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Electrophysiological distinctions between recognition memory with and without awareness

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ABSTRACT

The influence of implicit memory representations on explicit recognition may help to explain cases of accurate recognition decisions made with high uncertainty. During a recognition task, implicit memory may enhance the fluency of a test item, biasing decision processes to endorse it as "old". This model may help explain recognition-without-identification, a remarkable phenomenon in which participants make highly accurate recognition decisions despite the inability to identify the test item. The current study investigated whether recognition-without-identification for pictures elicits a similar pattern of neural activity as other types of accurate recognition decisions made with uncertainty. Further, this study also examined whether recognition-without-identification for pictures could be attained by the use of perceptual and conceptual information from memory. To accomplish this, participants studied pictures and then performed a recognition task under difficult viewing conditions while event-related potentials (ERPs) were recorded. Behavioral results showed that recognition was highly accurate even when test items could not be identified, demonstrating recognition-without-identification. The behavioral performance also indicated that recognition-without-identification was mediated by both perceptual and conceptual information, independently of one another. The ERP results showed dramatically different memory related activity during the early 300 to 500 ms epoch for identified items that were studied compared to unidentified items that were studied. Similar to previous work highlighting accurate recognition without retrieval awareness, test items that were *not identified*, but correctly endorsed as "old," elicited a negative posterior old/new effect (i.e., N300). In contrast, test items that were *identified* and correctly endorsed as "old," elicited the classic positive frontal old/new effect (i.e., FN400). Importantly, both of these effects were elicited under conditions when participants used perceptual information to make recognition decisions. Conceptual information elicited very different ERPs than perceptual information, showing that the informational wealth of pictures can evoke multiple routes to recognition even without awareness of memory retrieval. These results are discussed within the context of current theories regarding theN300 and the FN400.

1. Introduction

Long-term memory has been classically divided into explicit and implicit memory (Squire & Zola, 1996). Explicit memory is commonly assessed by intentional learning tasks and direct tests like recognition, where participants view a test item and judge whether it was previously studied or not. In contrast, implicit memory is commonly assessed by incidental learning tasks and indirect tests that make no reference to studied information, and unlike explicit memory, behavior on implicit memory tests can accurately indicate evidence of memory without a subjective sense that the test information was previously studied. In other words, implicit memory retrieval lacks retrieval awareness. Although the dissociation between explicit and implicit memory has long been supported (Graf, Squire & Mandler, 1984; Verfaellie, Bauer & Bowers, 1991; Paller & Kutas, 1992; Rugg et al., 1998), less is known about how the two kinds of memory interact (Dew & Cabeza, 2011). Certainly, previous work has shown that tasks targeting explicit memory can be influenced by implicit memory and vice versa (Jacoby & Dallas, 1981; Verfaellie & Cermak, 1999; Voss, Baym & Paller, 2008). For this reason, it is important to understand how different memory systems inform decision-making related to memory.

The influence of implicit memory on explicit memory decisions may help to explain three effects in the memory literature in

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which recognition decisions are made with varying levels of uncertainty. First, *familiarity* is a subjective sense of having previously encountered an item without any available recollected details to assure certainty of its studied or unstudied status. Familiarity has been characterized within a signal detection framework as a measure of memory strength along a continuum, and items associated with high levels of subjective familiarity allow for fairly accurate recognition decisions (Yonelinas, Aly, Wang & Koen, 2010). Second, recognition decisions can also be highly accurate even when participants report that they are guessing, an effect called *implicit recognition* (Voss et al., 2008; Voss & Paller, 2009). In these studies, participants were instructed to "guess" when they had no confidence of memory, indicating a high level of uncertainty with little or no sense of familiarity or retrieval awareness. Finally, recognition decisions can be accurate even when the test item cannot be identified, an effect called *recognition-without-identification* (Cleary & Greene, 2001, 2005). Presently, the cognitive processes that underlie recognition-without-identification remain unclear, but we speculate that levels of retrieval awareness, certainty, and familiarity remain at their lowest because test items are not identified. Previous research has investigated the neural activity related to familiarity (Rugg & Curran, 2007; Rugg et al., 1998; Woodruff, Hayama & Rugg, 2006), implicit recognition (Voss & Paller, 2009), and more recently, recognition-without-identification for *words* (Ryals, Yadon, Nomi & Cleary, 2011). The objective of the current study was to understand neural activity related to recognition-without-identification for *pictures*. Primarily, we wanted to understand whether recognition-without-identification for pictures evoked similar ERP activity as that associated with implicit recognition or that associated with familiarity. Since pictures convey a rich amount of information, we were also interested in whether recognition-without-identification for pictures was primarily based on perceptual or conceptual information, and whether it would evoke distinct neural patterns of activity depending on the kind of information used during retrieval.

How does an underlying implicit memory representation, which is generally not accompanied by awareness of previous exposure, influence explicit memory decisions? One popular model, the fluency heuristic model, proposes that when a test item on a recognition task is relatively easy to process, participants often attribute this experience of *processing fluency* to having previously studied the test item (Jacoby & Dallas, 1981). Under conditions of uncertainty, the sense of fluency can lead to accurate responses when the item activates a previous implicit memory representation (Jacoby & Dallas, 1981; Whittlesea, 1993; Conroy, Hopkins & Squire, 2005). However, fluency can also lead to significant false recognition (Jacoby & Whitehouse, 1989), particularly when test items create high levels of subjective fluency by activating associative conceptual or semantic networks (Karpicke, McCabe, & Roediger, 2008). Previous research has shown that the use of fluency heuristics often leads to recognition judgments based purely on familiarity (Rajaram, 1993). *Familiarity* is an acontextual, vague subjective sense that an item has been seen before, and stands in contrast to *recollection*, which is a vivid, contextually-boundform of recognition (Yonelinas, 2002). Electroencephalogram (EEG) measures have shown that familiarity strength modulates a negative-going frontal event-related potential (ERP) called the FN400 by evoking more positive activity for test items reported as "old" compared to those reported as "new" (Ally & Budson, 2007; Rugg & Curran, 2007; Rugg et al., 1998; Woodruff et al., 2006). However, the relationship between familiarity and the FN400 has become controversial, as some investigators have linked the FN400 with conceptual implicit memory (Voss, Lucas & Paller, 2010, 2012). This controversy will be discussed in more detail below as it relates to our hypotheses.

The fluency heuristic model may also help to explain the phenomenon of *implicit recognition*, which is highly accurate guessing during recognition decision-making (Voss et al., 2008; Voss & Paller, 2009). As an example, Voss and Paller (2009) had participants study abstract "kaleidoscope"images under full or divided attention. At test, participants performed a two-alternative forced-choice recognition task and followed their choice with a subjective "remember", "know", or "guess" response to indicate whether their choice was based on recollection, familiarity, or a guess lacking retrieval awareness, respectively. ERPs recorded at test showed distinct old/new effects depending on these subjective ratings of awareness. "Know" and "remember" responses to studied items compared to new items evoked positive activity in both early (180–220 ms) and late (600–900 ms) epochs over frontal and parietal areas. In contrast, correctly "guessed" items evoked a greater *negativity* compared to new items between 200 and 400 ms (N300) over occipital areas. Voss and Paller (2009) proposed that these ERP findings indicated distinct neural bases for recognition driven by explicit memory with retrieval awareness and implicit memory lacking retrieval awareness. Voss and colleagues (2008; see also Voss & Paller, 2009) further proposed that, during the forced-choice recognition, the higher perceptual fluency of studied items relative to unstudied items influenced participants to choose studied items as "old" even if they were unaware of previously viewing either item. This account is similar to how fluency can lead to familiarity judgments, except that instead of a weak sense of retrieval, participants lacked awareness at retrieval.

Our final example of how implicit memory influences explicit memory decisions, recognition-without-identification, describes accurate recognition of a test item even when it cannot be identified by the participant. As an example, Cleary and Greene (2005) had participants study a word list and then view test items that were rapidly presented and masked. These conditions rendered a large portion of test items unidentifiable but, remarkably, recognition responses were highly accurate, even for the test items that participants reported as unidentifiable. Like familiarity and implicit recognition, accurate recognition-without-identification may be driven by enhanced fluency of studied test items under very high levels of uncertainty. In accordance with this account, Cleary and Greene (2001, 2005) have suggested that recognition-without-identification is mediated by the same process as familiarity, based on behavioral research showing recognition-without-identification to be observed under the same conditions that give rise to familiarity. However, Ryals et al. (2011) recently demonstrated that recognition-without-identification for words elicited ERP waveforms that were distinct from the FN400 typically associated with familiarity. Instead, they found that unidentified words that were studied elicited more negative activity than unidentified words that were unstudied around 300 ms post-stimulus onset in the right frontal and left occipital regions, similar to the N300 ERP effect of implicit recognition found by Voss and Paller (2009). This finding suggested that recognition-without-identification for words is mediated by a process very similar to that underlying implicit recognition, but very different from that underlying familiarity.

Our review of the literature on familiarity, implicit recognition, and recognition-without-identification shows that they commonly elicit memory-related (old/new) ERP effects within the 200–500 ms epoch, but with differing scalp topographies. Importantly, this common time course overlaps with the time course of implicit memory, and supports the possibility that familiarity, implicit recognition, and recognition-without-identification are mediated by implicit memory representations. On a word recognition task, Rugg et al. (1998) found that, regardless of whether a word was recognized, old words evoked more positive activity than new