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Evaluative conditioning of positive and negative valence affects P1 and N1 in verbal processing

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ABSTRACT

The present study examined the effect of contextual learning on the neural processing of previously meaningless pseudowords. During an evaluative conditioning session on 5 consecutive days, participants learned to associate 120 pseudowords with either positive, neutral or negative pictures. In a second session, participants were presented all conditioned pseudowords again together with 40 new pseudowords in a recognition memory task while their event-related potentials (ERPs) were recorded. The behavioral data confirm successful learning of pseudoword valence. At the neural level, early modulations of the ERPs are visible at the P1 and the N1 components discriminating between positively and negatively conditioned pseudowords. Differences to new pseudowords were visible at later processing stages as indicated by modulations of the LPC. These results support a contextual learning hypothesis that is able to explain very early emotional ERP modulations in visual word recognition. Source localization indicates a role of medial-frontal brain regions as a likely origin of these early valence discrimination signals which are discussed to promote top-down signals to sensory processing.

1. Introduction

Based on an evolutionary perspective information which indicates a possible advantage or disadvantage for the survival of the species should be recognized and processed with priority. Such motivationally relevant information consists, for example, of cues indicating threat, nurturance and reproduction. Within a culturally shaped environment such information is coded in symbols such as the emotional connotation of spoken and written language. The process of stimulus evaluation has been shown to occur at different time windows as revealed by recent event-related potential (ERP) studies in visual word recognition. Emotional effects have been documented in the ERPs at very early processing stages around 100 ms (N1/P1 complex), during the time frame of the early posterior negativity (EPN, 200–300 ms after stimulus presentation) and at later controlled processing stages as reflected by positive deflections around 400–800 ms (the late posterior complex, LPC, over temporo-occipital brain regions; e.g., Bayer et al., 2012; Briesemeister et al., 2014; Hofmann et al., 2009; Kissler et al., 2007; Kissler and Herbert, 2013; Scott et al., 2009; for a recent review see Citron, 2012).

In particular the very early effects are in need of further examination as 150–200 ms are often called a lower limit of lexical access in visual word recognition (e.g., Kissler and Herbert, 2013; Pulvermüller et al., 2001; Sereno and Rayner,

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2003), i.e. the earliest emotional effects take place at stages of processing when a presented word stimulus cannot have been fully identified. Although some models propose that automatic affective evaluation is likely to occur already pre-attentively at pre-conscious processing stages (e.g. the affective primacy hypothesis, Murphy and Zajonc, 1993, and the automatic vigilance model, Pratto and John, 1991; also Anderson and Phelps, 2001), and thus bypass perceptual analysis, others argued that it is highly unlikely that an affective analysis takes place before the stimuli are categorized (e.g., Lai et al., 2012; Nummenmaa et al., 2010; Storbeck et al., 2006). In particular it has been discussed that the affective primacy hypothesis cannot account for the data in case of novel visual stimuli (Nummenmaa et al., 2010).

In the case of highly overlearned symbolic stimuli like words the pre-lexical ERP effects do not necessarily need to be explained by an automatic evaluation account. We recently proposed a mechanism based on acquired associations (Hofmann et al., 2009; Fritsch and Kuchinke, 2013), which operates on the hypothesis that contextual learning is a key process in linking verbal to emotional information (e.g. Barrett et al., 2007; Panksepp and Watt, 2011). A possible mechanism to explain how emotional connotation modulates early ERPs, thus, could rely on conditioned associations between the visual features and the emotional connotation of a word (Fritsch and Kuchinke, 2013, Kuchinke et al., 2014). One assumption in line with early (and late) emotional modulation of visual processing is that top down projections enhance the activation in primary visual areas during processing of emotional stimuli (e.g. V1, V4; see Lindquist et al., 2011; Duncan and Barrett, 2007). I.e. partial activation of such conditioned emotional associations in higher-order processing regions while the visual features of a stimulus are processed would resonate in a top-down signal that triggers a shift of attention towards a more elaborate processing of these features and furthermore the whole input stimulus. In this regard, very early modulations have been observed for emotionally conditioned symbolic stimuli (Stolarova et al., 2006) within the time interval of the C1 (60–90 ms) and the P1-N1 (150 ms) time window (Schacht et al., 2012); both ERP components show their maximum over primary visual areas (e.g. Luck et al., 2000).

Therefore a possible explanation how emotional connotation modulates early ERPs refers to conditioned associations between certain visual features and the emotional connotation of the word (e.g. Ortigue et al., 2004; Kissler et al., 2009; Fischler and Bradley, 2006; Schacht et al., 2012). A repetition of the same visual word form within a specific emotional context transfers the emotional significance of the context to these visual features. Subsequently, these learned affective associations indicate emotional significance very early during the word recognition process which can be used to guide and facilitate word recognition in a top-down manner. Consistent with this assumption, the very early emotion effects have been linked to brain areas associated with lexico-semantic processing (e.g., the medial temporal gyrus; Keuper et al., 2014) and the recognition of the visual word form (e.g., fusiform gyrus; Hofmann et al., 2009).

A recent study by Fritsch and Kuchinke (2013) demonstrated that previously meaningless letter strings (so-called pseudowords) receive an emotional connotation by means of an associative learning procedure based on the evaluative conditioning (EC) approach (e.g., Stahl and Unkelbach, 2009; see Hofmann et al., 2010 for a review). Participants rated pseudowords previously paired with negative pictures as more negatively valenced than pseudowords that were paired with neutral pictures; furthermore, very early ERP components elicited by the conditioned pseudowords around 100 ms were also affected by the previous emotional conditioning. Since EC leads to a creation of valence associated with a previously unconditioned verbal stimulus (Stahl and Unkelbach, 2009), these results might be taken as first evidence supporting the hypothesis of acquired associations that drive the very early effects in visual word recognition. Interestingly, in a recent meta-analysis of EC studies both, positive and negative valence, have been shown to be acquired equally well as revealed by similar effect sizes (Hofmann et al., 2010).

Because only negative and neutral valence was conditioned in the Fritsch and Kuchinke (2013) EC study, the present study aimed at an examination of positive valance acquisition in a recognition memory paradigm. A recognition memory paradigm was chosen to minimize the influence of motor preparation during lexical decisions on the ERPs in the time window of interest, which might have corroborated ERP conditioning effects in previous analyses (Fritsch and Kuchinke, 2013; Montoya et al., 1996). Thus, all 120 conditioned pseudowords and 40 new pseudowords were presented as the first stimulus of pseudoword-picture sequences. Of those pairs some had been presented in the exact same composition during the acquisition phase and some pairs were new and had never been paired in the acquisition phase. Due to the sequential presentation of the pseudowords and pictures, old/new responses could only be made following picture onset and were thus expected to have only little effects on the recorded ERPs in response to pseudoword presentation.

Negative words are more often observed to elicit very early ERP effects in visual word recognition (Scott et al., 2009; Kissler and Herbert, 2013), but also reports of positive valence effects in this early time window exist (Bayer et al., 2012; Briesemeister et al., 2014; Hofmann et al., 2009). In addition, in picture processing, differences between positive and negative valence are already visible at the P1 component when the material is matched on levels of stimulus arousal (see Olofsson et al., 2008). Hence, if these effects are transferable to the processing of verbal stimuli, not only differences between emotional and neutral stimuli should be visible following evaluative conditioning but also differences between positive and negative stimuli. Effects of positive outcome conditioning on the P1 have been reported using picture-like stimuli in Schacht et al. (2012), but a direct comparison of positive vs. negative valence is missing in the literature, in particular for verbal stimuli. We expected that if an association learning mechanism underlies the early ERP effects in visual word recognition (Fritsch and Kuchinke, 2013) acquired positive and negative valence of formerly meaningless letter strings should also lead to differences in the P1 with more positive going amplitudes for negatively conditioned pseudowords as it would be indicative of a 'processing system that is sensitive to unpleasant stimuli'