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Are there similarities between emotional and familiarity-based processing in visual word recognition?

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ABSTRACT

Previous ERP research revealed emotion effects on visual word processing in early time windows (P1) and during later evaluative processing (LPC). In both time windows interactions with word familiarity measures have been reported.

Using an evaluative conditioning paradigm participants learned to associate meaningless pseudowords with neutral or negative valence. In addition, one set of pseudowords was learned three times as often as the others in order to manipulate familiarity.

Behavioral results confirmed that evaluative conditioning was effective. Small effects of emotion on P1 and of overall conditioning on the LPC were visible, while familiarity only modulated later ERP amplitudes (> 300ms). Exploratory analyses demonstrated a functional relationship between P1 and LPC emotion effects but not for familiarity. Post-hoc examinations illustrated that good learners showed effects of emotion and familiarity on LPC amplitudes which were not evident in participants performing below average. These results are discussed in light of questions regarding the representation and processing of valence and familiarity that are of interest for theoretical models of visual word recognition.

1. Introduction

Neuroscientific examinations in emotion word recognition that mainly relied on the event-related potentials (ERP) method have revealed emotional effects at different levels of processing. Evidence exists that such effects can be visible already at very early stages of word processing approximately 100–140 ms after a word is displayed (P1 and/or N1 components of the ERP, see Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009; Scott, O'Donnell, Leuthold, & Sereno, 2009; Kissler & Herbert, 2013; Palazova, Mantwill, Sommer, & Schacht, 2011). Additionally, later controlled processing stages often visible as a late positive deflection of the ERP (the LPC) around 400–600 ms have been found to be modulated by the words' emotional connotations (see Citron, 2012, for a review). LPC modulations have been interpreted to indicate that the subsequent access to the words' emotional and semantic features and meanings trigger additional explicit evaluative processing.

We have recently been able to show that to some extent the early effects can be explained by a contextual learning hypothesis (Fritsch & Kuchinke, 2013; Kuchinke, Fritsch, & Mueller, 2015; Kuchinke, Krause, Fritsch, & Briesemeister, 2014) where verbal and emotional information are interconnected based on previous learning episodes. This hypothesis states that it are not the emotional features themselves that trigger the early emotion effects in visual word recognition, but learned associations between lexical representations, their physical attributes and valence. In these studies previously meaningless letter strings are presented together with unconditioned emotional pictures during different conditioning sessions. Thereby affective associations are established that associate

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a letter string with the valence category of the pictures (so-called evaluative conditioning, e.g. Fritsch & Kuchinke, 2013). In visual word recognition such learned affective associations likely signal emotional significance very early during the word recognition process and are thought to shift attention to these affective features and towards faster (Kissler & Herbert, 2013) and more elaborated processing of emotional words (Kuchinke et al., 2015).

Such early emotional modulations (100–140 ms after a word is displayed) occur temporarily in parallel to the so-called lexical access, i.e. the point in time when a word is identified. One way to infer the time window of lexical access is to examine word frequency effects in visual word recognition. A manipulation of (objective) word frequency in word recognition aims at the familiarity with which a stimulus word is processed, assuming that high frequency words are accessed faster compared to low frequency words (Sereno & Rayner, 2003). Earliest effects of word frequency are visible before 140 ms (Sereno, Rayner, & Posner, 1998), but also later effects have been reported often visible as a frontal N400 component (FN400) and at the level of the LPC (e.g. Hauk & Pulvermüller, 2004; also; Dufau, Grainger, Midgley, & Holcomb, 2015; Laszlo & Federmeier, 2014). Such later effects are discussed to reflect post-lexical processing or the re-processing of word information (Hauk & Pulvermüller, 2004).

In visual word recognition behavioral and neuroscientific data have revealed an interaction between emotional valence and word frequency (a measure of a words' familiarity; e.g. Kuchinke, Võ, Hofmann, & Jacobs, 2007; Mendez-Bertolo, Pozo, & Hinojosa, 2011a; Palazova et al., 2011; Scott et al., 2009, Scott, O'Donnell & Sereno, 2012). The observation of emotion*frequency interactions in ERPs before 150 ms (e.g. Scott et al., 2009) thus shed light on encoding processes early in visual word recognition that are commonly affected by emotional features of a word and by its frequency of occurrence. In the study by Scott et al. (2009) for example, early emotion effects were only visible for high-frequency words. Additionally, emotion*frequency interactions have been observed to influence the LPC. Mendez-Bertolo et al. (2011a) for example reported reduced LPC amplitudes for neutral compared to negative nouns but only for low and not high frequency words. Taken together, emotion*frequency interactions in these ERP studies point to word recognition processes that are triggered by both of these word characteristics in a comparable fashion or to common functions of these variables visible in at least two time windows.

Of interest for the present study is the direction these effects elicited by emotion and frequency have: In the behavioral data both variables, higher values of emotion (i.e., more extreme positive or negative valence or higher arousal of a word) and higher values of word frequency/familiarity, lead to faster response times (Kuchinke et al., 2007). At the neurophysiological level, higher values of emotion and higher values of frequency seem to have opposing effects. Regarding the emotion variables the behavioral assumption is still right that higher values lead to larger effects visible as larger deflections in the ERP components at N1/P1 and the LPC (see Citron, 2012; Hofmann et al., 2009; Mendez-Bertolo et al., 2011a). In general, larger ERP amplitudes are interpreted as a relatively larger recruitment of, for example, attentional resources during early processing or more elaborate processing at late processing stages. Regarding word frequency and familiarity, it are the lower values, i.e. low-frequency, unfamiliar words, that attract attention and demand additional controlled processing (again reflected in larger early and/or later ERP deflections; Sereno et al., 1998; Hauk & Pulvermüller, 2004; Scott et al., 2009).

Studies on immediate repetition priming, which more directly modulates the familiarity of a word stimulus, have revealed that emotion variables interact with the effect of stimulus repetition at multiple stages of word processing, namely the early P1/N1 complex, P300 and N500 (e.g. Mendez-Bertolo, Pozo, & Hinojosa, 2011b). Specifically, although repetition priming operates at a short temporal interval during which the feeling of familiarity is established by presenting the target word twice in a row, first as a prime and directly afterwards as a target, the results seem comparable with the above reported frequency manipulations. Again, these authors discussed that higher amplitudes at early processing stages reflect attentional shifts to repeated (vs. unrepeated) words that are only visible for negative words (Mendez-Bertolo et al., 2011b). This seems comparable to what is found in Scott et al. (2009) where only the familiar, high-frequency words triggered effects of the P1.

This parallelism in behavioral data and the opposition in the direction of the neurophysiological effects is often neglected. While higher values of emotion are thought to attract attention and to facilitate lexical access (e.g. Kissler & Herbert, 2013), it is assumed that word frequency operates on the familiarity dimension of a word stimulus. More familiar words are processed faster but with less attentional processing. As a consequence faster lexical access for familiar words goes along with less attentional demands. At the theoretical level this is also considered: familiarity enhances the overall activation level in the hypothetical mental lexicon. Hence it are the unfamiliar stimuli that demand additional processing to gain a similar activation level necessary to trigger word identification (cf. Grainger & Jacobs, 1996; Kuchinke et al., 2007). This additional effort is assumed to account for higher amplitudes at post-lexical evaluative processing stages for unfamiliar words.

At present, no theoretical or computational model of word recognition exists that is able to incorporate and explain emotional effects at early processing stages (for a review see Hofmann & Jacobs, 2014). While familiarity is represented as higher levels of resting activity based on previous encounters with a word (e.g. Grainger & Jacobs, 1996), no such prediction is made for emotional features. The present study will contribute to this literature by applying an evaluative conditioning (EC) paradigm adapted from Fritsch and Kuchinke (2013, also Kuchinke et al., 2014) and examining the effects of emotion and familiarity manipulations at the level of electrophysiological responses. Since emotion and familiarity variables are known to correlate already at the database level (i.e. more positive words have higher familiarity levels, see Citron, Weekes, & Ferstl, 2014), it seemed advantageous to manipulate these variables using a-priori meaningless stimulus material: Evaluative conditioning refers to an association learning paradigm to establish an emotional connotation for meaningless pseudowords while at the same time avoiding a one-to-one mapping or identity learning. Thus, following multiple repetitions of learning trials with random pairings of pseudowords with emotional (or in the neutral condition neutral) pictures one can show that these items now possess an emotional valence (e.g. Hofmann, de Houwer, Perugini, Baeyens, & Crombez, 2010). It should be noted that we observed large interindividual differences in our previous evaluative conditioning ERP studies (Fritsch & Kuchinke, 2013; Kuchinke et al., 2015). The performance measures of the evaluative conditioning