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# Stimulus type and design influence hemodynamic responses towards visual disgust and fear elicitors

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**Abstract**

The question to what extent emotion-related brain activation depends upon the presentation design (block design vs. event-related design) and the stimulus type (scene pictures vs. pictures with facial mimic) has hardly been addressed in previous functional magnetic resonance imaging (fMRI) research. In the present fMRI experiment, 40 right-handed subjects viewed pictures with fear-inducing and disgust-inducing content as well as facial expressions of fear and disgust. Pictures of neutral objects and neutral facial mimic were used as control stimuli. The pictures were presented in a block design for half of the subjects; the other half viewed the same stimuli as singular events in randomized sequence. The participants had been instructed to passively view the pictures.

Disgust-evoking scenes provoked activation in the amygdala, the insula and the orbitofrontal cortex (OFC). This applied to the blocked as well as to the event-related design. Fear-relevant scenes were associated with activity in the insula, the OFC and the middle temporal gyri in the event-related design. The presentation in a block design only led to activation in the middle temporal gyri. Facial expressions of disgust and fear did not trigger significant activation neither in the blocked nor event-related design.

This surprising outcome may be a result of context and task effects. The face stimuli which were presented together with the more complex scenes in a passive viewing paradigm possibly were not salient enough to trigger emotional processing.


*Keywords:* Emotion; Disgust; Fear; fMRI; Block; Event

## 1. Introduction

Neuroimaging research has helped to gain valuable knowledge about the brain mechanisms underlying affective processing. Numerous studies have been concerned with basic emotions, such as happiness, fear, anger, sadness and disgust (Phan et al., 2002). Over the last years, a special research effort has been directed towards the neural substrates of fear in healthy subjects as well as in patients suffering from anxiety disorders (e.g. specific phobias, obsessive compulsive disorders (OCD), posttraumatic stress disorders). This resulted in a great number of studies on the perception, processing and conditioning of fear stimuli (for a review see Calder et al., 2001).

Besides fear, disgust has recently attracted increasing research interest in the field of affective neuroscience. This new focus may be a result of clinical observations on patients suffering from anxiety disorders who often experience feelings of disgust when confronted with disorder-relevant material. Many spider phobics report that they are disgusted when looking at spiders, and many OCD patients suffering from contamination fears execute their cleaning rituals due to the felt repulsion (Thorpe and Salkovskis, 1998; Schienle et al., 2005).

Disgust has been described as a basic, cultural invariant emotion with a distinct pattern of physiological responses and a typical facial expression (Ekman, 1992). The disgust mimic is characterized by a wrinkled nose and a raised upper lip. This may indicate that disgust evolved as a

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food-related emotion in order to prevent the incorporation of harmful substances into the body (Rozin and Fallon, 1987). The somatic indicators of disgust are predominantly parasympathetic (e.g. nausea, heart rate deceleration, blood pressure decrease; Levenson et al., 1990). This activation pattern distinguishes disgust from other negative emotional reactions such as fear, which is sympathetically dominated.

Several brain regions have been identified by means of neuroimaging studies as crucial for the processing of the basic emotions fear and disgust. The amygdala is primarily involved in the recognition of fear stimuli (Calder et al., 2001) and in fear conditioning (LeDoux, 1999). Another brain area that has been discussed as fear-relevant is the orbitofrontal cortex (OFC), which is known to modulate amygdalar activation and is a part of an emotion-processing network as proposed by Rolls (1999).

The emotion disgust engages different brain regions than fear. Phillips et al. (1997) observed activation of the insular cortex and the basal ganglia as a reaction to disgusted facial expressions. This finding has been replicated by Sprengelmeyer et al. (1998), Phillips et al. (1998) and Wicker et al. (2003), who concluded that the insula is a specific brain locus for disgust processing, whereas fear specifically engages the amygdala. However, this conclusion might be premature, since there are neuroimaging data pointing to a participation of the amygdala and the insular cortices in other emotions as well. For example, Schienle et al. (2002a) have shown that reactions to disgust-inducing scenes involved the amygdala and the OFC. Activation of insular cortices occurred to both fear-inducing and disgust-evoking stimuli, while amygdalar activation was even stronger towards disgust. These findings are in clear contradiction with the assumption of distinct brain regions for the processing of various basic emotions.

Many neuroimaging studies concerned with fear and disgust have used pictures with facial emotional expressions for the emotion induction (e.g. Phillips et al., 1997; Winston et al., 2003). A second approach arranges the stimulus material on the dimensions valence and arousal (e.g. Codispoti et al., 2001). As a consequence, a differentiation between distinct emotions is not possible. Finally, there are several authors who have investigated different basic emotions with scene stimuli (e.g. Schienle et al., 2002a; Stark et al., 2004) and attempted to detect those brain areas with a specific reactivity towards different emotion elicitors and those generally involved in affective processing.

Besides various stimulus material, different tasks have been applied while examining reactions to emotion stimuli, e.g. gender and age discrimination (Gur et al., 2002). Recently, it has been demonstrated that limbic activation strongly varies with the task condition. Taylor et al. (2003) reported a decrease in limbic activation when using a rating compared to a passive viewing task. Altogether, neuroimaging research has hardly addressed whether there are differences in the neural correlates of emotions depending on the stimulus material and the chosen instruction for the subjects on how to process the emotion elicitors.

Another important question for neuroimaging studies on emotions concerns the stimulus arrangement. Does the design type matter such as block- and event-related designs? Many researchers favor event-related designs due to their applicability in different kinds of experimental variations (Josephs and Henson, 1999). However, others use block designs due to their easy application. While event-related designs are best in estimating the hemodynamic response function, blocked designs have more power to detect activation (e.g. Liu et al., 2001). There is substantial variation in applied designs in the literature, but theoretical considerations imply that there are remarkable differences in detection power between block- and event-related designs. Yet, little effort has been made to vary the design type while keeping the stimuli and the experimental task constant.

One aim of the present study on fear and disgust processing was to investigate whether face and scene stimuli would lead to comparable brain activation patterns. We expected that both mimic and scenes should mainly engage the same structures. Based on previous work (Schienle et al., 2002a), we hypothesized that the viewing of disgust and fear inducing pictures would activate occipito-temporal areas (the ventral visual pathway) and limbic areas like the amygdala, as well as insular and orbitofrontal cortices. The second question referred to possible differences in the activation degree between a blocked and an event-related design. Since not all paradigms are easy to implement in both design types, we used a picture perception paradigm with a passive viewing task. Considering that block designs have a higher detection power, we hypothesized that the block design would lead to a more pronounced activation.

## 2. Method

### 2.1. Subjects

Forty right-handed (assessed by the Edinburgh Inventory of Handedness, Oldfield, 1971) volunteers (20 males; 20 females) with a mean age of 23.93 years (range: 19–32 years) participated in this study. Half of them underwent a block paradigm, the other half viewed pictures as singular events. Subjects were checked for current psychiatric illness and history of brain injury. Written informed consent was obtained after the experiment had been explained to them. The study had been approved by a local ethics committee.

### 2.2. Stimulus materials

Seventy-two visual stimuli were used in this study. Thirty-six were selected from the International Affective Picture System (IAPS, Lang et al., 1995) and material used