



## Reduced recollective memory about negative items in high trait anxiety individuals: An ERP study<sup>☆</sup>

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### ABSTRACT

The present study investigated whether trait anxiety reduce the contribution of episodic retrieval to recognizing negative words. Behavioral and electrophysiological responses in anxious individuals were measured during an exclusion recognition task to compare with a previous report about control participants (Inaba et al., 2007). At test, participants were asked to respond “old” when an item had been included in a target study list. According to the process-dissociation framework, the difference in the waveforms for the “old” responses between target and non-target items is considered to be a measurement of recollection. It was shown to be the difference in the slow waves. As with the behavioral estimate of recollection, the difference in the slow waves at left-parietal area was smaller for negative items compared to other items in the anxiety group. This result was in contrast to a greater difference in the slow positivity for negative words in the control group. These findings suggest that excess old judgments for negative items in the anxious group might be associated with less recollective memory.

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### 1. Introduction

Memory discrimination is thought to be facilitated by the recollective memory of novel item associations, such as those made during learning episodes (for a review, see Richardson-Klavehn et al., 1995). It has been proposed that lower discriminability among memories due to less recollection can lead to emotional confusion (e.g., Anderson et al., 1994; MacLeod and Macrae, 2001). In particular, such emotional confusion may occur when some negatively-valenced items are not sufficiently discriminated due to insufficient recollective memory about them. Anxiety has been suggested to have an impact on memory discrimination (for example, Kverno, 2000). Previous studies have reported that participants with high levels of trait anxiety are prone to show higher hit and false alarm rates to negative stimuli. Anxiety-related overproduction of “old” responses, given in the test phase to items recognized as having been learned in the study phase, is often explained as the result of simple response bias rather than a problem of retrieval. The aim of this study was to elucidate whether less discrimination of negative words for anxious individuals correlates with difficulty in recollecting the negative stimuli, using behavioral and electrophysiological data.

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Studies investigating the influences of high trait anxiety on recognition memory have found that anxious individuals are less able to discriminate threatening or negative items (Dowens and Calvo, 2003; Kverno, 2000; Nugent and Mineka, 1994). These studies all had results showing excessive “old” responses. Dowens and Calvo (2003) instructed high- or low-trait anxiety undergraduates to perform an orienting task and subsequent unexpected recognition tasks using physical-threat, ego-threat, positive, and neutral words. While highly anxious participants recognized more threat-related words presented in the study phase, they also reported non-presented threatening words. Kverno (2000) instructed participants to remember positive, threatening, and neutral words shown with varying frequencies of presentation. He found that individuals with high trait anxiety generally thought threatening words were presented both more frequently than was actually the case, and more frequently than other words. Such excess recognition has sometimes been interpreted as a reflection of response bias, and not a reflection of memory processing itself (Dowens and Calvo, 2003; Nugent and Mineka, 1994). Nugent and Mineka (1994), for example, have suggested that high trait anxiety participants may simply react to stimuli that appear emotionally threatening or negative, producing many “old” responses regardless of whether those items had appeared in the study phase.

Nevertheless, there remains the possibility that anxiety-characteristic memory processes may yield more “old” responses for negative items. Not only by recollecting episodic information, “old” responses may also be promoted by familiarity, that is, processing fluency or the unelaborated feeling of having learned a stimulus previously (Graf and Schacter, 1985; Moscovitch et al., 1993; Roediger and McDermott, 1993). Anxious participants may have a greater

feeling of experiencing negative items because they show greater performance for negative stimuli in implicit memory tasks, which are thought to measure mainly familiarity-related processing (Lang and Craske, 1997; MacLeod, 1990; Richards and French, 1991). Thus, greater feelings of familiarity may increase “old” responses to negative items among highly anxious individuals. However, “old” responses for items that require a “new” response should be inhibited if learning episodes are recollected regardless of whether there is familiarity (for example, see Jacoby, 1991). Thus, difficulty in recollecting episodic memory may cause anxious individuals to produce higher numbers of “old” responses to not only studied, but also to non-studied negative stimuli having greater feeling of familiarity. Nevertheless, it is impossible to examine the contribution of recollection to recognition using yes–no recognition tasks not designed to separately estimate recollection and familiarity. Moreover, it is difficult to isolate the impact of anxiety on memory retrieval without considering the possible effects of response bias when only observing behavioral responses that are always involved in processing at the response-selection stage.

The goal of this study was to clarify whether the lower likelihood of recollection contributes to the recognition of negative items in individuals with high-trait anxiety. We obtained data on high-trait anxiety individuals in the same manner used previously in Inaba et al. (2007), which reported findings on individuals having average or lower-than-average trait anxiety among the same population of participants in this study. Our previous study reported on the electrophysiological measurement of recollection, known to be rarely affected by response bias, along with a behavioral measurement. To obtain these measurements, the exclusion recognition paradigm of the process-dissociation procedure (PDP; Jacoby, 1991) was used. This paradigm considers estimates of recollection and familiarity by comparing the probability of “old” responses to targets that were included in one of two studied lists with that of non-targets in another studied list (Dienes et al., 1995; Hay and Jacoby, 1999). In event-related potential (ERP) studies, this exclusion recognition test has been reported to elicit greater positive components in late latency for correct responses to targets and non-targets than that for distracters (Dzulkifli and Wilding, 2005; Fraser et al., 2007; Friedman et al., 2005; Inaba et al., 2007; Kane et al., 2000; Johnson and Rugg, 2006; Mathewson et al., 2005; Wilding et al., 2005; Wilding and Rugg, 1996, 1997a,b). This positive-going shift that dominantly appears at the left-parietal area is often interpreted as an indicator of recollection (for example, Fabiani and Donchin, 1995; Wilding and Rugg, 1997a). However, a facilitated sense of familiarity may also increase the component in this late latency (Bentin and Moscovitsch, 1990; Maratos et al., 2000; McNeely et al., 2004; Schnyer et al., 1997; Walla et al., 1999). In previous studies using an exclusion recognition task, the waveform for “old” responses for non-targets, and especially those in late latency, was thought to be associated with familiarity (Inaba et al., 2007; Kane et al., 2000; Wilding and Rugg, 1996, 1997a, b). These findings appear to be compatible with the process-dissociation framework: “old” responses for targets are produced by the mixture of the recollected memory in which list items have been included and the feeling of familiarity facilitated by presentation in the study phase while those for non-targets are only on the basis of the familiar-feeling increased similarly to the targets. Thus, to assess the retrieval processes individually, several studies have applied the process-dissociation framework to the analysis of ERPs (Inaba et al., 2007; Kane et al., 2000). The difference in the waveforms of “old” responses to targets and to non-targets was thought to yield a measurement of the recollective process. These studies proposed that the observed difference in the slow positive wave around the left-parietal area represented an electrophysiological index of recollection. It is likely that this electrophysiological index is unaffected by response bias, as the components after 500 ms in recognition have been reported to be insensitive to response bias (Windmann et al.,

2002). Thus, we employed the difference in the slow wave elicited especially around the left-parietal area to examine the effect of anxiety on memory processing.

We expected a lower estimate of recollection to negative items in the anxious group as opposed to the control group, whose estimate of recollection for these items has been reported to be higher compared with the other items. Emotional valence, especially negative meaning, usually produces more accurate memory (Inaba et al., 2005; Kensinger and Corkin, 2003; Ohira et al., 1998). Research suggests this is because emotional valence is likely to evoke attention, and increased attention leads to higher accuracy in memory tasks (Smith et al., 2003; Tabert et al., 2001; Taylor, 1991). Highly anxious groups also have shown increased performance to negative items in attentional tasks (Bradley et al., 1999; Byrne and Eysenck, 1995; Yiend and Mathews, 2001; MacLeod and Rutherford, 1992; Richards et al., 1992). However, previous research has reported that such a facilitated attentional process seldom provides a preponderance of memory retrieval, whereas the feeling of familiarity measured by implicit memory tasks is sometimes facilitated (Lang and Craske, 1997; MacLeod, 1990; Richards and French, 1991). One of the possible interpretations is that anxious people tend to avoid elaborative processing of negative items followed by attentional processing in the early stage (for example, Williams et al., 1997). According to this suggestion, the anxious group was expected to show a lower estimated recollection for negative items than the control group because less elaboration may reduce recollective memory (Curran, 2004; Yonelinas, 2002). On the basis of the behavioral predictions above, the difference in the slow waves for “old” responses between target and non-target items, which is assumed to be the electrophysiological index of recollection, was expected to be smaller for negative words compared with other words among anxious individuals. This predicted result was in contrast to a greater difference in the slow positivity for negative words among control individuals. Considering that the increase in the magnitude of late positivity may be associated with greater activity around the left hippocampal formation, which is thought to serve a main role in recollecting memory (Rugg et al., 1998; Woodruff et al., 2006; Yonelinas, 2002; Yonelinas et al., 2005), the effect of anxiety on the electrophysiological index of recollection was expected to be maximal over the left posterior scalp.

## 2. Materials and methods

### 2.1. Participants

High-trait anxious participants were selected from the same population of participants as the control participants (Inaba et al., 2007). Two-hundred and thirty-eight Japanese undergraduate and graduate students at Nagoya University completed the State-Trait Anxiety Inventory (STAI; Mizuguchi et al., 1980), which is the Japanese adaptation of the STAI developed by Spielberger et al. (1970). The STAI is used to assess anxiety as a personality trait (trait anxiety/X2) and situational state (state-anxiety/X1). Within the framework of this investigation, only trait anxiety was assessed as the screening measure for participants prior to the experiment. The mean score of all collected data was 41.34. The cut-off trait anxiety score for the highly anxious group was 55, approximately twice the standard deviation ( $SD = 8.18$ ) from the mean score. A total of 18 native Japanese-speaking undergraduate students who scored 55 or above agreed to participate in the ERP experiment and gave written informed consent (11 males and 7 females, mean age 21.8,  $SD = 2.2$ ). Each participant was notified of their selection as a highly anxious participant after the experiment. The anxious participants were matched for age and sex with 20 control participants whose trait anxiety scores were below the mean score (12 males and 8 females, mean age 21.8,  $SD = 2.1$ ). To focus on non-clinical high trait anxiety, participants were interviewed regarding history of any mental

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