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# Hemodynamic responses to fear and disgust-inducing pictures: an fMRI study

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**Abstract**

The majority of neuroimaging studies on affective processing have indicated that there are specific brain structures, which are selectively responsive to fear and disgust. Whereas the amygdala is assumed to be fear-related, the insular cortex is most likely involved in disgust processing. Since these findings are mainly a result of studies focusing exclusively either on fear, or on disgust, but rarely on both emotions together, the present experiment explored the neural effects of viewing disgusting and fear-inducing pictures in contrast to neutral pictures. This was done by means of functional magnetic resonance imaging (fMRI) with 19 subjects (nine males, ten females), who also gave affective ratings for the presented pictures. The fear and the disgust pictures were able to induce the target emotions and they received comparable valence and arousal ratings. The processing of both aversive picture types was associated with an increased brain activation in the occipital–temporal lobe, in the prefrontal cortex, and in the thalamus. The amygdala was significantly activated by disgusting, but not by fear-inducing, pictures. Thus, our data are in contrast with the idea of highly emotion-specific brain structures and rather suggest the existence of a common affective circuit.


*Keywords:* Fear; Disgust; Hemodynamic response; fMRI; Visual stimuli

## 1. Introduction

The number of studies investigating the neural circuitry of emotion regulation has tremendously increased over the last decade. This development is strongly connected with the availability of modern brain imaging techniques like positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). These methods allow to directly and non-invasively study the activated brain regions while subjects are experiencing various emotions.

Different evocation methods have been used in these studies: emotions were elicited by auditory stimulation (Blood et al., 1999; Morris et al., 1999), by olfactory stimulation (Sobel et al., 1998;

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Royet et al., 2001), or by the recall of previous emotional situations (Damasio et al., 2000; Kimbrell et al., 1999). However, the most common approach consists of the presentation of visual stimuli, such as emotion-relevant film clips (e.g. Lane et al., 1997a), pictures of affective mimic (e.g. Phillips et al., 1997) or emotionally relevant scenes (e.g. Lane et al., 1997b; Lang et al., 1998; Schienle et al., 2002). This great diversity of stimulation techniques often makes it difficult to distinguish between emotion-specific effects and stimulation-specific confounds. Thus, a problem is reiterated which has accompanied psychophysiological emotion research from its early beginning.

Therefore, it is very helpful to have a standardized emotional stimulus set as the International Affective Picture System (IAPS, Lang et al., 1995). This system includes pictures, which have been rated by representative samples on different emotional dimensions; mainly valence, arousal and dominance. Since the IAPS covers a lot of different emotional scenes it is also possible to use these pictures to elicit specific emotions. This was done within the present fMRI study. Our investigation aimed at the identification of those brain regions, which are activated by either disgust alone, by fear alone, or by both emotions. We focused on these basic emotions since disgust and fear share common features but can also be clearly distinguished from each other. Both emotions belong to the category 'negative affect', which is associated with the withdrawal from the emotion elicitor serving to protect the organism from being harmed.

However, from an evolutionary standpoint, both emotions are also part of different warning systems dealing with different kinds of threats. While fear is elicited as a response when the intactness of the body is threatened, the elicitors of disgust are more diverse. Besides the innate disgust response, which is related to food rejection, there has been a cultural evolution of relevant elicitors, now including stimuli such as body products, certain small animals, poor hygiene, or injury and death (Rozin and Fallon, 1987; Rozin et al., 1993).

Besides these differences in the emotional experience, fear and disgust also differ with regard to their physiological pattern. Here, it is of special interest that heart rate acceleration is often reported under fear conditions (Lang et al., 1993), while only minor heart rate changes or even decelerations have been observed under disgust (Vrana, 1993; Schienle et al., 2001).

The screening of the neuroimaging literature on these two basic emotions shows that there are several studies on fear, but only a few studies on disgust (Phan et al., 2002). A comprehensive review of the relevant studies for both emotions has been given by Calder et al. (2001), who suggest that the amygdala plays a crucial role for fear, whereas the insula and the basal ganglia are associated with disgust processing. However, as mentioned above, the comparability of the different studies is questionable due to the heterogeneity of the experimental paradigms for the emotion induction.

The particular importance of the amygdala for fear could be found for the most part in those studies where subjects were presented with pictures of human faces expressing fear (Breiter et al., 1996; Morris et al., 1996, 1998a; Whalen et al., 1998; Wright et al., 2001) and in those studies using a fear conditioning paradigm (e.g. Morris et al., 1998b; Whalen et al., 1998). In the few fMRI studies identifying the insula as the neural substrate of disgust, stimuli such as pictures with facial disgust expressions (Phillips et al., 1997, 1998; Sprengelmeyer et al., 1998) or disgusting scenes (e.g. cockroaches, wounds Phillips et al., 2000) were applied. However, when using vocal disgust expressions, the insula showed no response (Phillips et al., 1998).

The assumption that the amygdala is specifically involved in fear and the insula is specifically involved in disgust seems too simple, especially since more and more evidence arises that both emotions recruit similar brain structures. For example, in a previous investigation by our own research group (Schienle et al., 2002) we observed amygdala activity under disgust, but not under fear stimulation, while insula activation was present during fear as well as during disgust. These data are in line with a recent review by Zald (2003) about the role of the human amygdala for the emotional evaluation of sensory stimuli. He concludes that stimuli with disgusting features are able to induce amygdala activation, and that these