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Age-related effects on the neural correlates of autobiographical memory retrieval

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Abstract

Older adults recall less episodically rich autobiographical memories (AM), however, the neural basis of this effect is not clear. Using functional MRI, we examined the effects of age during search and elaboration phases of AM retrieval. Our results suggest that the age-related attenuation in the episodic richness of AMs is associated with difficulty in the strategic retrieval processes underlying recovery of information during elaboration. First, age effects on AM activity were more pronounced during elaboration than search, with older adults showing less sustained recruitment of the hippocampus and ventrolateral prefrontal cortex (VLPFC) for less episodically rich AMs. Second, there was an age-related reduction in the modulation of top-down coupling of the VLPFC on the hippocampus for episodically rich AMs. In sum, the present study shows that changes in the sustained response and coupling of the hippocampus and prefrontal cortex (PFC) underlie age-related reductions in episodic richness of the personal past.

Keywords: Aging; fMRI; Autobiographical memory; Hippocampus; Prefrontal cortex; Episodic memory retrieval; Effective connectivity

1. Introduction

The main effect of healthy aging on autobiographical memory (AM) retrieval is attenuation in *episodic richness*, which refers to a decrease in the ratio of specific episodic details compared with broad semantic information. Although this behavioral effect has been observed in several studies (Levine et al., 2002; Piolino et al., 2002; St Jacques and Levine, 2007) its neural mechanisms are largely unknown. In particular, it is unknown *when* the age effect occurs during retrieval. A memory cue (*Where did I see these data before*?) triggers an effortful search process guided by semantic knowledge of one's own life (. . . *the Cognitive Neuroscience Society meeting*? . . . *Society for Neuroscience*?), which eventually leads to successful recovery of a target memory (*in a Society for Neuroscience poster*. . .). Memory for the target might be elaborated by recovering additional episodic details (. . . *it was early in the morning*. . .). In the case of AM, search and elaboration processes can take as long as 15–30 seconds, which allows the use of functional MRI (fMRI) to disentangle the activations associated with these 2 phases (e.g., Addis et al., 2007; Daselaar et al., 2008). The present fMRI study investigated age-effects on search and elaboration processes during AM retrieval.

The age-related reduction in episodic richness could occur early during retrieval, while one is searching for the target memory, or late during retrieval, while one elaborates upon recovered information. Elaboration processes might be more sensitive to aging because they depend on an interaction between the recovery of specific details mediated by the hippocampus and strategic control processes mediated by the prefrontal cortex (PFC), and both processes, and their associated brain regions, are known to decline with aging (for a review see Dennis and Cabeza, 2008). For example, fMRI studies have shown that hippocampal activity related to recollection is attenuated by aging, such that older adults rely more on familiarity processes associated with other medial temporal lobe (MTL) regions (e.g., Cabeza et al., 2004; Daselaar et al., 2006).

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Aging also involves changes in strategic control processes linked to frontal activation, with under-recruitment observed during memory conditions that lack environmental support (e.g., Logan et al., 2002; Paxton et al., 2008), as well as compensatory over-recruitment (Cabeza, 2002). Furthermore, episodic richness is mediated by activations that occur late during AM retrieval (Svoboda et al., 2006; Cabeza and St Jacques, 2007), and relies on the recruitment of additional self-initiated retrieval processes (Daselaar et al., 2008). In contrast, an age-related reduction in early search processes might be less likely because AM search tends to be guided by semantic memory (Conway and Pleydell-Pearce, 2000), which is a memory function relatively well preserved in older adults (Craik and Jennings, 1992). In sum, aging may have less impact on the search strategy and cue specification processes in AM that are guided by semantic information, but have greater impact on the elaboration of AM which involves additional control processes that interact with the recovery of episodic information.

To investigate the neural basis of age-related differences in episodic richness during search and elaboration phases of AM retrieval we used a self-paced design in which young and older adults searched for an AM elicited by a generic cue word, pressed a key when the memory was found, and then elaborated on the memory until the end of the trial. After scanning, participants verbally described the memories they recalled in the scanner and objective analysis of these descriptions were used to determine episodic richness. We investigated the hypothesis that age-related declines in episodic richness are associated with reduced recovery of specific details mediated by the hippocampus and strategic control processes mediated by the PFC during elaboration.

2. Methods

2.1. Participants

There were 17 young (18–35 years of age) and 16 older participants (60–75 years of age), who were healthy, right-handed and without history of neurological or psychiatric episodes. All participants reported that they were not taking medication known to affect cognitive function, and older adult participants were screened for uncontrolled hypertension. Participants gave written informed consent for a protocol approved by the Duke University Institutional Review Board. One young adult and 1 older adult were excluded due to symptoms of depression as indicated by scores > 13 on the Beck Depression Inventory (BDI; Beck and Steer, 1978). Furthermore, 2 young adults and 1 older adult were excluded from the analyses because of problems with completing the task as instructed. Thus, the reported results are based on data from 14 young (7 females; mean Age = 24.43, *SD* = 3.73) and 14 older (6 females; mean Age = 64.21, *SD* = 2.86) participants.

Demographic and psychometric data (Table 1) were obtained in a separate session within 1 week of the scanning session. All participants had obtained at least a secondary school education (12 years). Participants scored a minimum of 28 on the MiniMental State Exam (MMSE; Folstein et al., 1975) and a maximum of 11 on the BDI. There were no age-related differences in the number of years of education, MMSE, BDI, the Weschler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), verbal fluency (FAS), or categorical fluency (animal names and supermarket items).

Table 1
Participant variables by age group

	M		SD		t (26)
	Young	Older	Young	Older	Y vs. O
Age (years)	24.43	64.21	3.73	2.86	31.79**
Education (years)	16.50	17.43	2.28	1.91	1.17
MMSE	28.71	28.50	0.61	0.76	−0.82
BDI	3.93	5.07	3.29	3.47	0.89
WASI-Full IQ	122.36	126.00	7.66	10.07	1.08
WASI-Verbal IQ	120.93	123.79	7.87	7.37	0.99
WASI-Performance IQ	118.14	122.00	7.49	11.79	1.03
Verbal Fluency	47.43	42.79	10.87	16.12	−0.89
Categorical Fluency	48.79	41.21	13.55	11.78	−1.58

* $p < .0001$.

2.2. Materials

Memory cues consisted of 60 emotionally arousing words selected from the affective norms for English words (ANEW) database (Bradley and Lang, 1999), such that there were 30 positive (Valence mean = 7.93, *SD* = 0.45; Arousal Mean = 5.96; *SD* = 0.83) and 30 negative (Valence Mean = 2.17, *SD* = 0.52; Arousal Mean = 6.00; *SD* = 1.03) words that were equally arousing. In order to create auditory cues the words were recorded in a female voice and constrained to an equal duration of 1 second.

2.3. Procedure

The procedure was similar to Daselaar et al. (2008; also see Greenberg et al., 2005). During scanning participants were asked to search for AMs triggered by the auditory cue words. Participants were instructed to retrieve an AM that was specific to time and place. They indicated when a specific AM was found by making a response on the button-box and then continued to elaborate on the retrieved event in as much detail as possible for the rest of the trial. Thirty seconds following the onset of the auditory cue participants were given auditory instructions to rate the amount of emotion (−4 = negatively arousing to +4 = positively arousing) and reliving (1 = low to 8 = high) associated with the memory on an 8-point scale. Rating responses were self-paced (up to 6 seconds) and separated by at least 0.5 seconds. Participants underwent extensive training to familiarize them with the timing of the trials. There were 6 functional runs, with 10 memory cues in each run (5 positive words and 5 negative word), and an intertrial interval at least 1.5 to 7.5 seconds. Participants were instructed to keep their eyes closed for the duration of each run.