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Time course of implicit processing and explicit processing of emotional faces and emotional words

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ABSTRACT

Facial expressions are important emotional stimuli during social interactions. Symbolic emotional cues, such as affective words, also convey information regarding emotions that is relevant for social communication. Various studies have demonstrated fast decoding of emotions from words, as was shown for faces, whereas others report a rather delayed decoding of information about emotions from words. Here, we introduced an implicit (color naming) and explicit task (emotion judgment) with facial expressions and words, both containing information about emotions, to directly compare the time course of emotion processing using event-related potentials (ERP). The data show that only negative faces affected task performance, resulting in increased error rates compared to neutral faces. Presentation of emotional faces resulted in a modulation of the N170, the EPN and the LPP components and these modulations were found during both the explicit and implicit tasks. Emotional words only affected the EPN during the explicit task, but a task-independent effect on the LPP was revealed. Finally, emotional faces modulated source activity in the extrastriate cortex underlying the generation of the N170, EPN and LPP components. Emotional words led to a modulation of source activity corresponding to the EPN and LPP, but they also affected the N170 source on the right hemisphere. These data show that facial expressions affect earlier stages of emotion processing compared to emotional words, but the emotional value of words may have been detected at early stages of emotional processing in the visual cortex, as was indicated by the extrastriate source activity.

1. Introduction

Emotional stimuli are prioritized in visual processing, even at very early stages. This effect was shown for emotional pictures (Carretie et al., 2004; Foti et al., 2009; Keil et al., 2002) and facial expressions of emotions (Adolphs, 2002), but this effect may also be relevant for more symbolic cues, such as for emotional words (Bernat et al., 2001; Ortigue et al., 2004; Scott et al., 2009; Skrandies, 1998). Although recent event-related potential (ERP) studies have provided evidence for early modulatory effects during the independent processing of these different types of emotional stimuli, little is known about the similarities and the specific differences in processing of these stimuli. The present study, therefore, aims at specifically comparing the processing of emotional words and facial expressions within one experimental design. Although both facial expressions and emotional words are core components of daily social interactions, they signal emotions on very different levels of visual representation. Facial expressions are biologically significant cues, whereas words represent emotions on a symbolic level. Thus, the common appearance and importance of both types of stimuli in social interactions may suggest similarities in stimulus processing; however, there may also be differences in the time course of processing due to their differing levels of emotional representation.

Separate investigations using ERP measures provide evidence for the time course of processing these different types of emotional stimuli. With respect to the time course of processing facial expressions, recent studies indicate that emotional facial expressions affect early ERP components around 100 ms post-stimulus compared to neutral facial expressions (Batty and Taylor, 2003; Eger et al., 2003; Pizzagalli et al., 1999), as well as a subsequent face-sensitive component over the occipito-temporal brain regions, referred to as N170 (Ashley et al., 2004; Batty and Taylor, 2003; Blau et al., 2007; Williams et al., 2006). For mid-latency components, studies frequently suggest that the "early posterior negativity" (EPN), which evolves around 200–350 ms over occipito-temporal brain regions, is modulated by facial expressions (Schacht

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and Sommer, 2009; Schupp et al., 2004). Finally, the emotional modulation of late components, such as the sustained "late parietal complex/positivity" (LPC/LPP), starting around 400 ms, reflects enhanced encoding of emotional expressions (see Schupp et al., 2004; Schutter et al., 2004). Amongst other components (Codispoti et al., 2007; Olofsson and Polich, 2007), the LPP may code the intensity or arousal level of emotional stimuli (Cuthbert et al., 2000; Olofsson et al., 2008).

Thus, facial expressions affect various temporal levels of processing. Similarly, the decoding of emotional words involves various levels of processing. Emotional words have been shown to modulate early ERPs within the first 200 ms of information processing (Ortigue et al., 2004), such as during the P1-N1 time period (Bernat et al., 2001; Scott et al., 2009; Skrandies, 1998; van Hooff et al., 2008) or for the P2 component (Herbert et al., 2006; Thomas et al., 2007). Specifically, emotional words modulate a negative ERP component at a similar latency as the face-sensitive N170 (Scott et al., 2009), and words elicit a comparable N170 component as that found for faces (Rossion et al., 2003b; Simon et al., 2007), but this component is seemingly more left lateralized for words as compared to faces (Mercure et al., 2008; Simon et al., 2007). With respect to later ERP components, emotional words also modulate the EPN (Herbert et al., 2008; Kissler et al., 2007, 2009; Schacht and Sommer, 2009; Scott et al., 2009) and the LPC/LPP component (Fischler and Bradley, 2006; Herbert et al., 2008, 2006; Kissler et al., 2009; Schacht and Sommer, 2009).

The present body of evidence suggests that emotional faces and emotional words affect the same ERP components across a wide temporal range of processing stages with a strong similarity in the decoding of emotional information from these different stimulus modalities. However, whereas the modulation of late ERP components by emotional words is a frequently replicated finding, the effects on very early ERP components are still unclear (Fischler and Bradley, 2006; Kissler et al., 2006). Unlike facial expressions, which signal the emotional value directly from facial features, emotional words carry the emotional value through the semantic meaning. This meaning is usually extracted beyond 200 ms of stimulus processing (Posner et al., 1999). This challenges the notion that early effects are solely driven by the emotional value of words (Fischler and Bradley, 2006; Kissler et al., 2006).

The time courses of processing emotional expressions and emotional words share some similarities but also reveal some important differences, especially during early levels of processing. However, very few ERP studies have directly compared the time course of processing facial expressions with that of emotional words. Vanderploeg et al. (1987) used words and faces that were rated as negative, neutral, and positive. They found a left lateralized modulation of the P3 and right lateralized slow wave activity for emotional faces, but not for emotional words. Using an implicit emotional task in which subjects judged the lexical and configural integrity of words, Schacht and Sommer (2009) found an early EPN-like effect and a late modulation of the LPP, both for emotional faces and words. Besides a similar topographical distribution, the effect of emotional words was considerably delayed in both time periods as compared to emotional faces. This shift suggests delayed access to the emotional value of words compared to faces. However, this delay may also be caused by the different cognitive processes underlying the judgment of the lexical integrity of words compared with judging the integrity of faces. The integrity of faces could be judged directly based on facial features. This may affect early ERP components within the first 200 ms (Boutsen et al., 2006; Macchi Cassia et al., 2006). The lexical integrity of words, however, requires judgments based on using a whole-word approach by matching the individual word to a stored lexical knowledge of this word. This matching is done beyond 200 ms (Simon et al., 2004). Interestingly, a recent study by Scott et al. (2009) found early effects of emotional words on the P1, N1 and EPN, using a similar implicit word integrity task. These early effects were also demonstrated in a study using an explicit judgment of the emotional value of words (Begleiter et al., 1979). Therefore, recent studies provide heterogeneous data about very early modulatory effects during the processing of emotional words.

Taken together, various factors, such as slightly different versions of an implicit task and low-level stimulus properties (e.g., luminance and contrast), which have not been controlled in previous studies (Schacht and Sommer, 2009; Vanderploeg et al., 1987), may have caused the heterogeneous results obtained when directly comparing the time course of emotional faces and word processing. In the present study, we attempt to address these issues by investigating the explicit processing and implicit processing of emotional faces and words within a single task, using a lexical and facial variant of the emotional Stroop task (see Williams et al., 1996). The typical emotional Stroop task requires subjects to name the color of a word that is printed in a specific color and to ignore the emotional word meaning. This same procedure can also be applied to facial expressions printed in different colors (Kolassa et al., 2007). This procedure allows us to consistently modulate two additional factors, besides the main experimental factor of *stimulus valence* (negative vs. neutral), within the same experimental design. These additional factors were *stimulus modality* (face vs. word) and *experimental task* (explicit task/emotion judgment vs. implicit task/color naming). Previous studies either combined the factors of stimulus valence and stimulus modality (Schacht and Sommer, 2009; Vanderploeg et al., 1987) or the factors of stimulus valence and experimental task (Kolassa et al., 2007; Perez-Edgar and Fox, 2003; Thomas et al., 2007).

The distinction between explicit processing and implicit processing of emotional stimuli is an important experimental factor. Emotions from facial expressions are decoded when either explicitly (Ashley et al., 2004; Eger et al., 2003; Schupp et al., 2004; Schutter et al., 2004; Williams et al., 2006) or implicitly attended (Batty and Taylor, 2003; Blau et al., 2007; Kolassa et al., 2007; Schacht and Sommer, 2009). This effect was also shown for explicitly (Fischler and Bradley, 2006; Herbert et al., 2008, 2006) or implicitly attended emotional words (Kissler et al., 2009; Ortigue et al., 2004; Perez-Edgar and Fox, 2003; Schacht and Sommer, 2009; Thomas et al., 2007; van Hooff et al., 2008). There is, however, some evidence that the attention orientation towards emotional stimuli may affect mid-latency and late ERP components in differing manners. The LPP during processing of emotional stimuli appears to be reduced during implicit tasks when attention is oriented towards non-emotional stimulus features (Hajcak et al., 2006). Positive facial expressions seem to elicit a larger frontal LPP when explicitly attending to the emotional value, but this effect also appeared at the parietal scalp regions during implicit attention (Van Strien et al., 2010). Finally, a modulation of ERP components, such as the EPN or the LPP, requires explicit attention to the emotional content of words (Hinojosa et al., 2010).

Based on these arguments, we designed a comparable implicit and explicit task for both emotional faces and emotional words in the present study. We created facial and word stimuli that were identical with respect to low-level stimulus properties, such as luminance, contrast, and the total amount of color information that could have an effect on early ERP components. We focused the data analysis on the modulatory effects on two early (P1, N170), one mid-latency (EPN), and one late ERP (LPP) components because the effects on these components were consistently reported in previous studies. Emotional faces were expected to reveal earlier influences on these components compared to words, independent of the attentional focus. Furthermore, emotional words, which may depend on explicit attention to emotional meaning, were expected to modulate late ERP components.