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Sympathetic and parasympathetic responses to a core disgust video clip as a function of disgust propensity and disgust sensitivity

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ABSTRACT

It is generally assumed that disgust is accompanied by increased activation of the parasympathetic nervous system (PNS). However, empirical support for the role of PNS in disgust is scarce. This study tested whether (i) activation of the PNS is indeed involved in disgust and (ii) disgust-induced autonomic activation is especially pronounced in individuals with high disgust propensity or enhanced disgust sensitivity. Participants ($N = 60$) viewed a 5 min disgust-inducing video clip. Participants showed increased parasympathetic activity of both the cardiac and the digestive components of the autonomic nervous system (ANS), together with increased sympathetic activation of the cardiac system. ANS responses were independent of subjective disgust and individuals' habitual disgust propensity or sensitivity. Results support the hypothesis that PNS activation is involved in disgust. The absence of a relationship between subjective and physiological indices of disgust indicates that both types of responses reflect independent phenomena.

1. Introduction

Disgust has long been acknowledged as one of the basic emotions, recognized across cultures and societies with an evolutionary basis but culturally shaped content. However, in comparison with its complementary emotions, it has long been neglected in scientific research (Olatunji and McKay, 2010; Vaitl et al., 2005). This neglect is even more accentuated when it comes to its psychophysiological signature (Vrana, 2010).

It is generally assumed that disgust is accompanied by increased parasympathetic responses (e.g., Levenson, 1992). Consistent with the view that disgust is accompanied by parasympathetic activation of the cardiac system, it has been shown that participants who engaged in facial prototypes of the expression of disgust or were asked to relive a past disgusting experience did not display the cardiac acceleration that was typically found for other negative emotions such as fear (e.g., Ekman et al., 1983). Furthermore, studies using a passive picture viewing approach found that specifically disgust is related to decreased heart rate (HR) (e.g., Stark et al., 2005). The general finding that disgust tends to elicit HR reduction rather than HR increase is often taken to reflect dominance of the parasympathetic branch of the ANS (see e.g., Levenson, 1992).

However, for the understanding of the physiological basis of the cardiac deceleration, it is important to register additional vagal indices like heart rate variability (HRV) to test whether the bradycardia indeed reflects enhanced vagal tone rather then sympathetic withdrawal. Since HRV needs a much longer time window than used in the typical picture viewing or facial expression paradigm, this requires a different experimental timing. Therefore, in previous work we used prolonged disgust imagery (5 min) rather then picture viewing to investigate further whether disgust is indeed characterized by parasympathetic responses (van Overveld et al., 2009). This earlier study showed that elicited feelings (and facial expressions) of disgust were accompanied by changes in digestive as well as cardiac components of the autonomic nervous system (ANS). For the digestive component, increases were observed in saliva production which most likely indicates an increase in parasympathetic activity (Proctor and Carpenter, 2007). For the cardiac component, increases were observed in T-wave amplitude which generally can be taken to indicate sympathetic withdrawal (Kline et al., 1998). There was, however, no evidence for increased parasympathetic activity of the cardiac component of the ANS with HRV remaining unaffected by disgust imagery.

Yet, the absence of parasympathetic cardiac responding might have been the result of the task demands that are evoked by an imagination procedure. Imagery necessitates considerable mental effort and is often associated with cardiac acceleration (e.g., Vrana, 1993). It would, therefore, be important to examine the role of the parasympathetic component of the ANS in the context of

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other types of prolonged disgust elicitors without this potential confound. Germane to this, a recent study on the cardiovascular dynamics in blood phobia included a non-blood disgust-relevant film of 320 s duration. This passive film viewing study, however, did not provide support for a major role of the cardiovascular component of the parasympathetic nervous system in disgust. Neither blood phobics ($N = 14$) nor non blood-fearful controls ($N = 17$) showed enhanced parasympathetic responsivity during the disgust film (Sarlo et al., 2008). However, the film that was used in this latter study concerned a cockroach invasion. Although cockroaches are undoubtedly disgust-relevant animals (e.g., Davey, 1994), the invasion component may have activated threatening cognitions related to unwanted physical contact with disgusting stimuli (de Jong and Muris, 2002). This type of cognitions will logically elicit physiological fear responses preparing for avoidance and/or escape thereby overshadowing the disgust-specific autonomic responding (cf. Vrana, 2009).

Consistent with this, a subsequent study that used a disgust-eliciting film without this potential confound (i.e., a chef who vomits into a transparent bowl after the oral intake of raw eggs) did show tentative evidence for disgust-related parasympathetic activation of the cardiac system. Participants in that study ($N = 100$) showed higher HR variability during passive viewing of this core disgust (vomit) clip of approximate 1 min duration, than during baseline (whilst watching a screensaver) (Rohrmann and Hopp, 2008). Moreover, in support of the view that perhaps the HR acceleration found in previous disgust imagery studies (e.g., Vrana, 1993) might have been due to task demands, viewing the clip did not affect HR per se. Thus watching the vomit clip elicited no cardiac acceleration.

The current study was designed to investigate further the alleged involvement of the parasympathetic branch of the ANS in the disgust response. In an attempt to replicate and extend the preliminary evidence for the parasympathetic involvement in the disgust response (Rohrmann and Hopp, 2008), we used a similar passive viewing approach. However, we used a (core) disgust film of longer duration (5 rather than 1 min), thereby complying with the recommendations by the Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (1996) who argued that a reliable assessment of relevant frequency components of HRV requires a measurement duration of at least 2 min. In line with our earlier imagery study (van Overveld et al., 2009), parasympathetic activity of the cardiac system was indexed by the high frequency (HF) power band of HRV. To test further the complementary involvement of the digestive component of the ANS (e.g., van Overveld et al., 2009), we also monitored EMG activity of the digastricus muscle (that is responsible for swallowing) as an indirect measure of saliva production (Nederkoorn et al., 1999). As a relatively independent index of the sympathetic activation/withdrawal of the cardiac system, we measured the T-wave amplitude which is inversely related to (beta adrenergic) sympathetic activation (cf. Palomba et al., 2000). As an additional peripheral index of sympathetic activation we measured skin conductance level.

As a second aim, the present study investigated whether the strength of the autonomic responses varied as a function of individual differences in disgust propensity (defined as a general tendency to respond with the emotion of disgust to any given situation). Assuming that disgust propensity reflects differences in the disgust processing neural networks, one would expect increased disgust propensity to be associated with elevated subjective and physiological disgust responses. In line with this, previous work using a picture viewing paradigm indeed found a relationship between disgust propensity as indexed by the Disgust Scale (DS; Haidt et al., 1994) and subjective disgust (Stark et al., 2005). However, there was no relationship between DS scores and physiological indices. This may indicate that subjective disgust and physiological responses reflect independent phenomena (e.g., van Overveld et al., 2009). Yet, an alternative explanation could be that the picture paradigm lacks sufficient sensitivity to measure the most important physiological concomitants of disgust (e.g., parasympathetic responses). Thus, it would be important to complement these earlier findings with a study testing the relationship between DS and ANS activation during more prolonged stimulus exposure.

In addition, it could be questioned whether the DS is indeed the most appropriate index of disgust propensity in this context. The DS covers a limited set of very specific disgust elicitors. Hence only when there is a strong overlap between the exact content of the items of the DS and the actual stimuli that are used in an experiment, the DS may provide an accurate reflection of participants' disgust propensity (e.g., van Overveld et al., 2010). Since it has been shown that individuals' disgust propensity may be highly domain specific (e.g., de Jong and Merckelbach, 1998; Olatunji et al., 2008), this is a serious drawback for using the DS in the current context. In an attempt to overcome this potential drawback of the DS, a decontextualised measure of trait disgust has been developed, the so-called Disgust Propensity and Sensitivity Scale (DPSS; van Overveld et al., 2006). Independent of particular disgust elicitors, the DPSS asks people to rate how often certain statements such as "I find something disgusting", "I experience disgust", apply to them. The DPSS was recently revised and validated (DPSS-R, van Overveld et al., 2010; Fergus and Valentiner, 2009). Attesting to the relevance of using a decontextualised measure of disgust propensity, the DPSS-R was shown to have added predictive value for disgust-induced avoidance behavior over and above traditional indices of trait disgust (van Overveld et al., 2010). To test further the relationship between disgust propensity and disgust induced physiological responding, we therefore included both the DS and the DPSS-R in the present design.

Thus far, research on individual differences in trait disgust predominantly focused on people's general tendency to respond with the emotion of disgust to any given situation (disgust propensity). Therefore, the common trait disgust questionnaires such as the DS typically ask people to indicate to what extent they feel disgusted by certain stimuli. However, people may not only show relevant variation regarding their threshold for experiencing disgust (i.e., disgust propensity), but also regarding their appraisal of the experienced disgust responses (disgust sensitivity). That is, people not only vary in their tendency to experience the emotion of disgust more readily but also in their tendency to find the emotion of disgust unpleasant. By now there is considerable evidence that disgust propensity and disgust sensitivity represent separate constructs (e.g., van Overveld et al., 2006, 2010). Underlining the relevance of differentiating between both types of trait disgust, several studies showed that disgust propensity and disgust sensitivity are differentially related to symptoms of psychopathology. For example, in the context of post traumatic stress disorder (PTSD), disgust propensity was found to be associated with the probability of experiencing peritraumatic disgust, whereas disgust sensitivity moderated the predictive relationship between peritraumatic disgust and subsequent PTSD-symptom severity (Engelhard et al., 2011).

One explanation for the relatively negative appreciation of the experience of disgust in people with high disgust sensitivity could be that these people are characterized by relatively strong physiological responses towards disgusting stimuli. Therefore, as a third and final issue, we also tested whether higher scores on disgust sensitivity indeed coincide with stronger disgust-induced physiological responses. Insight in this relationship may not only be relevant in its own right, but may also provide relevant clues that may help improving our understanding of the relationship between disgust sensitivity and psychopathology.