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# Self-referential processing is distinct from semantic elaboration: Evidence from long-term memory effects in a patient with amnesia and semantic impairments

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## ABSTRACT

We report data demonstrating that self-referential encoding facilitates memory performance in the absence of effects of semantic elaboration in a severely amnesic patient also suffering semantic problems. In Part 1, the patient, GA, was trained to associate items with the self or a familiar other during the encoding phase of a memory task (self-ownership decisions in Experiment 1 and self-evaluation decisions in Experiment 2). Tests of memory showed a consistent self-reference advantage, relative to a condition where the reference was another person in both experiments. The pattern of the self-reference advantage was similar to that in healthy controls. In Part 2 we demonstrate that GA showed minimal effects of semantic elaboration on memory for items he semantically classified, compared with items subject to physical size decisions; in contrast, healthy controls demonstrated enhanced memory performance after semantic relative to physical encoding. The results indicate that self-referential encoding, not semantic elaboration, improves memory in amnesia. Self-referential processing may provide a unique scaffold to help improve learning in amnesic cases.

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## 1. Introduction

## 1.1. Self-referential effect on memory (SRE)

There is a substantial body of work showing that memory performance is enhanced when participants refer a stimulus to themselves (e.g., does this word describe you? – a self-evaluation decision), compared to when other high-level semantic judgments are made (e.g., does the word mean the same as 'XXXX') (Rogers, Kuiper, & Kirker, 1977). This is referred to as the self-referential effect in memory. The SRE occurs in different types of memory test including both recall (Maki & McCaul, 1985; Rogers et al., 1977) and recognition (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Wells, Hoffman, & Enzle, 1984) and it links to introspective judgments of remembering rather than a feeling of knowing, following recognition (Zhu & Zhang, 2002; Zhu, Zhang, Fan, & Han, 2007). One account for this phenomenon is that people have a well-established self-schema which facilitates the encoding and retrieval of information when it is related to the self (e.g., Maki &

McCaul, 1985; Rogers et al., 1977), perhaps by heightening attention to stimuli as they are encoded. On the other hand, Klein and Kihlstrom (1986) proposed that the organization of information rather than elaborative coding determined the SRE. In a meta-analysis study, Symons and Johnson (1997) suggested that the SRE results from a well-established self-representation which supports elaborative coding and the better organization of encoded information.

## 1.2. The SRE and semantic elaboration

From the first studies of the effects of depth of processing on memory ( Craik & Lockhart, 1972), it has been known that elaborative semantic processing of a stimulus enhances its subsequent recognition and retrieval. These effects of semantic elaboration provide an alternative account to the SRE. For example, some researchers argue that there is nothing special with regards to the self (Gillihan & Farah, 2005), but rather the SRE stems from deeper semantic processing of stimuli when they are associated to the self (Greenwald & Banaji, 1989). Consistent with this, the SRE is reduced when self-reference conditions are compared against conditions requiring deep, elaborative encoding (Symons & Johnson, 1997). On the other hand, it has also been shown that self-referential processing (e.g., imagining carrying out an action)

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enhances performance relative to semantic encoding (e.g., judging how well a sentence matched a short story), consistent with the SRE reflecting more than deep semantic processing (Grilli & Glisky, 2010). Other recent studies also provide evidence that self-association between items and the self, rather than semantic elaboration triggered by self-relevant judgments, is sufficient to lead to the SRE (Cunningham, Turk, & Macrae, 2008; Cunningham, Brady-Van den Bos, & Turk, 2011). For example, rather than using an explicit self-evaluation task, Cunningham and colleagues had participants categorize items as belonging to themselves or to someone else based on the color of the stimulus (e.g., red cues referred to self-owned objects, and blue cues referred to objects owned by others). After encoding the stimuli in terms of personal vs. other ownership, participants performed a surprise memory task. They found that participants had enhanced memory for items assigned to self-ownership compared with items assigned to the ownership of another person irrespective of whether the items assigned to self-ownership were owned in reality or not. The authors argued that only personally owned objects would elicit stored self-knowledge and since this was not critical in the experiment, they argued that self-association was more important. They suggest that self-ownership decisions may enhance attention during stimulus encoding, facilitating subsequent memory performance (Cunningham et al., 2011). Nevertheless it remains the case that it is difficult to dissociate effects of self-association from semantic elaboration in the SRE in healthy participants, as both strategies may be available and both may enhance memory. This is also the case for prior studies with amnesic patients, where some benefits of semantic encoding are also apparent (Grilli & Glisky, 2010). In such examples, the greater effectiveness of self-referential processing may be because this is simply a strong form of semantic encoding.

### 1.3. The SRE and neuroimaging evidence

Although experimental psychological studies have debated why the SRE in memory arises, neural evidence indicates that self-referential processing can dissociate from referential processing in relation to other people, and from semantic processing (Heatherton et al., 2006; Johnson et al., 2002; Kelley et al., 2002; Macrae et al., 2004; Northoff et al., 2006). For example, there are studies showing that self-referential processing (e.g., decisions about personal ownership of objects) facilitates memory (Cunningham et al., 2008; Van den Bos, Cunningham, Conway, & Turk, 2010), and this is associated with activation of the dorsal medial prefrontal cortex, the bilateral supramarginal gyri, and the insula when participants made self-referential judgments (Turk, van Bussel, Waiter, & Macrae, 2011) – regions not typically related to deep semantic elaboration (Badre & Wagner, 2007; Binder, Desai, Graves, & Conant, 2009). Macrae and colleagues (2004) also report that the SRE is predicted by activity in the medial prefrontal cortex during self-referential encoding which is thought to reflect self processing rather than semantic processing (Northoff & Bermpohl, 2004). Craik and his colleagues (1999) scanned participants when they made trait judgments in relation to the self (self-evaluation judgments), a public figure, social desirability, or the number of syllables in a word. They reported that self-evaluation encoding was associated with both left superior and medial frontal gyrus (BA 8, 10, and 47) and right middle and inferior frontal cortex (BA 10 and 45). It was concluded that the concept of the self involves both general schematic structures and further specific components that modulate episodic memory retrieval. The activation in the left frontal cortex found when participants engaged in self-referential processing was similar to that reported when people encode stimuli semantically (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994). On the other hand, there

were also distinct activation patterns in the right frontal cortex (Craik et al., 1999), which may relate to the engagement of specific autobiographical memories supporting memory retrieval. Kelley et al. (2002) further showed that the medial prefrontal cortex was selectively associated with self-referential processing relative to other types of semantic processing, while the left frontal cortex was engaged in both self- and other-referential judgments, more consistent with general semantic encoding effects. These neuroimaging studies using both self-evaluation and self-ownership encoding indicate that there are distinct effects of self-reference encoding on memory, compared with when individuals encode stimuli with reference to other people or semantic encoding. However, a limitation of neuroimaging studies is their correlative nature which cannot provide direct evidence on the necessary role of a region for cognition (Price, Mummery, Moore, Frakowiak, & Friston, 1999). This limitation can be overcome by investigating how brain lesions impact on the SRE.

### 1.4. The SRE and neuropsychology

There are several case reports of amnesic patients who, despite having severe memory impairments, seem to maintain good self-knowledge. For example, patient KC (Tulving, 2002) suffered serious anterograde amnesia for both semantic information and personal experiences, but maintained self-related knowledge such as his birthday and his home address. Patient PJM had severe retrograde amnesia but maintained an ability to cue memories by self-generated self concepts (Rathbone, Moulin, & Conway, 2009). Rathbone et al., (2009) proposed that PJM had a coherent, continuous sense of self, despite having lost episodic memories for an 18-month period. For example, after carrying out conceptual autobiographical retrieval by generating self-related statements (I am a mum, I am active etc.), PJM was asked to generate eight memories related to each self statement. The result showed that she could remember a few of the self-related memories. Klein, Loftus, and Kihstrom (1996) also noted the case of a head injury patient who temporarily lost access to her episodic memory. She was asked to make trait judgments about herself both during and following the resolution of her amnesia. Her ability to make trait judgments in relation to herself did not change as her amnesia varied, suggesting that self-related knowledge can be retrieved independent of episodic memory. It appears that patients with amnesia can use preserved conceptual autobiographical knowledge to support self processing when episodic memories are inaccessible.

One way to assess whether deeper semantic encoding is necessary to generate the SRE is to examine neuropsychological cases that show a poor ability to demonstrate effects on memory from deeper semantic encoding. Stronger effects of self-referential encoding compared with semantic encoding has previously been demonstrated in patients with memory problems (Grilli & Glisky, 2010, 2011; Grilli & McFarland, 2011), but these patients also showed a positive effect of semantic encoding on memory, when performance was compared relative to with baseline conditions (without semantic elaboration).

Here we attempt to separate the effects of self processing and semantic elaborations by comparing different self-related judgments in a case where no effects of semantic encoding were apparent. In addition, we evaluated source as well as recognition memory given previous findings that the SRE occurs across a range of memory tasks. Source memory can be particularly impaired in amnesia (Rathbone et al., 2009; Shimamura & Squire, 1987; Tulving, 2002), especially in patients with frontal lobe lesion (Janowsky, Shimamura, & Squire, 1989; Wheeler, Stuss, & Tulving, 1997), and so examining effects of self-referential processing on source memory tasks provides a strong test of whether the SRE can modulate amnesic memory performance.

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