Neuropsychologia 49 (2011) 945–960

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

The role of episodic memory in controlled evaluative judgments about attitudes: An event-related potential study

Ray Johnson Jr.*, Elizabeth J. Simon, Heather Henkell, John Zhu

Department of Psychology, Queens College/CUNY, 65-30 Kissena Blvd., Flushing, NY 11367, United States

ARTICLE INFO

Article history:
Received 21 June 2010
Received in revised form
16 November 2010
Accepted 14 January 2011
Available online 22 January 2011

Keywords:
Attitudes
Autobiographical memory
ERPs
Evaluative judgments
Parietal EM effect

ABSTRACT

Event-related potentials (ERPs) are unique in their ability to provide information about the timing of activity in the neural networks that perform complex cognitive processes. Given the dearth of extant data from normal controls on the question of whether attitude representations are stored in episodic or semantic memory, the goal here was to study the nature of the memory representations used during conscious attitude evaluations. Thus, we recorded ERPs while participants performed three tasks: attitude evaluations (i.e., agree/disagree), autobiographical cued recall (i.e., You/Not You) and semantic evaluations (i.e., active/inactive). The key finding was that the parietal episodic memory (EM) effect, a well-established correlate of episodic recollection, was elicited by both attitude evaluations and autobiographical retrievals. By contrast, semantic evaluations of the same attitude items elicited less parietal activity, like that elicited by Not You cues, which only access semantic memory. In accord with hemodynamic results, attitude evaluations and autobiographical retrievals also produced overlapping patterns of slow potential (SP) activity from 500 to 900 ms preceding the response over left and right inferior frontal, anterior medial frontal and occipital brain areas. Significantly different patterns of SP activity were elicited in these locations for semantic evaluations and Not You cues. Taken together, the results indicate that attitude representations are stored in episodic memory. Retrieval timing varied as a function of task, with earlier retrievals in both evaluation conditions relative to those in the autobiographical condition. The differential roles and timing of memory retrieval in evaluative judgment and memory retrieval tasks are discussed.

Attitudes are distinct from other mental processes because they embody evaluative judgments based on internal scales that reflect an individual's values. By providing a basis for deciding whether to approach or avoid particular people, situations and objects, attitudes play an important role in everyday behavior. However, despite the fact that behavior is affected strongly by attitudes, relatively little is known about how they are represented and processed in the brain. Previously, we described the event-related brain potential (ERP) correlates of some executive control and affective processes used to make truthful and deceptive attitude evaluations (i.e., agree-disagree) (Johnson, Henkell, Simon, & Zhu, 2008). Here, we examine whether the representations retrieved during conscious attitude evaluations are stored in episodic or semantic memory.

Although the processes used in attitude evaluations have been characterized using dual-process models for years (e.g., Breckler, 1984), researchers have only recently begun to specify how these processes are instantiated in the brain. In one model, reflexive responses are posited to be rapid, automatic and based on unconscious processes whereas reflective responses are thought to be slower, controlled and based on resource-demanding processes (Lieberman, 2003, 2007). The purpose of the reflective system is to enable the automatic evaluations produced by the reflexive system to be overridden so that responses can be adaptively determined based on the current context and goals. In another model, both reflexive and reflective evaluations are posited to be made hierarchically using a common set of processes, with the primary difference between them being the duration of the evaluation process (Cunningham & Zelazo, 2007). In both these models, reflexive and reflective evaluations are linked to different memory systems. For example, reflexive evaluations are believed to depend on the amygdala due to its role in processing affective information and storing affective memories (e.g., Cunningham, Raye, & Johnson, 2004; Lieberman, 2003; Stanley, Phelps, & Banaji, 2008). By contrast, reflective evaluations are posited to rely on declarative memory and brain areas such as the hippocampus and dorsolateral frontal cortex (e.g., Cunningham, Raye, & Johnson, 2005; Cunningham & Zelazo, 2007; Lieberman, 2003; Lieberman, Jarcho, & Satpute, 2004).

* Corresponding author.. Tel.: +1 718 997 3241; fax: +1 718 997 3257.
E-mail address: ray.johnson@qc.cuny.edu (R. Johnson Jr.).

0028-3932/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.neuropsychologia.2011.01.028

One unresolved question concerns whether the declarative memory representations used for controlled attitude evaluations rely on stores located in episodic or semantic memory. Characterizing attitudes as a type of self knowledge, some researchers have argued that they are stored in semantic memory along with other types of knowledge (e.g., Ochsner & Lieberman, 2001). According to this view, although attitudes are at least partially based on autobiographical and/or episodic memories about specific life events, they ultimately represent schematic versions of these events in which the specific contextual information associated with the memories has been lost. The result is a relatively stable memory representation, or "tag," containing information related to the valence and/or the type of response associated with the particular attitude item (e.g., approach or avoid). In this view, the acontextual nature of these attitude representations is seen as more closely resembling the characteristics of semantic memory than those of episodic memory (Tulving, 1983). Empirical support for this idea has come from studies of another type of self knowledge, that regarding one's personality traits. These studies have demonstrated that amnesic patients retain at least some ability to acquire new trait knowledge, despite having a diminished ability to make new episodic memories (e.g., Kihlstrom, Beer, & Klein, 2002; see Klein, Cosmides, Tooby, & Chance, 2002 for a review; Klein & Loftus, 1996). Thus, these researchers concluded that the ability to create new trait knowledge is relatively independent of episodic memory. Finally, a recent account by Wood and Grafman (2003) takes a different view that emphasizes the role of frontal brain areas as the location of storage and processing of social and self knowledge.

An alternate approach is to use brain imaging techniques, such as those providing measures of hemodynamic (e.g., positron emission tomography, PET; functional magnetic resonance imaging, fMRI) or electrical activity (e.g., ERPs), to study how healthy individuals make attitude evaluations. In one notable fMRI study, Zysset, Huber, Ferstl, and von Cramon (2002) compared the brain activity when participants made evaluative judgments (i.e., agree/disagree) about a series of short sentences (e.g., I like Leipzig) to when they retrieved autobiographical (e.g., I have been to Leipzig) or semantic memories (e.g., Leipzig is a large city). These researchers reported that their evaluative and autobiographical conditions produced largely overlapping patterns of brain activity that were significantly different from that found during semantic retrieval. Moreover, the evaluative-episodic differences that were found are best characterized as quantitative rather than qualitative. For example, both conditions produced activation in anterior medial frontal and precuneus regions, with evaluative judgments showing greater activity in the former and autobiographical retrieval showing greater activity in the latter. Zysset et al. (2002) interpreted their results as reflecting the differing contributions of self-referential processing (anterior medial frontal cortex) and autobiographical retrieval (precuneus cortex) in these two conditions. Semantic retrievals, by contrast, failed to show activation in either of these two regions. Nevertheless, semantic retrievals and evaluative judgments did show similar patterns of activity in left inferior prefrontal cortex, a result assumed to reflect the need for selection processes in both tasks (Thompson-Schill, D'Esposito, Aguirre, & Farah, 1997). Finally, all three conditions showed similar increases in activity in left and right inferior frontal cortex and occipital cortex. In sum, these researchers concluded that the processes used during attitude evaluations were more similar to those used for autobiographical retrievals than to those used for semantic judgments. The study did not, however, determine the nature of the memory representations for attitude evaluations.

Determining where attitude representations are stored is likely to be difficult based on hemodynamic data alone given the disparity between the speed of attitude evaluations and the sluggishness of the hemodynamic response. For example, temporal characterizations of hemodynamic responses in attitude studies typically show brain activations lasting many times the 1–2 s it actually took to complete the evaluations in these studies (e.g.,Cunningham, Johnson, Gatenby, Gore, & Banaji, 2003; Zysset et al., 2002). Although the timing of evaluation processes is an important component of models of attitude evaluation, the temporal resolution of the fMRI method is insufficient to specify either the duration or relative timing of the processes involved. For example, the main component of Cunningham and Zelazo's (2007) attitude model is an iterative re-processing loop in which memory representations can be retrieved and modified repeatedly prior to reaching a final evaluation (Cunningham & Zelazo, 2007). In view of the fact that their iterative loop is posited to cycle at a rate of several times per second, hemodynamic methods are ill suited for testing a least this aspect of their model.

The high temporal resolution of the ERP can, however, reveal details about the timing of the processes used to make controlled attitude evaluations. Further, given the substantial body of research showing that episodic and semantic retrieval elicit different patterns of ERP activity, the question of where these representations are stored can also be addressed. Episodic retrieval, for example, elicits a specific pattern of ERP activity, which is revealed when ERPs elicited by items not in episodic memory (i.e., "new") are subtracted from ERPs elicited by items in episodic memory (i.e., "old"). The resulting old-new difference ERP consists of a series of subcomponents, collectively known as the "old/new" or "episodic memory" (EM) effect, each of which correlates with a different aspect of the retrieval process and has its own unique spatio-temporal characteristics (for reviews see Friedman & Johnson, 2000; Johnson, 1995; Rugg & Curran, 2007). The parietal EM effect, which is most relevant here because of its association with recollective processes, appears as additional amplitude for old items that is superimposed on the late positive component (LPC). The parietal EM effect is maximal over left parietal scalp between 500 and 800 ms after stimulus onset (e.g., Johnson, Pfefferbaum, & Kopell, 1985; Smith, Haynes, Lazarus, & Pope, 1993; Van Petten, 1995; Wilding, Doyle, & Rugg, 1995). Although the latency of the parietal EM effect increases with retrieval difficulty (Johnson et al., 1985; Johnson, Kreiter, Zhu, & Russo, 1998; Johnson, Barnhardt, & Zhu, 2005), its scalp topography, which reflects activity of the underlying neural generators, does not vary as a function of either retrieval timing or type of retrieval (i.e., recognition or recall) (Donaldson & Rugg, 1999). It should be noted that the parietal EM effect reflects recollection of item information because retrieval of associated source information elicits ERP activity that is maximal over right frontal scalp in a later time window (see Friedman & Johnson, 2000). Finally, when verbal stimuli are used, the ERPs elicited by "new" words, which by definition are only in semantic memory, reflect the brain activity associated with semantic retrieval.

Recent studies aimed at identifying the functional significance of the parietal EM effect have found that its amplitude reflects the amount of information retrieved (Vilberg, Moosavi, & Rugg, 2006; Vilberg & Rugg, 2009b). Further, by combining data from two brain imaging methods, Vilberg and Rugg (2009b) provided ERP evidence to support the idea that the parietal EM effect reflects the online maintenance of recollected episodic memories and fMRI evidence to show that this ERP activity is generated in left inferior parietal cortex. After ruling out other processes that it might represent (e.g., reorientation of attention to retrieved information), these investigators suggested that the parietal EM effect may functionally be part of Baddeley's (2000) proposed "episodic buffer" (Vilberg & Rugg, 2008, 2009a).

Despite some similarities, there are important differences between autobiographical retrieval and attitude evaluations that affect how the stimuli in these tasks are processed. These differ-