Emotional arousal enhances lexical decision times

CHAPTER 4

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Abstract

In a lexical decision experiment emotional valence and emotional arousal were varied as an experimental factor. Using well controlled stimulus material, neutral, high-arousing negative and low-arousing negative words, as well as pronounceable nonwords were presented to the subjects while their response times and skin conductance responses were recorded. A processing advantage was observed for the high-arousing negative words, whereas the low-arousing negative words did not produce a behavioral effect. In addition, skin conductance responses were not affected by the emotional content. Thus, the present results show an effect of emotional arousal for negatively valenced words in the behavioral data which was not visible in the psychophysiological measures. The results are discussed in relation to an early evaluation system for emotional content.

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Introduction

Reading a word like ‘pain’ rapidly activates its semantic meaning and its emotional background. According to the notion of a pre-attentive memory system categorizing any incoming information with respect to its emotional content (Murphy and Zajonc, 1993), such activation can not solely be attributed to an explicit and conscious evaluation of the word. A number of studies tried to answer the question of whether emotional content affects word recognition before the letter string has been evaluated consciously using the lexical decision paradigm (Kuchinke et al., 2005; Siegle et al., 2002; Windmann et al., 2002). In the lexical decision task subjects are asked to categorize verbal stimuli as words or nonwords, and therefore their attention is primarily directed toward non-emotional features of the stimulus (Grainger and Jacobs, 1996).

The literature regarding affective influences in the lexical decision task is quite heterogeneous. Using a lexical decision task Siegle et al. (2002) did not find an effect of emotionally arousing verbal material. Furthermore, these authors presented a meta-analysis of seven lexical decision studies in which reaction times for negative and neutral words were reported. None of these studies observed a significant difference between the emotional valence conditions in normal participants (Siegle et al., 2002). Taken together, these findings closely correspond to studies on implicit information processing with emotionally valenced words, e.g. wordstem completion tasks, which also found no difference in subjects’ ability to complete negative words compared to neutral words (Danion et al., 1995; Nugent and Mineka, 1994). Danion et al. (1995) concluded that in situations where previously encoded information is subsequently processed without any conscious recollection behavioral data is not affected by the emotional valence of the words.

However, the opposite pattern was observed in a number of recent studies: Here, emotional valence clearly had an impact on word recognition performance in the lexical decision task. Windmann et al. (2002) found evidence of pre-lexical effects of affective information when they presented their stimuli subliminally, i.e. presentation conditions of the stimuli were near the perceptual threshold for conscious awareness. Word - nonword discrimination performance as well as the bias to classify a stimulus as a ‘‘WORD’’ were significantly enhanced for negative compared with neutral words. The authors therefore suggest that any visually presented verbal stimulus is initially evaluated for its emotional significance at a pre-lexical level. At this processing stage negative emotional associations are thought to enhance the bias to respond ‘word’. Similar results which point to emotional effects in early word recognition were obtained by different groups using the lexical decision task (Bradley et al., 1994; Challis and Krane, 1988; Kuchinke et al., 2005; Matthews and

Southall, 1991; Nakic, Smith, Busis, Vythilingham, and Blair, 2006; Ruiz-Caballero and Moreno, 1992; Williamson et al., 1991; Windmann and Krüger, 1998), but the direction of the effect is still controversial. While positive words seem to enhance subjects' reaction times (Bradley et al., 1994; Challis and Krane, 1988; Kuchinke et al., 2005; Williamson et al., 1991), the effect is less clear regarding negative material, where only two of the studies reported speeded reaction times for negative words in the lexical decision task compared with neutral words (Challis and Krane, 1988; Nakic et al., 2006).

Since emotional valence and emotional arousal are thought to represent two orthogonal dimensions that constitute the affective space (Lang et al., 1990; Bradley et al., 1992), it seems possible that the above mentioned studies differ on their mean arousal values for the negative word material. If it is the higher arousal of negative items which influences word recognition as recently suggested by a repetition priming study (Thomas and LaBar, 2005), then low-arousing negative words should lead to smaller or null effects on lexical decision performance compared to high arousing negative words. Contrasting high- and low-arousing negative words is therefore the main objective of the present study.

The associative network model (Bower, 1981) is the most prominent theory to describe the interaction between emotion and memory. Here, emotional states are seen as nodes in a semantic network and representations emerge as a function of activated nodes associated with cognitive and emotional content. Thus, it seems possible that early in word recognition evaluative processes which categorize the emotional significance of incoming stimuli and orthographic, phonological or morphological processes can operate in parallel (Kitayama, 1990). In this case, emotional significance can be thought as lowering the threshold for lexical access when subjects process a letter string, as recently shown in a naming study with masked presentation of high-arousing negative words (Gaillard, Del Cul, Nacaache, Vinckier, Cohen, and Deheane, 2006).

In addition to the behavioral data subjects skin conductance responses (SCRs) during the lexical decision task were measured in the present study to monitor sympathetic activity associated with emotional arousal. SCRs have been shown to reliably covary with emotional arousal of nonverbal stimuli, e.g. when looking at pictures (Lang, Greenwald, Bradley, and Hamm, 1993) or during encoding in a recognition memory task (Bradley et al., 1992). SCRs are phasic measures of sympathetically innervated sweat gland activity, and higher SCRs are associated with the processing of pictures which are rated high in arousal. In word processing larger SCRs have been found as a reaction to high-arousing taboo words (LaBar and Phelps, 1998) or fear words (e.g., 'SPIDER', van den Hout, De Jong, and Kindt, 2000) during encoding but not when processing low-arousing negative words (Phelps et al., 1997).

Methods

Participants

Twenty-six students (18 female, mean age 25.3 years) from the psychology department at Freie Universität Berlin participated voluntarily or to partially fulfill course credit. All subjects gave informed consent and were native German speakers who reported no history of mental illness or depression.

Stimulus material

Special attention was given to the stimulus selection process to prevent lexical decision performance from being biased by orthographic word features (see Graf et al., 2005). In a first step 600 German nouns were selected from the Berlin Affective Word List (Võ et al., in press). The Berlin Affective Word List contains normative valence ratings ranging from (-3) negative over (0) neutral to (+3) positive for more than 2200 German words. For the selected 600 words normative arousal ratings were obtained using the Self-Assessment-Manikin rating system (Lang, 1980). The normative arousal ratings were sampled from at least 20 subjects (per word) on a seven point scale ranging from (1) calm to (7) arousing.

In a second step a subset of 20 neutral, 20 low-arousing negative, 20 high-arousing negative words was selected from the larger Corpus of 600 German nouns as the word material for the present study. It is important to note that the set of high-arousing negative words does not contain taboo words (see Table C1 in Appendix C for a complete list of stimuli). High- and low-arousing negative words did not differ in valence but in their arousal ratings, whereas low-arousing negative words and neutral words were selected to be comparable in their arousal ratings and to differ on the valence dimension. In addition, the three word lists were carefully matched for mean word frequency, number of letters, number of orthographic neighbors, and number of higher frequency orthographic neighbors (word statistics derived from German CELEX database, Baayen, et al., 1995; see Table 4.1). The stimulus material was completed by the selection of 60 pronounceable nonwords which were matched to the words on their number of letters.

Table 4.1
Summary Statistics for the Word Material including Emotional Arousal, Emotional Valence, Word frequency per million (F), Mean Letter Length, Number of Orthographic Neighbors (N), and Number of Higher Frequency Orthographic Neighbors (HFN)

	Arousal		Valence		F		Letter		N		HFN	
Word Type	M	SD	M	SD	M	SD	M	SD	M	D	M	SD
High-Arousing Negative	4.23	0.21	-1.75	0.23	23.0	20.8	6.15	1.18	1.20	1.85	0.30	0.66
Low-Arousing Negative	3.39	0.40	-1.78	0.22	23.2	22.9	6.25	0.91	1.55	1.50	0.35	0.67
Neutral	3.22	0.22	-0.01	0.27	24.7	26.0	6.10	0.85	1.10	1.52	0.25	0.44

M = Mean, SD = Standard Deviations

Procedure

Subjects were seated in a comfortable chair approximately 90 cm away from the 17'' computer screen. To record the skin conductance responses, two Ag-AgCl electrodes (8 mm diameter of active area) filled with 0.5 % NaCl electrolyte were attached to the thenar and hypothenar eminence of the subjects' non-dominant hand by means of double-sided adhesive collars. The electrodes were connected to a PARON™ (PAR-Medizintechnik, Berlin, Germany) system linked to a microcomputer whose software PARON (PAR-Medizintechnik, Berlin, Germany) allowed visualization and storage of electrodermal activity. The electrodermal data was measured with a sampling rate of 100 Hz by means of the constant voltage method (0.4 V). To spot electrodermal artifacts due to respiration irregularities, respiration was measured by a respiration belt attached around the waist of the subjects. In addition, subjects were instructed to avoid unnecessary movements. The experiment consisted of 10 training trials (with a different set of 5 words and 5 nonwords) and the 120 experimental trials and lasted about 15 min.

A single trial started with the presentation of a fixation cross'+' for 1000 ms in the centre of the screen, followed by the appearance of the experimental item for 2500 ms and the interstimulus interval of 5000 ms as indicated by the presentation of '∗∗∗'. Subjects were instructed to respond as quickly and accurately as possible, by pressing the left mouse button for ''word'' and the right mouse button for ''nonword''. The mapping between fingers and mouse buttons was counterbalanced across the subjects.

Data preparation and analysis

Skin conductance data were analyzed similarly to the procedure in Lang et al. (1993). Respiratory artifacts were removed following visual inspection of the single trials (7.2% of the trials had to be discarded). The baseline SCR was defined as the average response during the 200 ms preceding stimulus onset, which was then subtracted from the skin conductance value. The maximum response was computed in the interval between 0.5 s and 6 s post stimulus onset, and a log-transformation was applied to normalize the skewed data. Averaged mean SCRs, reaction times and error rates per experimental condition and subject were submitted to a two-way repeated measures analysis of variances (ANOVA) comprising the within-subject factor 'emotional arousal' (high-arousing negative, low-arousing negative, neutral). Significance level was set at alpha = 0.05 and a Greenhouse-Geyser correction was applied if necessary.

Results

Following data preparation (behavioural outliers = 5.3 %) the repeated measures ANOVA indicated a significant effect of emotional arousal in the reaction times, *F(2,50) = 4.906, MSE = 1376.284, P = 0.011* (Table 4.2). Bonferroni-corrected follow-up t-tests revealed that high-arousing negative words were processed faster than both, low-arousing negative words *(P = 0.020*) and neutral words (*P = 0.044*). Low-arousing negative words and neutral words did not differ significantly. Analyzing the error data did not reveal a significant effect of emotional arousal, *F(2,50)=2.141, MSE = 0.001*. In contrast to the reaction times no significant differences could be observed on the SCR amplitudes regarding the emotional arousal manipulation, *F(2,50)=0.126, MSE = 0.001* (Table 4.2).

Table 4.2
Lexical Decision Performance Data including Reaction Times in ms (RT), Error rate and Skin Conductance Responses (SCR)

Word Type	RT		Error rate		SCR	
	M	SD	M	SD	M	SD
High-Arousing Negative	731	98	0.025	0.036	0.121	0.169
Low-Arousing Negative	754	102	0.012	0.026	0.119	0.164
Neutral	762	103	0.029	0.044	0.122	0.170

M = Mean, SD = Standard Deviations

Discussion

In the present study, we asked whether emotional arousal influences word recognition, even when the subjects do not have to pay attention to the emotional content of the stimuli for executing the task. The study directly contrasted the processing of high- and low-arousing negative words in a lexical decision task. Using a well-controlled stimulus material manipulating emotional arousal and emotional valence resulted in a significant effect in the reaction times, but not in the psychophysiological measure of SCRs. High-arousing negative words were processed faster than low-arousing negative and low-arousing neutral words, indicating a clear effect of emotional arousal, while negative valence alone did not affect reaction times when word lists were controlled for emotional arousal (as revealed by the comparison with neutral words). This result indicates that emotional arousal is an important factor in visual word recognition when processing negative words. As concerns the processing of high frequency nouns this observation challenges previous findings regarding null effects of negative valence in the lexical decision task, because only high-arousing negative words show the processing advantage. This result is in accordance with recent findings on repetition priming, where implicit memory was found to be selectively enhanced by high arousing taboo words and not by low-arousing negative words (Thomas and LaBar, 2005). In this task, like in the present lexical decision study, the emotional arousal manipulation was incidental to the subjects. Interestingly, Thomas and LaBar (2005) used a lexical decision task in their test phase of the experiments and observed a response time cost for novel taboo words, a result which was also observed in a lexical decision task by MacKay et al. (2004) although this effect remained non-significant. Nonetheless these studies used taboo words, which are not comparable to the material used in the present study.

How does emotional arousal influence the processing of a verbal stimulus? One account stems from automatic evaluation models (Anderson and Phelps, 2001; Murphy and Zajonc, 1993; Windmann et al., 2002). Such a mechanism could also compute the significance or intensity of any stimulus. If stimuli were automatically classified regarding their emotional significance early in perception, this would increase the likelihood that an emotional stimulus reaches awareness. In their attentional blink study Anderson and Phelps (2001) identified the amygdala as the neural substrate which may enhance the perceptual sensitivity of emotionally arousing words at an early processing stage. Amygdala involvement has recently been observed in a lexical decision task on negative words using functional imaging (Nakic et al., 2006), which is discussed to enhance the perceptual processing through its projections to visual areas (Whalen, Kagan, Cook, Davis, Kim et al., 2004).

As another important finding, skin conductance measures were not found to be influenced by the arousal manipulation. Although the interpretation of null effect is always problematic, the present finding suggests that words, which are rated high in emotional arousal, do not consistently modulate subjects' physiological arousal (as indexed by the SCR). There has been some dispute about whether processing single words does cause emotional reactions in a similar way that pictures do (Damasio, 1994; Kensinger and Corkin, 2004; Kuchinke et al., 2005; LaBar and Phelps, 1998; Phelps et al., 1997). For example, Phelps et al. (1997) could not observe differences in the SCR relative to the processing of emotionally valenced word categories, whereas taboo words mediated higher SCRs during stimulus encoding (LaBar and Phelps, 1998). This is different from the processing of pictures where high arousing positive and negative stimuli enhance SCR responses (Bradley et al., 1992).

According to their functional imaging results Kuchinke et al. (2005) suggested that early evaluation might be also subserved by prefrontal cortical regions. It is possible that the present null effects regarding the psychophysiological measures were observed because implicitly processing emotional arousal in word recognition does not mediate autonomic emotional reactions. In contrast to the observed SCR effects in processing taboo words (LaBar and Phelps, 1998), our experiment was designed to examine the implicit processing of high- and low-arousing negative words that were explicitly not sexually arousing or shocking taboo words but familiar words of high frequency which belong to the every day lexicon.

In summary, the results of the present study provide evidence that incidental effects of emotional arousal are visible in word recognition regarding negative word material, which were not observed for low-arousing negative stimuli. Thus, emotional arousal appears to modulate the speed at which a verbal stimulus is processed and hence a lexical decision can be made. Because the present data only focused on the processing of negatively valenced words, future studies using high- and low-arousing positive words will help to see if this arousal-based hypothesis can be generalized beyond the scope of negative material. According to our experience lexical decisions on positive words may be processed differently in the brain compared to negative words (Kuchinke et al., 2005) and it is questionable whether higher arousal produces similar processing advantages for positive words, because behavioral effects are already observable using low-arousing positive words.