Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/brainres

Research Report

Memory for shape reactivates the lateral occipital complex

*Jessica M. Karanian**, *Scott D. Slotnick*

Department of Psychology, Boston College, Chestnut Hill, MA, United States

ARTICLE INFO

Article history:
Accepted 16 January 2015
Available online 23 January 2015

Keywords:
Encoding
fMRI
LOC
Retrieval
Shape

ABSTRACT

Memory is thought to be a constructive process in which the cortical regions associated with processing event features are reactivated during retrieval. Although there is evidence for non-detailed cortical reactivation during retrieval (e.g., memory for visual or auditory information reactivates the visual or auditory processing regions, respectively), there is limited evidence that memory can reactivate cortical regions associated with processing detailed, feature-specific information. Such evidence is critical to our understanding of the mechanisms of episodic retrieval. The present functional magnetic resonance imaging (fMRI) study assessed whether the lateral occipital complex (LOC), a region that preferentially processes shape, is associated with retrieval of shape information. During encoding, participants were presented with colored abstract shapes that were either intact or scrambled. During retrieval, colored disks were presented and participants indicated whether the corresponding shape was previously "intact" or "scrambled". To assess whether conscious retrieval of intact shapes reactivated LOC, we conducted a conjunction of shape perception/encoding and accurate versus inaccurate retrieval of intact shapes, which produced many activations in LOC. To determine whether activity in LOC was specific to intact shapes, we conducted a conjunction of shape perception/encoding and intact versus scrambled shapes, which also produced many activations in LOC. Furthermore, memory for intact shapes in each hemifield produced contralateral activity in LOC (e.g., memory for left visual field intact shapes activated right LOC), which reflects the specific reinstatement of perception/encoding activity. The present results extend previous feature-specific memory reactivation evidence and support the view that memory is a constructive process.

1. Introduction

Memory is thought to be a constructive process in which cortical regions associated with processing event features during perception/encoding are reactivated during retrieval (for a review, see Schacter et al., 1998). That is, the construction of a memory, which is comprised of multiple features, can be described as linking the features that are processed in different cortical regions. For example, retrieval of visual information (i.e., pictures) and auditory information (i.e., sounds) reactivates visual and auditory processing regions (Wheeler et al., 2000; see also, Nyberg et al., 2000; Stark et al., 2010; Vaidya et al., 2002),

*Corresponding author at: Boston College, Department of Psychology, McGuinn Hall, Room 316, 140 Commonwealth Avenue, Chestnut Hill, MA 02467, United States. Fax: +1 617 552 0523.
E-mail address: jessica.karanian@bc.edu (J.M. Karanian).

http://dx.doi.org/10.1016/j.brainres.2015.01.024
0006-8993/

retrieval of actions reactivates motor processing regions (Nilsson et al., 2000; Nyberg et al., 2001), and retrieval of odors reactivates olfactory processing regions (Gottfried et al., 2004). These findings provide support for the constructive memory framework in which sensory activity associated with perception/encoding is reinstated during retrieval.

There is also evidence that sensory reactivation occurs during more detailed, feature-specific memories. Specifically, memory for color reactivates color processing region V8 (Simmons et al., 2007; Slotnick, 2009a), memory for motion reactivates motion processing region MT+ (Karanian and Slotnick, 2014; Slotnick and Thakral, 2011; Ueno et al., 2009), and memory for spatial location reactivates contralateral extrastriate cortex (i.e., shapes previously presented in the right visual field reactivate left extrastriate regions, and vice versa; Slotnick, 2009b). These feature-specific results provide compelling evidence that details at perception/encoding are reactivated during retrieval. However, to our knowledge, no studies have investigated whether memory for shape reactivates the lateral occipital complex (LOC), a region that preferentially processes shape.

In the present study, we investigated whether memory for shape reactivates LOC. LOC is comprised of multiple sub-regions including a lateral occipital region adjacent to MT/V5, which is referred to as LO, and a ventral region that lies within the posterior fusiform gyrus, which is referred to as pFs (Grill-Spector et al., 1998, 2000, 2001; Kourtzi and Kanwisher, 2000, 2001; Larsson and Heeger, 2006; Liu et al., 2004; Malach et al., 1995, 2002). In terms of function, LOC generally responds to shapes and objects to a greater degree than textures, patterns, and random visual noise (Malach et al., 1995). LOC is also more responsive during perception of intact images than scrambled images under numerous stimulus manipulations (i.e., lines, shading, texture, and depth cues; Kourtzi and Kanwisher, 2000), and neurons within LOC decrease in firing rate as images become more scrambled (Grill-Spector et al., 1998). It has also been suggested that LOC processes higher-level shape information, as opposed to lower-level feature information (Kourtzi and Kanwisher, 2001), and its activity is correlated with accurate object perception (Grill-Spector et al., 2000). Reiterating the role of LOC in higher-level representation of shape, this region is also active during mental imagery of geometric properties (Newman et al., 2005; see also, Deshpande et al., 2010).

During the encoding phase of the current study, participants viewed a series of intact shapes and scrambled shapes that were each presented in a unique color (Fig. 1, left). During the retrieval phase, colored disks were presented in the center of the screen and participants were asked to classify the corresponding shape as previously "intact" or "scrambled" in the "left" or "right" visual field (Fig. 1, right). To localize LOC, we contrasted perception/encoding of intact shapes and scrambled shapes (i.e., encoding-intact shapes > encoding-scrambled shapes). Activity associated with memory for intact shapes was isolated by contrasting accurate retrieval of intact shapes and inaccurate retrieval of intact shapes (i.e., intact-hits > intact-misses) in addition to contrasting accurate retrieval of intact shapes and accurate retrieval of scrambled shapes (i.e., intact-hits > scrambled-hits). Based on the constructive memory framework, we hypothesized that memory for intact shapes would activate LOC.

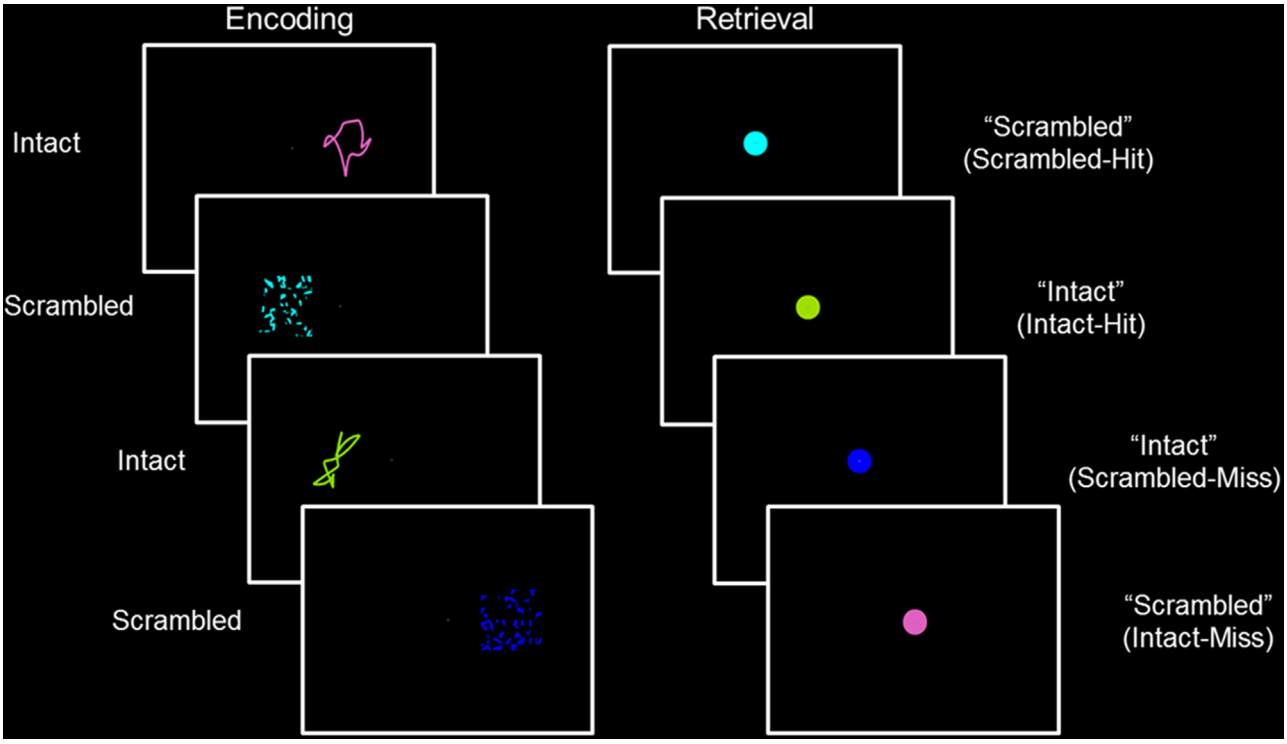

Fig. 1 – Stimulus paradigm and responses. At encoding, intact or scrambled shapes were presented to the left or right of fixation. At retrieval, colored disks were presented at fixation and participants classified the corresponding item as previously "intact" or "scrambled" within the "left" or "right" visual field. Example responses and event types are shown to right.