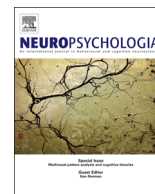




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Age-related differences in agenda-driven monitoring of format and task information



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ABSTRACT

Age-related source memory deficits may arise, in part, from changes in the agenda-driven processes that control what features of events are relevant during remembering. Using fMRI, we compared young and older adults on tests assessing source memory for format (picture, word) or encoding task (self-, other-referential), as well as on old–new recognition. Behaviorally, relative to old–new recognition, older adults showed disproportionate and equivalent deficits on both source tests compared to young adults. At encoding, both age groups showed expected activation associated with format in posterior visual processing areas, and with task in medial prefrontal cortex. At test, the groups showed similar selective, agenda-related activity in these representational areas. There were, however, marked age differences in the activity of control regions in lateral and medial prefrontal cortex and lateral parietal cortex. Results of correlation analyses were consistent with the idea that young adults had greater trial-by-trial agenda-driven modulation of activity (i.e., greater selectivity) than did older adults in representational regions. Thus, under selective remembering conditions where older adults showed clear *differential* regional activity in representational areas depending on type of test, they also showed evidence of disrupted frontal and parietal function and reduced item-by-item modulation of test-appropriate features. This pattern of results is consistent with an age-related deficit in the engagement of selective reflective attention.

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1. Introduction

Normal aging is associated with a disproportionate decrement in the ability to correctly recollect specific features of events (source memory), relative to less specific forms of memory such as old–new recognition (see Cansino (2009), Craik and Rose (2012), Daselaar and Cabeza (2008), Grady (2008), Henkel, Johnson, and De Leonardis (1998), Naveh-Benjamin and Ohta (2012), Park and McDonough (2013), Park and Reuter-Lorenz (2009), for reviews). The use of neuroimaging in source memory studies with healthy older adults is beginning to yield important information about the relative impact of aging on the various, intertwined factors involved in source memory (e.g., encoding features and binding them together, controlled reflective attention to particular features during remembering), but there is still much to be learned. In particular, little is known about age-related changes in the neural correlates of selective, agenda-driven processes engaged during remembering—that is, those processes involved in determining which features are sought, revived, and used in making a specific memory attribution (see

Johnson, Hashtroudi, and Lindsay (1993), Mitchell and Johnson (2009), for further discussion and reviews). This is the focus of the current study.

Source memory is related to encoding activity in representational regions associated with the processing of specific features, such as perceptual processing of color or location (Uncapher, Otten, & Rugg, 2006; Uncapher & Rugg, 2009), and auditory or visual information (Gottlieb, Uncapher, & Rugg, 2010). In addition, consistent with the context reinstatement hypothesis (Tulving and Thomson, 1973), the extent to which this activity (or pattern of activity) is recapitulated at test is related to episodic memory accuracy (see Rissman and Wagner (2012) for a review). But there also is behavioral (Lindsay & Johnson, 1989; Marsh & Hicks, 1998) and neuroimaging (Johnson, Kounios, & Nolde, 1997; Nolde, Johnson, & D'Esposito, 1998; see also, McDuff, Frankel, & Norman, 2009) evidence that remembering does not depend only on what is “there,” but also on what the rememberer “looks for” and how they use or evaluate (e.g., weight) what they find (Johnson et al., 1993). That is, the same encoded information can give rise to different memory outcomes and/or brain activity depending on participants’ agendas during remembering, which affect not only what they “look for,” but also what they “look at” among activated information. Similar concepts include, for example, “retrieval orientation” (e.g., Rugg and Wilding (2000)),

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“domain-sensitive biasing” (e.g., [Dobbins and Wagner \(2005\)](#)), and “cue-based planning” (e.g., [Dobbins and Han \(2006\)](#)), except that these other concepts focus more on the “looking for” than the “looking at” aspect of remembering.

There are several reasons to expect that older adults may be less able to adopt and/or carry out agendas to look for and/or evaluate specific information during remembering. Older adults are less able to, or slower to, constrain retrieval to task relevant information ([Dew, Buchler, Dobbins, & Cabeza, 2011](#); [Duverne, Motamedinia, & Rugg, 2009](#); [Jacoby, Bishara, Hessels, & Toth, 2005](#)). Hasher and Zacks and colleagues have reported considerable evidence that older adults are more distracted by task irrelevant information in many contexts (e.g., [Campbell, Grady, Ng, & Hasher, 2012](#); [Hasher & Zacks, 1988](#)). Evaluating based on an agenda presumably involves not only looking for the appropriate information, but also selectively attending to (i.e., “looking at”) a subset of activated information; older adults have deficits in selective reflective attention ([Higgins & Johnson, 2009](#); [Mitchell, Johnson, Higgins, & Johnson, 2010](#); [Oberauer, 2001](#); [Raye, Mitchell, Reeder, Greene, & Johnson, 2008](#)). Consistent with evidence that areas of lateral frontal and parietal cortex are involved in reflective monitoring of information ([Cabeza, Ciaramelli, & Moscovitch, 2012](#); [Chun & Johnson, 2011](#); [Ciaramelli, Grady, & Moscovitch, 2008](#); [Nelson et al., 2010](#)), there is evidence of age-related differences in activity in both lateral prefrontal cortex (PFC) and lateral parietal regions associated with memory monitoring (e.g., [Daselaar, Fleck, Dobbins, Madden, and Cabeza \(2006\)](#), [McDonough, Wong, and Gallo \(2012\)](#), [Mitchell, Raye, Johnson, and Greene \(2006\)](#), [Morcom, Li, and Rugg \(2007\)](#)).

To investigate agenda-dependent source memory, studies often contrast a single source identification test with old–new recognition (ON) (see [Mitchell and Johnson \(2009\)](#) for a review). Of course, old–new recognition may be agenda-driven, but it is less selective in the features that are relevant and can be based on a general feeling of familiarity ([Jacoby, 1991](#); [Mandler, 1980](#)). Nevertheless, although ON and source identification tests typically differ in the specificity of the information *required*, the same information that is relevant for a source judgment is also relevant for an ON judgment (though typically not vice versa). In other words, although specific features are not *necessary* to make an old–new discrimination, they may be used under some circumstances, especially when the old–new test occurs in the context of a source identification task. Hence, for investigating agenda-driven source monitoring, there should be an advantage to contrasting two source identification tests that direct participants to different classes of features (e.g., format, task).

Some aging studies have included two types of source test (e.g., spatial and temporal), but collapsed across them in analyses in order to, for example, compare accurate source decisions on old items with correct rejections (e.g., [Duarte, Henson, and Graham \(2008\)](#)). We are aware of only two fMRI studies that assessed age-related differences comparing two different source identification tests, and both focused primarily on changes in PFC. In a short-term source memory task designed to minimize retrieval demands and highlight activity associated with selective evaluation of format or location information relative to item recognition, older adults showed source test deficits in left lateral PFC ([Mitchell et al., 2006](#)). A study reported by [Rajah, Languay, and Valiquette \(2010\)](#) used a mini-blocked test design, and showed age-related deficits in memory for spatial and temporal information associated with age differences in activity in right dorsolateral and left anterior prefrontal cortex, respectively. The current design is an advance in that it assesses trial-by-trial selectivity of source monitoring in distinct representational areas, as well as frontal and parietal areas involved in source monitoring. Similarities and differences in young and older adults’ brain activity

under these circumstances should help clarify the nature of age-related changes in the processes involved in selective targeting of specific features according to an agenda.

We combined fMRI with a procedure that used short study-test cycles to assess young and older adults’ source memory for item format and encoding task information. In each cycle, participants saw eight labels of concrete objects presented sequentially; for half there was a corresponding picture above the label. For half of each format condition (word only, word+picture), participants were asked to indicate whether they liked the object, and for the other half whether Sarah Palin would like the object (me–Sarah encoding task). (Given that Sarah Palin was the 2008 Republican candidate for vice president, and that she continued to be in the news, we expected our participants would have a sense of her as a person on which to base their “like” judgment.) Next, participants were shown six labels successively; two trials tested whether the item was shown at encoding with a picture or only as a word (format: PW), two whether participants did the “like” task for me or Sarah (task: MS), and two whether the item was old or new (ON).

We chose these two features (format and encoding task) because processing of these two types of information should generate activity in distinct brain regions. There is considerable evidence that (in young adults) both encoding and remembering visual information are associated with activity in posterior sensory regions, including parahippocampal gyrus, fusiform gyrus, and middle occipital cortex ([Kensinger & Schacter, 2006](#); [Slotnick, Thompson, & Kosslyn, 2012](#); [Takahashi, Ohki, & Miyashita, 2002](#); [Wheeler, Petersen, & Buckner, 2000](#)), and that greater activity is associated with better memory for specific detail ([Garoff, Slotnick, & Schacter, 2005](#); [Kensinger & Schacter, 2007](#)). There is evidence of age-related changes in the processing of visual information by posterior brain areas during both passive viewing and memory tasks ([Carp, Park, Polk, & Park, 2011](#); [Chee et al., 2006](#); [Park et al., 2004](#); [Payer et al., 2006](#)), though the extent to which, and circumstances under which, these age differences reflect differences in perceptual vs. reflective processing remains to be clarified ([Mitchell et al., 2010](#); see also, [Chee et al., 2006](#)).

On the other hand, previous findings across a range of tasks suggest that anterior and posterior midline regions (medial prefrontal cortex [mPFC] and posterior cingulate/precuneus) play a role in processing and/or representing person information (see [Denny, Kober, Wager, and Ochsner \(2012\)](#), [Murray, Schaer, and Debbané \(2012\)](#), [Northoff et al. \(2006\)](#), for reviews and meta-analyses). An additional reason to expect activity in mPFC to be associated with our encoding task is that, in source memory tasks, activity in medial and lateral anterior PFC is associated with records of reflective cognitive operations, such as those engaged by evaluative judgment tasks, even when they do not explicitly reference the self (e.g., [Dobbins and Wagner \(2005\)](#), [Kensinger and Schacter \(2006\)](#), [Mitchell et al. \(2008\)](#), [Simons, Henson, Gilbert, and Fletcher \(2008\)](#), [Turner, Simons, Gilbert, Frith, and Burgess \(2008\)](#), [Vinogradov et al. \(2006\)](#)). Several studies show that older adults’ memory, including memory for details, can benefit from self-referential processing as much as young adults’, though this does not completely ameliorate age-related deficits ([Dulas, Newsome, and Duarte \(2011\)](#), [Gutchess, Kensinger, Yoon, and Schacter \(2007\)](#), [Hamami, Serbun, and Gutchess \(2011\)](#)). Also, evidence suggests that there may be age-related changes in medial frontal activity during encoding or remembering person or task information ([Feyers, Collette, D’Argembeau, Majerus, and Salmon \(2010\)](#), [Gutchess, Kensinger, and Schacter \(2010\)](#), [Mitchell et al. \(2009\)](#)). Other data suggest young and older adults’ brain activity often looks fairly similar under these circumstances ([Dulas et al. \(2011\)](#), [Gutchess, Kensinger, and Schacter \(2007\)](#), but see [Li, Morcom, and Rugg \(2004\)](#)).

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