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Research Report

False memory for face in short-term memory and neural activity in human amygdala

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ABSTRACT

Human memory is often inaccurate. Similar to words and figures, new faces are often recognized as seen or studied items in long- and short-term memory tests; however, the neural mechanisms underlying this false memory remain elusive. In a previous fMRI study using morphed faces and a standard false memory paradigm, we found that there was a U-shaped response curve of the amygdala to old, new, and lure items. This indicates that the amygdala is more active in response to items that are salient (hit and correct rejection) compared to items that are less salient (false alarm), in terms of memory retrieval. In the present fMRI study, we determined whether the false memory for faces occurs within the short-term memory range (a few seconds), and assessed which neural correlates are involved in veridical and illusory memories. Nineteen healthy participants were scanned by 3T MRI during a short-term memory task using morphed faces. The behavioral results indicated that the occurrence of false memories was within the short-term range. We found that the amygdala displayed a U-shaped response curve to memory items, similar to those observed in our previous study. These results suggest that the amygdala plays a common role in both long- and short-term false memory for faces. We made the following conclusions: First, the amygdala is involved in detecting the saliency of items, in addition to fear, and supports goal-oriented behavior by modulating memory. Second, amygdala activity and response time might be related with a subject's response criterion for similar faces.

1. Introduction

False memory is a phenomenon in which accurate memory formation is disturbed and a novel item is mistaken as a previously seen item in laboratory testing (Schacter and Slotnick, 2004). The processes involved in false memory occur during encoding, and during retrieval where the accuracy of a memory is being monitored (Roediger III et al., 2001).

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The occurrence of false memories was increased in a task developed by Roediger and McDermott (1995), based on earlier work by Deese (1959), called the Deese–Roediger/McDermott (DRM) paradigm. In the original DRM paradigm, subjects are presented with lists of associated words that are related by a critical but unpresented lure word. In a subsequent recognition test, the proportion of old responses to the lure item (recognizing the item as previously presented) was significantly higher than for unrelated and unstudied items. Numerous behavioral (Dodson et al., 2000; Roediger III, 1996; Schacter and Dodson, 2001) and neuroimaging (Abe et al., 2008; Cabeza et al., 2001; Garoff-Eaton et al., 2006, 2007; Gonsalves et al., 2004; Iidaka et al., 2012; Kim and Cabeza, 2007; Okado and Stark, 2003; Schacter et al., 1996, 1997; Slotnick and Schacter, 2004; Umeda et al., 2005) studies have investigated memory distortion by inducing a false memory for items in episodic and long-term memory domains.

False memory for stimuli other than words has been investigated using detailed colored pictures (Koutstaal and Schacter, 1997), photographs (Koutstaal et al., 1999), and faces (Jones et al., 2006; Jones and Bartlett, 2009; Reinitz et al., 1992), all of which are highly memorable items in healthy subjects. False alarm rates for face stimuli, in which familiar and novel faces are combined, are higher than rates for completely novel faces and lower than the hit rates of studied, more familiar faces (Jones et al., 2006; Jones and Bartlett, 2009; Reinitz et al., 1992). In a study using natural face photographs, a conjunction error rate (i.e., false alarms to items composed of studied items) was almost equal to the feature error rate (i.e., false alarms to items composed of half-studied and half-new components) (Jones et al., 2006). These results suggest that memory errors for combined faces are mainly based on familiarity processes in the absence of the precise recollection process used in episodic memory (Jones and Bartlett, 2009).

False memory effects have recently been reported in the short-term memory (STM) domain (Atkins and Reuter-Lorenz, 2008; Coane et al., 2007; Flegal et al., 2010). In these studies, subjects learn sets of several items for a memory test. Immediately after the presentation of a memory set, a probe item is presented and the subject is instructed to indicate whether the probe item was included in the preceding memory set. Prior studies have examined the effect of relatedness on STM by using lists of semantically related items, such as words. There was a significantly higher false-alarm rate for probe items that were semantically related to the preceding memory set (i.e., the lure item) than for those that were not (i.e., a new item). These results indicate that a false memory can occur within a few seconds and there may be a common cognitive process shared between long- and short-term illusory memories. One study investigated the neural correlates of false memory in STM by using functional magnetic resonance imaging (fMRI) and a paradigm with 4-word lists (Atkins and Reuter-Lorenz, 2011). The authors found that activation in the left mid-ventrolateral prefrontal cortex was associated with semantic interference from the preceding word list regarding the decision about the probe word. However, to date, no study has used fMRI and a false memory paradigm to investigate false memory for faces in the STM range.

Theoretical explanations for false memories have been largely related to long-term memory (LTM) because the length of study list items and retrieval tasks are typically longer than the STM range. A brief retention interval between encoding and retrieval associated with STM is expected to minimize false recognition (Flegal et al., 2010). Although a recent study showed that a false memory of words could be induced with both a short and long delay at a similar rate (Flegal et al., 2010), recent findings showed that the effect of encoding manipulation (e.g., depth of the processing procedure) could increase false recognition rates only at the LTM. This suggests that different processes may be operating in STM and LTM conditions (Flegal and Reuter-Lorenz, 2014). Therefore, it is particularly interesting to investigate whether the neural correlates involved in false memories for faces differ between the LTM and STM.

A previous study from our laboratory investigated the neuroanatomical substrates of false memories for faces in episodic and long-term memory domains (Iidaka et al., 2012). In that study, the authors applied a modified version of the DRM paradigm that used morphed pictures of faces to induce false memories in an fMRI environment. We found that activity in the amygdala was associated with the sense of familiarity of items despite the experiment involving no emotional facial features. In particular, false responses to items similar to previously seen (old) items evoked a middle-range level of activity in the amygdala; the activity was at a level between that evoked for correct responses to old and new items and that evoked for incorrect responses to old and new items. This indicates that amygdala activity during the processing of false memories falls between correct and incorrect responses to true items, and suggest a possible role for the amygdala in determining the relevance of items with respect to episodic or long-term memory.[1]

The purpose of the present study was to investigate whether false memories for faces in the STM domain could be induced by using the same set of morphed faces as those used in the LTM experiment (Iidaka et al., 2012), and examine which neural correlates were involved in the formation of such illusory memories within a few seconds. To do this, three morphed faces were shown side-by-side to healthy subjects as a memory set for 2.5 s. After an interval of 1.5 s, a probe face was presented for 2.0 s (Fig. 1). Subjects were instructed to memorize three faces in the memory set and make a judgment as quickly and accurately as possible as to whether the probe face had been shown in the previous memory trial (a modified delayed match-to-sample test). There were three different conditions for the probe face: an old face that was presented in the memory set (OLD condition); a lure face that was similar to a face in the memory set (LURE condition); or a new face that had not been presented previously and was not a face similar to the memory set (NEW condition).

There are limited capacities for maintaining objects in memory in the visual STM and working memory (WM)

[1]In the present study, we used a term "lure" item only for a face picture that was similar to a previously presented item; however, in other memory studies, a new item is also referred to as a "lure" item.