correlates of age-related decline in prospective memory identified in recent electrophysiological studies using event-related brain potentials (ERPs) complimenting the behavioral data; and (3) to consider this behavioral and electrophysiological evidence within the context of two theoretical models of prospective memory.

1. Aging and prospective memory: behavioral data

One question that often arises in the area of prospective memory is how prospective remembering differs from other forms of memory or cognitive activity. For instance, some

* Corresponding author. Tel.: 574-631-7257; fax: 574-631-8883.
E-mail address: west.19@nd.edu (R. West).

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commentators have argued that there is little empirical evidence or conceptual necessity to distinguish between prospective memory and explicit episodic memory [7,25]. In contrast, other reviewers have suggested that there is relatively strong evidence supporting a distinction between those cognitive processes supporting prospective memory and explicit episodic memory [15]. McDaniel and Einstein [20] have proposed that the realization of intentions is supported by the interaction of multiple component processes. These processes can be broadly divided into those that support a *prospective component* and those that support a *retrospective component*. Those processes underlying the prospective component allow the individual to recognize a prospective memory (PM) cue as a stimulus that requires further action, in contrast, those processes underlying the retrospective component allow the individual to retrieve the intention associated with the cue from memory and execute the intended action. The retrospective component probably shares many of the functional characteristics of explicit episodic memory [20], while the prospective component may be more strongly aligned with processes supporting goal-directed attention [1].

A recent series of studies sought to determine the degree to which age-related differences in prospective memory result from declines in those processes supporting the prospective or retrospective components of prospective memory [3,32]. These studies used a moderate to large number of PM cues and to-be-realized intentions allowing one to estimate the frequency of prospective memory errors resulting from *omissions*, where a response appropriate to the ongoing activity was made, and *confusions*, where an inappropriate prospective response was made or the intention associated with the cue could not be retrieved from memory when the PM cue was recognized [3,32]. Omissions were taken to reflect failures of the prospective component, and confusions were taken to reflect failures of the retrospective component. Given these assumptions an estimate of the prospective component can be derived as the proportion of PM cues that elicit a prospective response regardless of whether that response is correct, and an estimate of the retrospective component can be derived as the proportion of correct prospective responses divided by the total number of prospective responses.

Estimates of the prospective and retrospective components from a number of studies using different methodologies and varying numbers of cues and intentions are presented in Table 1. Across these studies there is clearly an age-related decrease in estimates of the prospective component. In contrast, the magnitude of the age-related decline in the retrospective component varies widely across studies, being quite modest is some studies (e.g. 0.02) and larger in other studies (e.g. 0.20). One prominent finding across all of these studies is that age-related differences are greater for the prospective component than the retrospective component, even when a relatively large number of cues and intentions are included in the task [3]. Together these findings indicate that age-related declines in the efficiency of prospective memory can result both from failures to detect PM cues and instances where the individual fails to retrieve the intention associated with the cue from memory.

Table 1
Estimates of the prospective and retrospective components of prospective memory for younger and older adults in six experiments

	Prospective		Retrospective	
	Younger	Older	Younger	Older
Cohen et al. [3], Exp. 1	0.84	0.67	0.83	0.74
Cohen et al. [3], Exp. 2	0.84	0.60	0.69	0.49
Mäntylä [18]	0.72	0.46	0.81	0.65
West and Craik [32], Exp. 1	0.74	0.47	0.85	0.76
West and Craik [32], Exp. 2	0.87	0.66	0.98	0.96
West and Craik (unpublished)	0.84	0.71	0.98	0.95
Mean	0.81	0.60	0.86	0.76
95% Confidence interval	±0.05	±0.08	±0.08	±0.13

Note: The prospective component represents the proportion of PM cues that elicited a prospective response regardless of whether the correct intention was retrieved from memory or executed. The retrospective component represents the proportion of prospective responses that were correct divided by the total number of prospective responses.

In addition to being useful when studying the effects of aging on prospective memory, consideration of the prospective and retrospective components can also provide information about functional variables that influence these two aspects of prospective remembering. For instance, in one study changing the perceptual characteristics of the PM cue from formation to realization of the intention had a greater effect on the prospective component than the retrospective component, with this effect being greater for older than younger adults. In contrast, varying the degree of semantic relatedness between the PM cue and intention had a stronger influence on the retrospective component than on the prospective component. Furthermore, the findings of this study demonstrated that age-related differences in the retrospective component were somewhat smaller when the cue and intention were highly related relative to when the cue and intention were unrelated, and that the effects of aging on the retrospective component were eliminated when variance shared with cued-recall was statistically controlled using analysis of covariance [3]. This finding is consistent with the idea that older adults may have difficulty forming novel associations in a number of different contexts [28]. In contrast to the effects of aging on the retrospective component, the effects of aging on the prospective component appear to be at least partially independent of those processes supporting the recall of intentions from memory [3,32].

While the effect of aging may be greater on those processes supporting the prospective component than the retrospective component, it is certainly the case that reductions in the efficiency of the retrospective component also contribute to age-related declines in prospective memory. For instance, in one study age-related differences