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Research Report

The effects of aging on ERP correlates of source memory retrieval for self-referential information

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ABSTRACT

Numerous behavioral studies have suggested that normal aging negatively affects source memory accuracy for various kinds of associations. Neuroimaging evidence suggests that less efficient retrieval processing (temporally delayed and attenuated) may contribute to these impairments. Previous aging studies have not compared source memory accuracy and corresponding neural activity for different kinds of source details; namely, those that have been encoded via a more or less effective strategy. Thus, it is not yet known whether encoding source details in a self-referential manner, a strategy suggested to promote successful memory in the young and old, may enhance source memory accuracy and reduce the commonly observed age-related changes in neural activity associated with source memory retrieval. Here, we investigated these issues by using event-related potentials (ERPs) to measure the effects of aging on the neural correlates of successful source memory retrieval ("old–new effects") for objects encoded either self-referentially or self-externally. Behavioral results showed that both young and older adults demonstrated better source memory accuracy for objects encoded self-referentially. ERP results showed that old–new effects onsetted earlier for self-referentially encoded items in both groups and that age-related differences in the onset latency of these effects were reduced for self-referentially, compared to self-externally, encoded items. These results suggest that the implementation of an effective encoding strategy, like self-referential processing, may lead to more efficient retrieval, which in turn may improve source memory accuracy in both young and older adults.

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1. Introduction

Numerous source memory studies have shown that healthy aging is associated with disproportionate memory decline for details associated with previously encountered events relative to simple item recognition (Mitchell and Johnson, 2009; Spencer and Raz, 1995 for reviews). Specifically, older adults often demonstrate greater difficulty determining which experimentally manipulated context or source (e.g. spatial location, color, location, and encoding operation) was associated with an item during study than they do deciding whether the item had been studied (Johnson et al., 1993 for review). This disproportionate impairment may be related to the fact that source recognition depends upon strategic processing to a

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greater extent than does item recognition. For example, source retrieval requires initiation of repeated episodic memory searches until the requisite information is recovered (Dobbins and Han, 2006; Fletcher and Henson, 2001; Simons and Spiers, 2003). One must subsequently evaluate the retrieved information and make a selection relevant to one's current goal (i.e. "is this information more consistent with Source 1 or Source 2?") while ignoring irrelevant information (reviewed in Badre and Wagner, 2007; Johnson et al., 1993). Given that these and other executive processes are disrupted in aging (Hasher and Zacks, 1979; Johnson et al., 1993), it is reasonable to assume that memory tasks that place relatively heavy demands on such processes will yield the greatest age-related impairments.

Event-related potentials (ERPs) provide a way to assess the time course of neural activity associated with memory retrieval for different kinds of source details. Specifically, studies of young adults have identified several ERP "old–new effects" that dissociate recognized studied items (i.e. hits) from correctly rejected new items during both simple item, as well as source, recognition tests. Typically, hits are associated with more positive-going deflections in the waveforms than are correctly rejected new items. One such effect, termed the "parietal old–new effect," or "late posterior positivity," occurs between approximately 400 and 800 ms and is maximal at parietal scalp sites (see Friedman and Johnson, 2000; Johnson, 1995; Rugg, 1995 for reviews). As the parietal old–new effect is largest for items that elicit correct source (Ranganath and Paller, 2000; Trott et al., 1997; Wilding and Rugg, 1996; Wilding and Rugg, 1997) or "remember" judgments (Duarte et al., 2004; Duzel et al., 1997; Smith, 1993; Trott et al., 1999), it is generally believed to reflect recollection-based memory. A second positive frontal-maximal ERP effect is sometimes observed when participants must evaluate the retrieved episodic information, as in a source memory test. This effect onsets somewhat later (~700/800 ms), is sustained for several hundred milliseconds and has been associated with monitoring and evaluation of the products of retrieval in the service of making a source memory decision (Cruse and Wilding, 2009; Hayama et al., 2008; Senkfor and Van Petten, 1998; Trott et al., 1999; Wilding and Rugg, 1996). Unlike the parietal old–new effect, the late frontal effect is not necessarily dependent upon recollection success.

Results from previous studies investigating the effects of aging on ERP correlates of source memory retrieval have largely found that the ERP effects described above are often attenuated and temporally delayed in the old relative to the young. For example, some studies have shown that older adults exhibit impaired source memory accuracy as well as attenuated parietal (Swick et al., 2006; Wegesin et al., 2002) and frontal (Wegesin et al., 2002) old–new effects. Other studies have reported that source memory accuracy and frontal, but not parietal, old–new effects were reduced in the old adults (Trott et al., 1997, 1999). Yet another study reported impaired source memory accuracy in the old but equivalent old–new effects in young and old adults (Mark and Rugg, 1998). Finally, one study reported that when source memory performance was equated between young and old adults, parietal and frontal old–new effects were unaffected by age (Li et al., 2004). Despite these discrepant results with regard to magnitude, one common finding was an onset delay of approximately 100 ms in the old–new effects of the old, suggesting that even when older adults' ERP indices of successful source memory retrieval are equivalent in magnitude to those of the young, the retrieval operations are slowed and potentially less efficient in the old (Mark and Rugg, 1998).

What is not yet known is the extent to which these age-related source memory impairments and associated ERP changes depend on the manner in which information is encoded. For example, emerging behavioral evidence suggests that encoding instructions that facilitate the linking of an item with its context (source) (e.g. "how well does this chair (item) suit the room (source)?") can reduce older adults' source memory deficits compared to instructions that do not facilitate item-source binding (Glisky et al., 2001; Glisky and Kong, 2008; Hashtroudi et al., 1994; Naveh-Benjamin et al., 2007). Interestingly, compared to a less effective encoding strategy that does not facilitate source memory accuracy, a strategy like the kind described above may alleviate the demands on the strategic processes that are typically engaged during source retrieval, as evidenced by the lack of late-onset frontal maximal ERPs in young adults (Kuo and Van Petten, 2006). Thus, effective encoding strategies may enhance older adults' source memory accuracy in part, by reducing the demands on these executive processes, like post-retrieval monitoring and selection, which are disrupted in the old (Hasher and Zacks, 1979).

One potentially effective strategy that is of growing interest is the encoding of information in a self-relevant manner. A variety of tasks have been used to assess *self-referential* processing, including deciding whether an adjective describes oneself (e.g. "Does the word *honest* describe you?") relative to another individual (e.g. "…the president?") (Symons and Johnson, 1997 for review), rating one's own beliefs about an item (e.g. "George Bush was a good president: yes/no") (Zysset et al., 2002), making a preference judgment for one item over another (Johnson et al., 2005), and making pleasantness judgments about words or images (Gusnard et al., 2001; Raposo et al., 2010) vs. self-external semantic or perceptual decisions. Self-referential processing tasks like these enhance the effectiveness of encoding, via promotion of elaboration and organization of episodic information, and subsequent memory retrieval improves as a result (Rogers et al., 1977; Symons and Johnson, 1997 for review). Importantly, the *self-external* comparison tasks are also elaborative; so the mnemonic benefit obtained by self-referential encoding cannot be explained solely by a "depth of processing" argument (Craik and Tulving, 1975).

Although no previous studies have assessed the efficacy of self-referential encoding in promoting source memory accuracy, it is reasonable to predict that such a benefit may be observed in both the young and old. For example, it is believed that the concept of *the self* remains stable as we age (Terracciano et al., 2010) and that self-referential processing and its corresponding neural correlates are largely intact in healthy older adults (Gutchess et al., 2007b). Furthermore, recent studies find that self-referential encoding improves item recognition in older adults, like young adults (Glisky and Marquine, 2009; Gutchess et al., 2007c, 2010). Some evidence additionally indicates that age-related source memory impairments can be eliminated when the source is relevant to the participant's safety (e.g. recollecting whether a food item is