

Abstract

This dissertation examines the influences of the emotional valence of words on implicit and explicit word recognition. The research question arose from an ongoing debate in the scientific literature on whether emotional valence has an influence on cognition and how this influence is explained. Especially when looking at the implicit (non-intentional) processing of emotional information different authors proposed that no differences in the behavioural data should occur depending on the words' emotional valence (see Danion et al., 1995; Siegle et al., 2002).

In contrast to these considerations, different experimental studies observed that subjects' response times depend on the words' emotional valence in lexical decision tasks. In the lexical decision task subjects have to judge whether a letter string is a correct word (e.g. 'house') or no correct word (a so-called nonword, e.g. 'houxe'). It is well known that different features of a word affect subjects' response times even if they are not necessary to correctly process the task at hand (Graf et al., 2005). Since this kind of information processing is non-intentional or automatic, the lexical decision task is described as implicit word recognition. Studies that observe differences in the lexical decision task depending on the words' emotional valence contradict the above mentioned considerations where emotional valence is only expected to affect explicit (intentional) recognition tasks.

Using the lexical decision task, Challis and Krane (1988) observed that positive and negative words are both responded to faster than neutral words, whereas Bradley et al. (1994) found decreased response times only to positive words. Such implicit influences on visual word recognition are more generally explained in terms of a hypothesized affective evaluation mechanism. Going back to the 'affective primacy' hypothesis (Murphy and Zajonc, 1993), the proposition of an affective evaluation mechanism assumes the existence of a cortical system that categorizes every incoming stimulus on whether it has a positive or negative valence. An important assumption concerns the automaticity of this system, i.e. that the proposed mechanism operates without intentional control and does not demand additional processing resources. On an evolutionary perspective the affective evaluation mechanism is intended to shift attention towards the processing of emotionally valenced contents. Following the heterogeneous findings in previous literature concerning the lexical decision task, it can be asked whether such an affective evaluation mechanism is also evident when emotionally valenced words are processed implicitly.

A first proposition of this dissertation is that the heterogeneous results are at least partly ascribed to methodological differences between the mentioned studies. This concerns a number of variables, that are neglected in these studies, but have previously been shown to affect lexical decision times. Put another way, this means that the present dissertation gives special attention to the stimulus selection process. With the use of highly controlled stimulus material three different empirical studies and one simulation study were conducted to examine the implicit influences of emotionally valenced words on visual word recognition, whereas the last empirical study examined explicit recognition memory for emotionally valenced words. By doing so, the main research question was to test the construct 'emotional valence' in implicit word recognition. Does the words' emotional valence modulate performance in a lexical decision task? Or do methodological flaws, such as neglecting the influence of moderator variables in the stimulus material, contribute to the different results in the literature? In addition, psychophysiological and neuroimaging methods were used to analyse the processes and neural correlates responsible for the processing of emotionally valenced words, which will lead to the development of a computational model of visual word recognition that comprises an affective evaluation mechanism.

The first study (Chapter 2) was designed to examine the neural networks associated with the processing of the words' emotional valence during a lexical decision task, and whether these neural networks can be further dissociated regarding the valence-specific processing of positive and negative words. To answer this question, a functional magnetic resonance imaging experiment was conducted. The stimulus material for the lexical decision task consisted of each 50 positive, neutral and negative words. In both parts of this study a purely behavioral pre-experiment comprising 20 subjects and the functional imaging study comprising another 20 subjects, significant processing enhancements for positive words compared with neutral and negative words were observed, whereas the last two did not differ.

Words revealed activations in the left hemisphere when contrasted with nonwords, an activation pattern that has been associated with the processing of semantic information. Furthermore, orbitofrontal and bilateral regions along the inferior frontal gyrus were identified that elicited higher activations for the processing of emotionally valenced words compared with neutral words. Comparing positive and negative words directly revealed additional activations in anterior and posterior cingulate gyrus and the hippocampus associated with the processing of positive words. These regions are discussed in more general terms to support emotional information processing in explicit memory tasks. Hence, their involvement in implicit word recognition points to cortical networks that are responsible for semantic and emotional information processing. A general theoretical framework for this is the network model by Bower (1981) which proposes emotional information to be an inherent

characteristic of semantic networks. Spreading activation in such a network might support the activation and retrieval of emotional as well as semantic contents.

The second and the third study further examined the conditions for the null effect of negative words in the lexical decision task. Although it has not been observed in the first study, an processing advantage of negative words was expected from the proposition of an affective evaluation mechanism. In the second study (Chapter 3), 26 subjects performed a lexical decision task where word frequency was introduced as a second factor in the design (comprising high- and low-frequency words). In addition to the behavioral data, pupil dilations were measured by means of an eye-tracking device. The task-evoked pupillary response has been shown to be a reliable marker of emotional reactions (Janisse, 1974) or processing demands (Beatty, 1982). In the present study positive words showed a response time advantage independent of the word frequency condition, whereas only low-frequency negative words had a similar effect. No influences on the task-evoked pupillary responses were observed for the emotional valence variation. In contrast, word frequency had a significant effect: High-frequency words elicited smaller pupil dilations than low-frequency words. This main effect of word frequency is discussed in relation to increased cognitive demands during the processing of low-frequency words, whereas the results of the emotional valence conditions support the assumptions of an automatic affective evaluation mechanism.

The third study (Chapter 4) further examines the effects of high-frequency negative words. Do theories that propose a two-dimensional affective space (Lang et al., 1990) bring additional clarification? A two-dimensional approach of emotional valence (from negative across neutral to positive) and emotional arousal (from calm to arousing) is discussed in the literature. Emotional arousal of pictures correlates with peripheral-physiological measures, e.g. skin conductance responses, and contributes to performance in different explicit memory tasks independent of emotional valence (Ochsner, 2000). Before answering the question of whether valence and arousal influence word recognition, a word rating study was conducted to obtain normative arousal data for 600 German words. On the basis of the rated emotional arousal a stimulus set for a lexical decision experiment was selected. In this experiment, 26 subjects judged the lexicality of 20 neutral, 20 low-arousing negative, 20 high-arousing negative words and 60 nonwords, while their skin conductance responses were recorded. A significant processing advantage for high-arousing negative words was observed, while low-arousing negative words could not be differentiated from neutral words in their response times. Neither emotional arousal nor emotional valence affected skin conductance responses during the processing of the lexical decision task.

Following the results in the first chapters and the models discussed in the literature concerning early affective influences on cognitive processing a computational model of visual word recognition was developed in Chapter 5. According to the 'nested modelling' approach

the model is conceived as an extension of its predecessor, the multiple read-out model (MROM, Grainger and Jacobs, 1996). A nested modelling strategy is intended to lead to more powerful models which overcome the weaknesses of their predecessors while keeping their strengths (Perry et al., in press). To test this proposition the new model has to prove its appropriateness in different simulation studies on existing and new effects (Jacobs et al., 1998). The extended version of MROM, called MROME, contains a newly developed affective evaluation mechanism that simulates the outcomes of amygdala functioning. Activations in the mental lexicon that are associated with affective information will be detected and enhanced by the affective evaluation module. The affective evaluation mechanism which relies on minimal assumptions is able to model standard effects of MROM and allows even better predictions regarding the processing of emotionally valenced words in the lexical decision task compared with that of MROM.

To investigate emotional valence modulation in explicit word recognition a further functional magnetic resonance imaging study was conducted which is described in chapter 6. Twenty subjects studied 50 positive, neutral and negative words and had to judge in a follow-up test situation which of 300 presented words they had been studying before. The behavioral data support the notion of a processing advantage of emotionally valenced words that is also visible in an explicit memory task. The analysis of the imaging data in prefrontal cortex revealed valence-specific activations during the processing of this explicit recognition task that is discussed in relation to retrieval based memory processes.

To sum up, the results of this dissertation might be seen as evidence for a processing advantage of emotionally valenced material in implicit and explicit word recognition which is best explained by the proposition of an early affective evaluation mechanism that supports perceptual enhancement of emotionally valenced words in implicit tasks. It is probable that the perceptual enhancement of emotionally valenced words increases the familiarity of affective stimuli. This would lead to an increased number of errors in explicit memory tasks when emotionally valenced words appear to be recognized more easily. In addition, the results suggest that emotional valence and emotional arousal both contribute to the processing enhancement in the lexical decision task. Moreover, this effect is modulated by stimulus selection process in an important way, as indicated by the interactive influence of word frequency. The functional imaging data support the notion of a close relationship between semantic and emotional processing in implicit and explicit recognition, while the null effects for emotionally valenced words in the peripheral-physiological data point to little involvement of physiological reactions in the lexical decision task on single words. Future studies should focus on the temporal aspects of the influences of valence and arousal on word recognition. It is expected that the recording of event-related potentials will be an adequate candidate to investigate this issue. Furthermore, a systematic manipulation of

emotional arousal in implicit and explicit word recognition is necessary to examine whether emotional arousal has a non-linear influence on cognitive processing as proposed for highly-arousing taboo words. Is it possible to generalise the observed effects of emotional arousal on other word types (adjectives, verbs) and on low-frequency words? Or does emotional arousal only affect the processing of high-frequency words in word recognition. The proposed affective evaluation mechanism is expected to operate independently of the task used. Thus, it will be interesting to see, whether other implicit tasks that depend to a lesser degree on strategic factors than the lexical decision task, comprise similar effects of affective material. Furthermore, the examination of modulatory influences of affective material should be extended to the implicit processing of picture stimuli. Emotionally valenced pictures comprise a higher level of contextual information and are discussed to elicit increased physiological reactions.