

## Erotic and disgust-inducing pictures—Differences in the hemodynamic responses of the brain

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Received 1 February 2004; accepted 26 November 2004  
Available online 15 February 2005

### Abstract

The aim of this fMRI study was to explore brain structures that are involved in the processing of erotic and disgust-inducing pictures. The stimuli were chosen to trigger approach and withdrawal tendencies, respectively. By adding sadomasochistic (SM) scenes to the design and examining 12 subjects with and 12 subjects without sadomasochistic preferences, we introduced a picture category that induced erotic pleasure in one sample and disgust in the other sample. Since we also presented neutral pictures, all subjects viewed pictures of four different categories: neutral, disgust-inducing, erotic, and SM erotic pictures.

The analysis indicated that several brain structures are commonly involved in the processing of disgust-inducing and erotic pictures (occipital cortex, hippocampus, thalamus, and the amygdala). The ventral striatum was specifically activated when subjects saw highly sexually arousing pictures. This indicates the involvement of the human reward system during the processing of visual erotica.

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*Keywords:* fMRI; Emotion; Disgust; Pleasure; Sex behavior; Ventral striatum; Reward system

### 1. Introduction

Modern brain imaging techniques like functional magnetic resonance imaging (fMRI) provide new insights into the functioning of emotion-relevant brain structures and can therefore help to improve contemporary models of affective processing.

In many current biological theories of emotion the existence of at least two motivational systems is proposed: an approach and a withdrawal system (Arnold, 1960; Konorski, 1967; Lang et al., 1990; Davidson et al., 2000). The approach system responds to stimuli, which promote the survival of the species (e.g. food-related or sexual stimuli), whereas the withdrawal or defense system is triggered by

stimuli, which threaten the personal integrity (e.g. fear-inducing or disgust-inducing stimuli).

It is still under discussion how these systems are represented in the brain. While some theories suggest the existence of central structures, which are involved in both, the decision of whether something is good (and therefore should be approached), and the decision of whether something is bad (and therefore should be avoided), other theories assume a selective responsiveness of certain brain areas to either positive or negative stimuli. For example, Rolls (1999) describes the amygdala together with the orbitofrontal cortex as an entity, which decodes the salience of a stimulus independent of its valence. In contrast, Gray (1994) suggests a dissociation of brain structures involved in behavioral inhibition and approach. Davidson and Irwin (1999) also postulate a valence-specific topography of emotional processing in the form of a frontal asymmetry.

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These few examples demonstrate the diversity of concepts regarding emotional processing.

This model diversity could be partly a result of differences in experimental data resulting from different techniques of emotion induction. In brain imaging studies, visual, auditory (e.g. Blood et al., 1999), and olfactory stimulation (e.g. Royet et al., 2001) as well as emotional memories (Kimbrell et al., 1999) have been applied to evoke emotion. The most widely used visual material consisted of emotion-relevant movies (e.g. Lane et al., 1997a), pictures of affective faces (e.g. Phillips et al., 1997) or emotionally relevant scenes (e.g. Lane et al., 1997b; Lang et al., 1998; Schienle et al., 2002a). Furthermore, these visual stimuli differed with regard to their emotional content: for example, the induction of negative emotions has been accomplished by fear-inducing, sadness-inducing, or disgust-inducing pictures. The situation is similar for positive affect: besides erotic stimuli, pictures of sportive activities or smiling babies were presented. Finally, in some of the studies, pictures with humans (e.g. faces) were shown, whereas in others, non-human objects were displayed. Thus, when attempting to interpret the brain imaging data it is often difficult to decide whether the observed activation pattern is valence-specific, content specific, or the result of the physical features of the pictorial material.

Keeping these limitations in mind, the brain structures which have been repeatedly reported to be involved in the processing of pictures with a negative valence in comparison to neutral scenes are in the cortex: occipital–parietal–temporal areas (e.g. Lang et al., 1998; Schienle et al., 2002a; Bradley et al., 2003), the insula (Phillips et al., 1997; Schienle et al., 2002a), the anterior cingulate (Bishop et al., 2004), and the prefrontal cortex (Lane et al., 1997a,b; Schienle et al., 2002a; Blair et al., 1999). Subcortically, the involvement of the basal ganglia (Phillips et al., 1998; Calder et al., 2001), the thalamus (Lane et al., 1997a,b; Phan et al., 2002), and the amygdala (e.g. Irwin et al., 1996; Morris et al., 1996; Breiter et al., 1996; Stark et al., 2003; Zald, 2003 for a review) was reported.

Stimulation with positive pictorial material, especially with erotic stimuli, has been accompanied by an increased cortical activation in the occipital–parietal–temporal region (Redouté et al., 2000; Arnow et al., 2002; Karama et al., 2002; Bradley et al., 2003), the insula (Redouté et al., 2000; Park et al., 2001; Arnow et al., 2002; Karama et al., 2002), the anterior cingulate (Rauch et al., 1999; Redouté et al., 2000; Park et al., 2001; Arnow et al., 2002; Karama et al., 2002), and the prefrontal cortex (Lane et al., 1997b; Redouté et al., 2000; Park et al., 2001; Karama et al., 2002). Subcortically, elevated activation was observed in the basal ganglia (Redouté et al., 2000; Park et al., 2001; Arnow et al., 2002; Karama et al., 2002), the thalamus (Lane et al., 1997b; Rauch et al., 1999), the amygdala (Breiter et al., 1996; Schneider et al., 1997; Beauregard et al., 2001; Karama et al., 2002), the hypothalamus (Lane et al., 1997b, Beauregard et al., 2001), and the brain stem (Lane et al., 1997b; Rauch et al., 1999).

This review of the neuroimaging literature reveals that the processing of pleasant and unpleasant emotions shares several of the involved brain structures, but some structures appear to be selectively required in either positive or negative affect (for a review see Phan et al., 2002). The results are still somewhat inconsistent, which may be partly due to the fact that only a few studies included positive as well as negative emotional conditions in their experimental design.

We therefore conducted an experiment, in which both positive and negative pictures were presented in a block design. Since it is essential to control for the intensities of the studied emotions (Davidson and Irwin, 1999), we decided to contrast the brain-dynamic responses towards disgust-inducing and erotic pictures, which should result in similar arousal ratings (Lang et al., 1993). In general, the pictures of the different categories should be comparable with regard to physical features such as color, contrast and complexity in order to exclude the influence of these aspects on the results. Great effort is therefore usually made concerning the picture selection so as to ensure the comparability of the pictures; however the fact remains that typical disgust elicitors, for example, look different from typical erotic stimuli. In order to deal with this problem we decided to not only compare the differences in the hemodynamic responses towards disgust-inducing pictures and erotic pictures within the subjects, but we also asked whether it is possible to find groups of subjects who are stimulated differently by the same pictures. One group should be disgusted, the other sexually aroused by the same visual material. Following this consideration, we added pictures with sadomasochistic content to the stimulus material and examined two samples—one with (SM) and one without (nonSM) sadomasochistic sexual preferences. In a pilot study, which served the stimulus selection (see Section 2), we found that pictures with sadomasochistic scenes (bondage, padding etc.) did indeed induce erotic pleasure in subjects with these sexual preferences, while the same pictures resulted in significant disgust ratings by nonSM subjects.

For the present investigation, we studied a group of sadists and masochists, who did not fulfill the diagnostic criteria of the DSM IV (American Psychiatric Association, 1994). The SM subjects were instead characterized by their admission that they enjoy participating in psychological and physical acts of dominance and/or submission for their sexual pleasure. Humiliation is commonly a part of psychological acts of dominance/submission, while physical pain predominantly characterizes physical acts of dominance/submission. Distinct from clinical samples, however, members of this subculture stress that a mutual consent has to be present for their interactions (for description see e.g. Weinberg, 1995). They further claim that they do not suffer as a result of their sexual orientation but interpret their sexual activities as a broadening of their sexual experience.

The use of disgust-inducing, erotic, and neutral pictures together with the additional application of pictures with

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