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Acquired affective associations induce emotion effects in word recognition: An ERP study

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ABSTRACT

The present study examined how contextual learning and in particular emotionality conditioning impacts the neural processing of words, as possible key factors for the acquisition of words' emotional connotation. 21 participants learned on five consecutive days associations between meaningless pseudowords and unpleasant or neutral pictures using an evaluative conditioning paradigm. Subsequently, event-related potentials were recorded while participants implicitly processed the learned emotional relevance in a lexical decision paradigm. Emotional and neutral words were presented together with the conditioned pseudowords and a set of new pseudowords. Conditioned and new pseudowords differed in the late positive complex. Emotionally and neutrally conditioned stimuli differed in an early time window (80–120 ms) and in the P300. These results replicate ERP effects known from emotion word recognition and indicate that contextual learning and in particular evaluative conditioning is suitable to establish emotional associations in words, and to explain early ERP effects in emotion word recognition.

1. Introduction

Affective word processing is a growing field of research (for recent reviews see Abbassi, Kahlaoui, Wilson, & Joanette, 2011; Citron, 2012), revealing that a words' emotional connotation modulates word recognition at different levels of processing. A yet unanswered question is how words as symbolic units receive their emotional connotation. At the one hand it is well known that language and emotion are linked via phylogenetically old brain systems (Panksepp, 2008). But due to the late appearance of (spoken and literary) language in the human phylogenesis, an evolutionary explanation seems not plausible. Rather contextual learning has been suggested as a key process in linking verbal information to emotional one (Feldman-Barrett, Lindquist, & Gendron, 2007).

The temporal dynamics of affective word recognition can be studied by measuring event-related potentials (ERPs). Two main ERP effects have been reported repeatedly in the literature, a modulation of the early posterior negativity (EPN, 200–300 ms) and of the late positive complex (LPC, 400–800 ms). The EPN is a negative deflection in the ERP that peaks over posterior brain regions (e.g., Kissler, Herbert, Peyk, & Junghöfer, 2007). Emotionally arousing positive and negative words elicit more negative going deflections in the EPN time window relative to neutral ones (Herbert, Junghöfer, & Kissler, 2008; Kissler, Herbert, Winkler, & Junghöfer, 2009; Kissler et al., 2007). Less often only effects of positive words are reported (Hinojosa, Méndez-Bértolo, & Pozo, 2010; Schacht & Sommer, 2009). An ERP component with similar topography and latency like the EPN can be elicited by voluntary attention to non-emotional stimuli. The EPN is therefore discussed to reflect attention allocation due to the higher intrinsic motivation of emotional stimuli (Schupp, Junghöfer, Weike, & Hamm, 2003). In contrast, the LPC is suggested to reflect deep semantic and evaluative processing and semantic retrieval (Kutas & Federmeier, 2000). Several visual word processing studies report modulated ERP amplitudes by a words' emotional connotation in the LPC, with either larger amplitudes for positive and negative words compared to neutral words (e.g. Fischler & Bradley, 2006), or for positive words only (Kissler, Assadollahi, & Herbert, 2006; Kissler et al., 2009). One part of the family of late positive potentials is the P300, a positive deflection between 250 and 400 ms following stimulus onset (Picton, 1992), which generally indicates orienting to and evaluation of task relevant stimuli when participants explicitly attend to certain stimuli (Schupp et al., 2003). Emotionally modulations of the P300 have been reported for visual processing of pictures (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp et al., 2000) and words (Bernat, Bunce, & Shervin, 2001). Generally, late positive deflections indicate differences in task demands but also differences in explicit processing, e.g. memory encoding, recollection of a mental representation and evaluation (Dien, Spencer, & Donchin, 2004; Polich, 2007).

In addition to EPN and LPC effects, some studies in visual word recognition report earlier emotion effects before the EPN time

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window (e.g., Bernat et al., 2001; Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009; Ortigue et al., 2004; Palazova et al., 2011; Rellecke, Palazova, Sommer, & Schacht, 2011; Scott et al., 2009). A common finding in these studies is a modulation of the earliest deflections in the ERP (after 80–140 ms) for emotionally arousing negative words (Hofmann et al., 2009; Scott et al., 2009) or positive words (Hofmann et al., 2009). Such early emotional modulations of ERP amplitudes have been attributed to sensory processing (e.g. Stolarova, Keil, & Moratti, 2006). In visual word recognition such early ERP effects are discussed to mirror orthographic processing at implicit stages of word processing prior to full lexical and semantic access (Fischler & Bradley, 2006; Hauk, Davis, Ford, Pulvermüller, & Marseln-Wilson, 2006; Kissler et al., 2009). Of particular note is that diminished deflections at the first ERP component, e.g. the P1 (80–120 ms) in Scott et al., 2009, are often followed by enhanced amplitudes at the second component (e.g., an N1 135–180 ms post stimulus onset). Scott et al. (2009) assumes that this pattern reflects facilitated (sub-) lexical processing of high-frequency negative words (see also Hinojosa, Méndez-Bértolo, & Pozo, 2012). Accordingly, recent affective priming studies revealed that emotional compared to neutral primes modulate the processing of subsequently presented neutral targets (e.g., Calvo & Castillo, 2005; Hinojosa et al., 2012; Ihssen, Heim, & Keil, 2007; Stormark, Nordby, & Hughdal, 1995), and in particular their early (N1) and late electrophysiological responses (LPC; e.g., Hinojosa et al., 2012; Ihssen et al., 2007).

At a theoretical level early ERP modulations have been suggested to result from simple associative learning based on classical or operant conditioning (Fischler & Bradley, 2006; Kissler et al., 2009). Repeated association learning of certain visual features of these words with their associated emotional connotation transfer the emotional significance of the word to these specific features. These learned associations indicate emotional relevance which leads to a facilitated processing of the presented word.

Accordingly, early electrocortical correlates of emotionality conditioning have been observed. Schacht, Adler, Chen, Guo, and Sommer (2012) associated meaningless visual stimuli (Chinese characters presented to German participants) with positive and negative valence via operant conditioning. They found early emotion effects (around 150 ms after onset) and larger LPC amplitudes for positively conditioned stimuli. Similar, but even earlier effects of emotionality conditioning were observed by Stolarova et al. (2006). In this study, black-and-white grating stimuli were coupled either with a series of unpleasant or neutral pictures, resulting in an enhanced negativity in the very early C1 component (65–90 ms post stimulus) for negatively conditioned stimuli. An emotionality conditioning ERP effect is also known in word recognition. Montoya, Larbig, Pulvermüller, Flohr, and Birbaumer (1996) associated orthographically legal, meaningless letter strings (pseudowords) with either an electric shock or not. Shock words resulted in increased early deflections accompanied by a reduced LPC suggesting that such early effects are based on associative learning. Unfortunately, in this paradigm the effect of conditioning per se cannot be separated from that of conditioning due to an affective association, and because Montoya et al. (1996) associated their pseudowords only with a shock condition it remains unclear in how-far these results should be attributed to affective associations or to orienting reactions to avoid further painful stimuli.

The present study will therefore establish new affective associations to meaningless pseudowords based on the evaluative conditioning paradigm (EC) to examine whether contextual learning results in a changed emotional evaluation of a previously meaningless stimulus, and to examine the role of emotionality conditioning in explaining the early and late ERP modulations in emotion word recognition. The EC approach refers to changes in the liking or disliking of a neutral stimulus, due to a coupling with other negative or positive stimuli. Thus, in contrast to an identity transfer and the acquisition of conditioned reactions in classical or operant conditioning paradigms, the EC approach accentuates the transfer of valence trough associative learning and the establishment of emotional evaluations (De Houwer, Thomas, & Baeyens, 2001; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). In an EC paradigm a neutral stimulus serves as a conditioned stimulus (CS) and is paired with more than one emotionally arousing unconditioned stimulus (US). As a result a new emotional connotation is established. Accordingly, after the EC study phase the emotionality of the CS can be measured in implicit and explicit emotionality judgment tasks. Of note is that an awareness of the identity contingency of the CS–US pair seems to be less important for the formation of EC (Stahl, Unkelbach, & Corneille, 2009). Instead an awareness of the emotionality contingency of the CS–US pairs is discussed as the critical condition for a reliable establishment of EC (Stahl & Unkelbach, 2009; Stahl et al., 2009). Thus, EC of meaningless pseudowords with neutral pictures was expected to lead to neutral emotionality judgments, whereas EC of meaningless pseudowords with unpleasant pictures was expected to result in higher negative emotionality judgments. Following EC, differences in the ERPs of both, negatively and neutrally conditioned pseudowords, compared to previously non-presented new pseudowords should be attributed to an attention allocation based on the higher familiarity of the conditioned stimuli following the item repetition during learning. In contrast, ERP differences between negatively and neutrally conditioned pseudowords are best explained by differences in the conditioned emotionality. Thus, if contextual learning of the emotionality explains the emotion word recognition effects, larger amplitudes for negatively compared to neutrally conditioned pseudowords should be observed in the above mentioned ERP components, i.e. the early modulations, the EPN and the LPC.

2. Methods

2.1. Participants

Twenty-one native German speaking and neurologically healthy participants (16 woman, 5 men) took part in the study in return for course credits or € 40. According to the Edinburgh Handedness Scale (Oldfield, 1971), all participants were right handed.

2.2. Materials and procedure

The experiment consisted of two stages: an learning session first, followed by an experimental session consisting of a lexical decision task (LDT) with simultaneous EEG recording and two subsequent rating tasks. As US 150 unpleasant and 150 neutral IAPS pictures (Lang, Bradley, & Cuthbert, 2008) were selected which differed in both, mean emotionality (negative: 2.6, neutral: 5.2) and mean arousal (negative: 5.6, neutral: 3.4). As CS served 150 pronounceable pseudowords of 4–8 letters length. For each participant 50 pseudowords were randomly selected to be paired as a CS with the 150 unpleasant pictures, 50 were to be paired with the 150 neutral pictures, and the remaining 50 pseudowords re not shown during the EC sessions. Furthermore 75 negative and 75 neutral words were selected from the BAWL-R (Võ et al., 2009) matched for length (4–8 letters), word frequency, number of orthographic neighbors, number of syllables and imageability (all F'S < 1.3) so that they only differed at $p < .001$ in valence (negative: −1.6, neutral: 0.1) and arousal (negative: 3.5, neutral: 2.3) to be presented in the subsequent lexical decision paradigm together with the 100 conditioned and 50 previously not shown, new pseudowords.