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Bradygastric activity of the stomach predicts disgust sensitivity and perceived disgust intensity

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ABSTRACT

The aim of this study was to investigate gastric and non-gastric autonomic responses to disgusting pictures and to assess the relationship between autonomic changes, disgust sensitivity, and perceived disgust intensity. Healthy participants viewed pictures with affectively neutral or disgusting content of either a high or moderate arousal level. Electrogastrogram, electrocardiogram, and electrodermal activity were recorded, and participants' disgust sensitivity and disgust intensity were assessed. No main effect of condition on gastric myoelectrical activity was found. However, stepwise regression analyses indicated that the percentage of bradygastria predicted disgust ratings in case of the highly arousing disgust pictures. When moderately arousing pictures were shown, disgust ratings were predicted by disgust sensitivity, which in turn was predicted by the percentage of bradygastria. Heart periods and respiratory sinus arrhythmia increased to a similar extent during both the highly arousing and moderately arousing picture blocks, while a tendency for larger skin conductance responses during the highly arousing picture block was shown. The results suggest that feelings of disgust may be specifically related to increased bradygastria, which may represent a prodromal sign of vomiting.

1. Introduction

Disgust is considered to be a basic emotion that can be recognized universally by distinct facial expressions. The facial expression of disgust – wrinkled nose, open mouth, curled lips, and protrusion of the tongue – reflects its presumed core function, namely the avoidance and rejection of improper and potentially harmful food (Rozin and Fallon, 1987). However, disgust can not only be induced by food, but also by body products, certain animals and poor hygiene, or by violations of the normal body envelope, such as blood and mutilation, and death, and even by moral concerns (Rozin et al., 2000; Schnall et al., 2008).

While the behavioral expression of disgust appears to be universal, studies on the autonomic correlates of this emotion have revealed more complex results. In a comprehensive review on cardiovascular, electrodermal and respiratory changes in discrete emotions, Kreibig (2010) recently summarized that disgust in relation to contamination and pollution (e.g., pictures of dirty toilets, cockroaches, maggots on food) results in sympathetic–parasympathetic coactivation and faster breathing, whereas mutilation-related disgust is characterized by a pattern of sympathetic cardiac deactivation, increased electrodermal activity, unchanged vagal activation, and faster breathing.

Such domain-specific differences in autonomic disgust reactions may partially reflect differences in motivational activation induced by the respective stimuli (Bradley, 2009). Unpleasant affects are held to be associated with the brain's defensive motivation system and pleasant affects with appetitive motivation (Cuthbert et al., 2000). Reports of increased arousal and greater magnitude of sympathetically mediated responses (e.g., sweat-gland activity) index increased activation of motive systems (appetitive, defensive, or both). Among autonomic responses, heart rate co-varies most strongly with affective valence, whereas skin conductance increases with the judged affective arousal (motivational intensity) of both pleasant and unpleasant pictures (Bradley et al., 2001; Cuthbert et al., 2000). Indeed, there is evidence that disgust induces a mixture of both a more general response to unpleasant stimuli activating the brain's defensive motivation system and a specific activation pattern accompanying disgust (Wright et al., 2004). This implies an overlap between autonomic changes induced by motivational activation and those reflecting a specific activation pattern accompanying disgust and suggests that both concepts should be

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taken into consideration when investigating physiological disgust responses.

In addition to domain-specific differences, there is some evidence in the literature that a general physiological disgust response exists that – similar to the mimic disgust pattern – occurs in response to any type of disgust. Rohrmann and Hopp (2008) found cardiac output to be decreased during induction of both contamination-related disgust and mutilation-related disgust. They hypothesized that this decrease in cardiac output might represent a more pertinent marker of disgust because other negative emotions, such as fear, anger and sadness, either led to an increase or no change in cardiac output. They further hypothesized that the decrease in cardiac output might delineate a reaction pattern contrary to the feeding response, also known as the 'cephalic phase response'. This response is stimulated by the sight, smell, taste and thoughts of appetizing meals and leads to an increase in cardiac output in order to redirect blood flow from skeletal muscles to the gastrointestinal tract, in addition to gastrointestinal changes preparing the stomach for the ingestion of food (Power and Schulkin, 2008; Rohrmann and Hopp, 2008).

If disgust indeed elicits a reaction pattern contrary to the cephalic phase response, then gastric activity should be part of this response. In support of this view, Stern et al. (2001) found myoelectrical activity of the stomach associated with normal digestive activity ('normogastria') to be decreased during sham feeding with unappetizing food. Similar to Rohrmann and Hopp (2008), the authors argued that this decrease might reflect an inhibition of the cephalic phase response, which is usually accompanied by an increase of normogastria in the EGG. A similar decrease of normogastria was found during imagining eating unfavorable food (Zhou and Hu, 2006), and when tasting a bitter substance (Power and Schulkin, 2008). A reaction pattern opposite to the classical cephalic phase response would also be in accordance with the presumed core function of disgust, namely the avoidance and rejection of improper and potentially harmful food.

However, besides one study that did not find any effects of disgusting stimuli on gastric activity (Baldaro et al., 2001), another study reported a response that was inconsistent with the prior line of research: van Overveld et al. (2008) found salivary flow to be increased during imaging disgusting scenes, a response that usually delineates the classical cephalic phase response rather than its inhibition. The authors discussed their findings as being related to the occurrence of nausea and the urge to vomit which are known to increase salivary flow. From an evolutionary perspective, nausea and vomiting are thought to represent additional mechanisms for dealing with an unhealthy meal, when smell, taste and sight, the gatekeepers of the alimentary tract, are not effective in detecting the quality of food (Horn, 2008).

The proneness to react with disgust to different disgust elicitors is learned during childhood (Stevenson et al., 2010). Therefore, it is not surprising that interindividual differences in disgust sensitivity exist (Haidt et al., 1994; Schienle et al., 2002). It has been shown that individuals scoring higher in disgust sensitivity report more intense feelings of disgust and show different brain responses to disgusting stimuli than individuals with lower scores (Mataix-Cols et al., 2008; Schienle et al., 2005; Stark et al., 2005). Women on average score higher in disgust sensitivity scales than men (Curtis et al., 2004; Rohrmann et al., 2008). They are also more prone to develop nausea and show different neurobiological responses to nauseating stimuli (Klosterhalfen et al., 2005, 2008, 2006; Meissner et al., 2009; Rohleder et al., 2006). Whether the higher sensitivity of women to disgusting and nauseating stimuli is also reflected in higher disgust ratings and enhanced autonomic responses to disgusting stimuli is an interesting question that has not been definitely answered, but evidence from one psychophysiological study (Rohrmann et al., 2008) points in this direction.

1.1. Aims

The present experiment was designed to investigate the effects of viewing disgusting pictures on gastric myoelectrical activity and their relation to self-reported disgust intensity and disgust sensitivity. We selected 30 pictures from the International Affective Picture System (IAPS; Lang et al., 1999) known to explicitly induce disgust (Mikels et al., 2005). We divided them according to their normative arousal values into picture blocks with either high or moderate emotional intensity. Furthermore, we assessed disgust sensitivity by using a validated questionnaire (Schienle et al., 2002) and related this measure to disgust ratings and autonomic responses. Because women on average score higher in disgust sensitivity than men and also show more intense physiological reactions to emotional stimuli in general (Caseras et al., 2007; Codispoti et al., 2008; Rohrmann et al., 2008), we also explored possible gender differences in disgust responses.

1.2. Gastric measurements

Gastric myoelectrical activity was assessed non-invasively by positioning skin electrodes above the stomach and measuring the electrogastrogram (EGG). EGG signals contain components associated with digestive stomach activity ('normogastria') and the disruption of this activity ('tachygastria' and 'bradygastria'). Under normogastric conditions cardiac parasympathetic activity is increased and sympathetic activity is decreased and under tachygastric conditions it is the opposite (Gianaros et al., 2003; Koch and Stern, 2004; Muth et al., 1999; Stern et al., 2007). The autonomic sequelae of bradygastria are less well understood but bradygastria also reflects a disruption of the normal digestive activity of the stomach (Stern et al., 2007). Both tachygastria and bradygastria have been observed during acute and chronic nausea (Geldof et al., 1986; Horn, 2008; Hu et al., 1989; Jednak et al., 1999; Liberski et al., 1990; Stern et al., 1985, 1987). Remarkably, dysrhythmias can appear before nausea is actually experienced (Stern, 2002).

1.3. Hypotheses

Based on the aforementioned findings from the literature, we expected that viewing disgusting pictures would reduce gastric myoelectrical activity associated with the normal digestive activity of the stomach (normogastria). We wondered whether this decrease in normogastria would be accompanied by an increase in the dysrhythmic components of gastric activity, i.e., either bradygastria and/or tachygastria, because of their known association with nausea. We furthermore explored whether part of the variance of changes in gastric myoelectrical activity could be explained by individual differences in the perceived intensity of disgust and/or individual levels of disgust sensitivity. With respect to the non-gastric autonomic measures, we expected increases in skin conductance responses, especially when viewing the highly arousing pictures, delineating the well-known relationship between arousal and electrodermal activity (Bradley et al., 2001; Cuthbert et al., 2000) on the one hand, and the relationship between mutilation-related disgust and increases in electrodermal activity on the other hand (cf. Kreibig, 2010). We furthermore expected that heart periods would increase in response to the disgust-inducing pictures, because both aversive pictures (Bradley, 2009; Bradley et al., 2003; Moratti et al., 2004) and disgusting stimuli (as far as not restricted to contamination-related disgust; cf. Kreibig, 2010) are known to induce heart rate deceleration.