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The temporal dynamics of perceptual and conceptual fluency on recognition memory

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ABSTRACT

Recognition memory can be driven by both perceptual and conceptual fluency, but when and to what extent they contribute to recognition memory remains an open question. The present study used event-related potentials (ERPs) to investigate the neural correlates of perceptual and conceptual fluency, when they gave rise to recognition. We manipulated the perceptual and conceptual fluency of retrieval cues in the recognition test independently to obtain the effects of different types of fluency. Behavioral results showed that perceptual fluency selectively affected *K* hits, while conceptual fluency affected *R* hits and *K* false alarms. In addition, conceptual fluency facilitated the response times of *R* hits. The ERP results showed that perceptual fluency effect appeared at 100–200 ms and conceptual fluency effect appeared at 300–500 ms. The parietal LPC peaked earlier for conceptually primed trials compared to unprimed trials. These results suggest that perceptual and conceptual fluency had different effects on recognition judgments, and these two types of fluency can be delineated by distinct ERP correlates. The current finding indicates that unconscious memory processes can support recognition and have provided insights into the underlying mechanism involved in recognition memory.

1. Introduction

Fluency, which is typically defined as the speed and ease of processing, has been linked with a wide range of subjective judgments. For example, fluent stimuli are more likely to be judged as pleasing (e.g., Reber, Winkielman, & Schwarz, 1998), beautiful (e.g., Reber, Schwarz, & Winkielman, 2004) and familiar (e.g., Jacoby & Whitehouse, 1989). The relationship between fluency and a sense of familiarity was first proposed by Jacoby and Dallas (1981), who theorized that fluency is used as a heuristic in memory judgments. Many researchers demonstrated that fluent stimuli in recognition test tend to be endorsed as being studied previously, even if they are not (e.g., Kurilla & Westerman, 2008; Olds & Westerman, 2012; Westerman, 2001; Westerman, Lloyd, & Miller, 2002; Whittlesea, 2002; Whittlesea, Jacoby, & Girard, 1990).

Fluency has different varieties and there are many ways to manipulate them (for a review, see Alter & Oppenheimer, 2009). One can use stimuli with different contrast (Reber et al., 1998; Unkelbach, 2006) or clarity (Leynes & Addante, 2016; Leynes & Zish, 2012; Reber & Schwarz, 1999; Whittlesea et al., 1990) to manipulate perceptual fluency. Nevertheless, the most common method is repetition priming utilized first by Jacoby and Whitehouse (1989). Using this method, each item was preceded by a brief prime, which either does, or does not match the item (e.g., Li, Gao, Wang, & Guo, 2015; Li, Wang, Gao, & Guo, 2016). One can use predictive or non-predictive sentence stems to manipulate conceptual fluency, i.e., a predictive or non-predictive sentence was presented before the test word in recognition test (Whittlesea & Williams, 2000, 2001a; Wolk et al., 2004). In addition, some researchers used conceptual priming to enhance conceptual fluency, i.e., a conceptually related or unrelated word was presented before the test word (Taylor & Henson, 2012; Taylor, Buratto, & Henson, 2013).

According to the dual process theory of recognition, recognition memory is dependent on two distinct processes, recollection and familiarity (for a review, see Yonelinas, 2002). Studies manipulating fluency by priming or other means found that enhanced fluency often led to increased feelings of familiarity (Bruett & Leynes, 2015; Leynes & Zish, 2012; Lucas, Taylor, Henson, & Paller, 2012; Miller, Lloyd, & Westerman, 2008; Rajaram, 1993; Woollams, Taylor, Karayanidis, & Henson, 2008). In some of the studies, the increased familiarity was

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attributed to perceptual fluency (e.g., Johnston, Hawley, & Elliott, 1991; Rajaram, 1993), whereas in others, it was attributed to conceptual fluency (e.g., Rajaram & Geraci, 2000; Wolk et al., 2004). However, two studies conducted by Taylor and his colleagues found that the conceptual fluency could increase recollection (Taylor & Henson, 2012; Taylor et al., 2013). Moreover, a recent study from our laboratory also found that enhanced conceptual fluency could increase recollection and this effect was associated with an attenuation of N400 (Wang, Li, Gao, Xu, & Guo, 2015). In this study, participants were instructed to make "remember" or "familiar" judgment for the studied word. The results showed that conceptual fluency selectively affected remember hits and know false alarms. Therefore, the relationship between different kinds of fluency and the two recognition processes still awaits further evidence.

The ERP technique is widely used in the studies of recognition memory. For example, different ERP components known as FN400 (mid-frontal old/new effect) and LPC (late positive complex) were shown to be associated with familiarity and recollection respectively (e.g., Curran, 2000; Curran & Cleary, 2003; Rugg & Curran, 2007; Stróżak, Abedzadeh, & Curran, 2016). However, some argued that FN400 potentials indicated conceptual priming that co-occurs with familiarity during recognition tests (e.g., Gao, Hermiller, Voss, & Guo, 2015; Hou, Safron, Paller, & Guo, 2013; Paller, Voss, & Boehm, 2007; Voss & Paller, 2007). In a recent study, both theoretical views were supported (Leynes, Bruett, Krizan, & Veloso, 2017). Because of its high temporal precision, the ERP technique could provide evidence for teasing apart the time course of rapidly occurring cognitive processes and refine our understanding of memory mechanisms, such as the contribution of perceptual and conceptual fluency to recognition. For example, Woollams et al. (2008) found that the repetition priming may induce a central-focused ERP effect between 150 and 250 ms. In a recent study, Park and Donaldson (2016) revealed that repetition priming speeds the onset of recollection.

As mentioned above, many studies investigated the contributions of perceptual or conceptual fluency to recognition, and found that perceptual fluency or conceptual fluency could affect the feelings of familiarity or recollection (e.g. Leynes & Zish, 2012; Taylor & Henson, 2012). However, few studies manipulated these two types of fluency in one experiment. When and to what extent does perceptual and conceptual fluency influence the recognition? In a recent study, Lanska, Olds, and Westerman (2014) investigated the effect of perceptual and conceptual fluency in the same recognition context. In their study, two most commonly methods were utilized to manipulate the two kinds of fluency, i.e., perceptual priming for perceptual fluency and predictive sentence stems for conceptual fluency. They concluded that the relative effect of perceptual and conceptual fluency depended on both encoding and test factors. However, as Lanska et al. (2014) mentioned in their paper, the fluency induced by each manipulation were overlapping. For example, the priming manipulation may enhance both perceptual and conceptual fluency, especially the experiment used meaningful stimuli such as words and nameable pictures. In addition, the temporal course for effects of both types of fluency on recognition is unknown using the behavioral methods.

In a study conducted in our laboratory, we investigated the contributions of perceptual and conceptual fluency induced by repetition priming to recognition using ERPs. We classified Chinese pictographic characters into high meaningfulness or low meaningfulness levels on the basis of subjective meaningfulness ratings. The low meaningfulness items induced perceptual fluency and the high meaningfulness items induced both perceptual fluency and conceptual fluency. Then, we identified the distinct electrophysiological correlates of perceptual and conceptual fluency. The results showed that the two types of fluency differed in associated ERP effect: 150–250 ms effects for perceptual fluency and FN400 effects for conceptual fluency. In addition, these two fluency effects both showed that the ERPs of fluent items were more positive than that of less fluent items. Therefore, repetition priming could induce both types of fluency and they were indicated by different ERP components (Wang, Li, Gao, Xiao, & Guo, 2015). These findings suggested that the effect of perceptual fluency on recognition will confound with conceptual fluency effect when using repetition priming to manipulate fluency of meaningful stimuli. In other words, only the conceptually impoverished items such as kaleidoscope images (Voss & Paller, 2009b) serve as stimuli, the fluency effect induced by repetition priming could be attributed to perceptual fluency.

Other studies used alternative ways to manipulate fluency. For example, Leynes and Zish (2012) manipulated perceptual fluency independently of stimulus repetition by presenting half of the test words in a blurry form. Visual clarity varied randomly across trials in one experiment, and was held constant from trial to trial in a block of either clear or blurred test words in the other experiment. Consequently, blocking or randomizing visual clarity of image across trials led to different ERP results. In a recent study, Gomes, Mecklinger, and Zimmer (2017) adopted this paradigm in a functional magnetic resonance imaging (fMRI) experiment. Similarly, striking differences in the neural correlates of fluency between the random context and blocked context experiments were observed. These studies also suggest that the contribution of fluency to recognition is a complex process and depends on the learning and testing context. For example, the trial-by-trial fluency fluctuations might be an important factor in the effects of fluency on familiarity or recollection. The "random" condition in these studies might create a testing context that multiple sources of fluency (e.g., repetition fluency and perceptual fluency) vary across trials, which affected the contribution processes. Therefore, we believe that it is helpful to investigate the influence of different types of fluency on recognition and distinguish cognitive states of these effects through high temporal resolution ERP technique.

Our former study suggested that repetition priming could induce multiple types of fluency, but fluency was not manipulated independently in the experiment (Wang, Li, Gao, Xiao, et al., 2015). In the present study, we aim to investigate the time courses of influence of different types of fluency on recognition memory by using ERPs in one experiment. To avoid the overlapping between perceptual and conceptual fluency, conceptual priming and the clarity of the test items were used to manipulate conceptual fluency and perceptual fluency respectively. Both methods have been used to manipulate perceptual fluency (Leynes & Addante, 2016; Leynes & Zish, 2012) or conceptual fluency (Taylor et al., 2013; Taylor & Henson, 2012; Wang, Li, Gao, Xu, et al., 2015) previously, but no study used both in one experiment. Current experiment used two-character Chinese word as stimuli. In the study phase, the participants were asked to perform an "interestingness" judgment task. In the recognition test, two variables were manipulated. Conceptual fluency included masked conceptual primed (preceded by a conceptual related word) or unprimed (preceded by an unrelated word) items. Meanwhile, perceptual fluency included clear or blurry items. The two variables produced four categories: conceptual primed-clear; unprimed-clear; conceptual primed-blurry; unprimed-blurry. Thus, we could investigate the perceptual and conceptual fluency effects on recognition memory independently and obtain the electrophysiological correlates of both types of fluency in one experiment.

Some previous studies showed that the ERP components correlating with perceptual fluency were temporally and spatially dissociable from the FN400 potentials associated with conceptual fluency. For example, Voss and Paller (2010a) found a 100–300 ms effect linked with perceptual fluency. In another study, Voss, Schendan, and Paller (2010) found a frontal P170 potentials that was correlated with perceptual priming and it was distinct from the ERP correlate of conceptual priming. Research conducted by Leynes and his colleagues also linked perceptual fluency with an early ERP effect (Bruett & Leynes, 2015; Leynes & Zish, 2012). In addition, we found that perceptual fluency was associated with 150–250 ms effects and conceptual fluency was associated with FN400 effects (Wang, Li, Gao, Xiao, et al., 2015). According