CORTEX 49 (2013) 1585–1597

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

Differential effects of aging on the neural correlates of recollection and familiarity

Lucie Angel [a,b,*], *Christine Bastin* [a], *Sarah Genon* [a], *Evelyne Balteau* [a], *Christophe Phillips* [a], *André Luxen* [a], *Pierre Maquet* [a], *Eric Salmon* [a] *and Fabienne Collette* [a,c]

[a] *Cyclotron Research Centre, University of Liège, Liège, Belgium*
[b] *University François-Rabelais of Tours, UMR CNRS 7295 CeRCA, Tours, France*
[c] *Department of Psychology, Cognition and Behavior, University of Liège, Liège, Belgium*

ARTICLE INFO

Article history:
Received 7 May 2012
Reviewed 29 June 2012
Revised 16 August 2012
Accepted 1 October 2012
Published online 27 October 2012

Keywords:
Aging
Recollection
Familiarity
fMRI

ABSTRACT

The present experiment aimed to investigate age differences in the neural correlates of familiarity and recollection, while keeping performance similar across age groups by varying task difficulty. Twenty young and 20 older adults performed an episodic memory task in an event-related functional magnetic resonance imaging (fMRI) design. At encoding, participants were presented with pictures, either once or twice. Then, they performed a recognition task, with a Remember/Know paradigm. A similar performance was observed for the two groups in the Easy condition for recollection and in the Hard condition for familiarity. Imaging data revealed the classic recollection-related and familiarity-related networks, common to young and older groups. In addition, we observed that some activity related to recollection (left frontal, left temporal, left parietal cortices and left parahippocampus) and familiarity (bilateral anterior cingulate, right frontal gyrus and left superior temporal gyrus) was reduced in older compared to young adults. However, for recollection processes only, older adults additionally recruited the right precuneus, possibly to successfully compensate for their difficulties, as suggested by a positive correlation between recollection and precuneus activity.

1. Introduction

Dual-process models of recognition memory postulate that the ability to recognize previously encountered information depends upon two mechanisms: recollection and familiarity (Mandler, 1980; see Yonelinas, 2002 for review). Recollection refers to processes allowing mental reinstatement of the previous episode, implying a conscious retrieval of contextual details associated with the stimulus, whereas familiarity corresponds to retrieval of the item without specific contextual information. The efficiency of recollection and familiarity processes is typically assessed by either objective or subjective methods. For instance, in source memory paradigms, participants are instructed to retrieve specific contextual details associated with the target item during the study phase (e.g., color, spatial location, temporal information). Another frequently used method is the Remember/Know paradigm (Tulving, 1985); during a recognition test, participants are asked to choose Remember responses if they are able to recollect something associated with the previous

* *Corresponding author*. University François-Rabelais, UMR CNRS 7295 CeRCA, 3 Rue des Tanneurs, 37041 Tours Cedex, France.
E-mail addresses: lucie.angel@univ-tours.fr, lucieangel@yahoo.fr (L. Angel).
0010-9452/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.cortex.2012.10.002

presentation of the item, or Know responses if the item is familiar but no contextual information is available. A large body of evidence from behavioral studies suggests a differential effect of aging on recollection and familiarity processes (Bastin and Van der Linden, 2003; Bugaiska et al., 2007; see Davidson and Glisky, 2002 for review); while familiarity-based recognition is relatively preserved, the ability to recollect the spatio-temporal context is strongly impaired in healthy older adults. This dissociation may be related to the fact that recollection processes are supposed to be more resource-dependent than familiarity processes (see Yonelinas, 2002 for review).

Functional neuroimaging methods (e.g. fMRI) have started to explore age-related changes in the neural activity associated with memory retrieval, helping understand the factors that contribute to recollection and familiarity performance in aging. Studies in the field of cognitive neuroscience of memory aging have described two distinct patterns of age-related differences. First, some studies have reported decreases in retrieval-related activity in some brain areas in older adults, reflecting presumably a decline in the functional integrity of these regions (see Dennis and Cabeza, 2008; Grady, 2008; Park and Reuter-Lorenz, 2009 for reviews). Second, and perhaps more unexpectedly, a growing body of research has revealed an age-related increase in activations in some brain areas, especially in frontal and parietal areas. For instance, several studies have reported that older adults recruit supplementary areas in the contralateral hemisphere when carrying out cognitive tasks that are associated with lateralized brain activity in young adults, resulting in more symmetrical patterns of memory-related activity in older than younger adults [*Hemispheric Asymmetry Reduction in OLD age* (HAROLD model); Cabeza, 2002]. These findings have been interpreted either as reflecting a compensatory response to deficits in other brain areas (Cabeza et al., 2002; Manenti et al., 2011; Reuter-Lorenz et al., 2000), or as the consequence of an age-related cortical dedifferentiation process, leading to processing inefficiency (Morcom and Friston, 2012; Persson et al., 2006).

Very few studies have examined the effects of aging on the neural correlates of retrieval operations by dissociating recollection and familiarity processes. In the first fMRI study addressing this issue directly, Daselaar et al. (2006) isolated activity associated with recollection and familiarity by means of a recognition task with confidence judgments. They found that the neural correlates of recollection and familiarity were differentially affected by aging. While the recollection-related activity in the hippocampus and posterior cortical regions was reduced by aging, older adults showed enhanced familiarity-related activity in the rhinal cortex. This was interpreted as suggesting that older adults compensate for their recollection deficit by relying more than young adults on familiarity processes. This finding is of great interest since it suggests that older adults may sometimes implement alternative strategies to overcome their difficulties. Two fMRI studies explored age-related effects on recollection and familiarity processes using the Remember/Know paradigm (Duarte et al., 2010, 2008). Deficits of recollection in older adults were associated with impaired activity in parietal and retrosplenial regions (Duarte et al., 2008) or in parieto-occipital regions (Duarte et al., 2010). In addition, familiarity-related activity in the frontal and temporal cortex was also reduced in older adults (Duarte et al., 2010). It should be noted that these older adults had impaired behavioral estimates of familiarity, which is inconsistent with the classic finding of intact familiarity in aging. As explained by the authors, that study also aimed to explore the neural correlates of false recognition, so participants were selected in order to provide enough false alarms, which may explain this particular behavioral pattern.

Overall, these data suggest age-related differences in neural activity associated with recollection and familiarity. However, the interpretation of these findings is ambiguous because of age-related differences in performance. Indeed, as in most previous neuroimaging studies of cognitive aging, between-group differences in the pattern of brain activation could be attributed to age but also to differential memory performance. Older adults may show reduced activations only because they experience greater difficulty executing the memory task. Consequently, findings of increased or decreased brain activity can be unambiguously interpreted only if performance is equated between age groups. Furthermore, equating overall memory performance is not sufficient, since the relative contribution of different processes (e.g., recollection and familiarity) may still differ between young and older groups. Two earlier studies have addressed this issue directly (Duverne et al., 2008; Morcom et al., 2007; see also Li et al., 2004 for a study using ERPs). In both experiments, recollection performance, as indexed by the ability to retrieve encoding contextual details (source memory paradigms), was matched between a young group and an older group by varying the number of presentations of items at study (from 1 to 3). Older adults showed enhanced recollection-related activity compared to young adults in a hippocampal region and in the extrastriate visual cortex in one study (Duverne et al., 2008), and in a large left-sided network including prefrontal regions, parietal, temporo-parietal, occipital cortices and the right temporal lobe and left anterior medial temporal lobe in the other (Morcom et al., 2007). However, these studies did not examine familiarity-related neural activity. Another potential issue concerning these studies is that both used source memory paradigms to assess the ability to recollect information. With this method, items associated with incorrect source judgments are used to index familiarity. However, they may also include a contribution of recollection processes for the retrieval of contextual attributes that are irrelevant for the source memory task. As acknowledged by the authors, another limitation of these studies is that the brain correlates of recollection processes were isolated by contrasting neural activity for items that were recognized with a correct source judgment and neural activity for correctly rejected items. In addition to recollection processes, this contrast is likely to reflect the involvement of familiarity.

The present study was designed to address all the above-mentioned issues. We used fMRI to investigate the effects of aging on the neural correlates of recollection and familiarity. First, participants encoded pictures incidentally with a semantic orienting task. In order to avoid the confounding effects of age with performance factors, task difficulty was manipulated by varying the number of presentations of items during study. Thus, pictures were presented either once or