AN INVESTIGATION OF THE THREE TIER RELATIONSHIPS BETWEEN DISTATSTE, DISGUST EXPRESSION RECOGNITION, AND MORAL RESPONSIVITY

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An Investigation of the Three-Tier Relationships Between Distaste, Disgust Expression Recognition, and Moral Responsivity

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This thesis is submitted for the degree of
Master in Philosophy in the
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Abstract

Disgust is a negative and universal basic emotion that is elicited by a diverse set of sources, ranging from concrete physical sources (e.g. bad tastes, disease, feces) to abstract social sources (e.g. moral transgressions and the transgressors). The present study investigated the potential three-tier relationships between distaste (the proposed evolutionary origin of disgust), disgust sensitivity assessed by facial disgust recognition measures, and moral responsivity to explore whether: (a) more sensitive bitter tasters had greater facial disgust recognition accuracy, (b) more sensitive bitter tasters had greater moral responsivity, and (c) more morally sensitive individuals had greater facial disgust recognition accuracy. The bitter taste sensitivity test of 6-*n*-propylthiouracil (PROP), a standard basic Emotion Recognition Task (ERT) (Young et al., 1997) to measure facial disgust accuracy ("hits"), bias, and false positive errors, and a questionnaire to assess moral judgments of fairness transgressions from a standardized set compiled by Knuston et al. (2010) in addition to the moral disgust subscale from The Three Domain Disgust Scale (TDDS) (Tybur et al., 2009) were administered to 110 participants. Results showed that more sensitive bitter tasters had greater facial disgust bias rates and a trending association with increased disgust false positive error rates. There was no significant relationship found between bitter taste sensitivity and moral responsivity. Interestingly, individuals who found the fairness transgressions less morally inappropriate had a greater tendency to make more facial disgust false positive errors. These findings indicate that there are different levels at which distaste, disgust (in the form of facial disgust recognition dimensions), and moral responsivity are interrelated, providing insight into the multifaceted roles of disgust.

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1. Introduction

Disgust, a relatively primal emotion, is identified as one of the six basic and universal emotions – emotions that can be recognized and experienced regardless of an individual's origin (Darwin, 1872; Ekman & Friesen, 1975). Behaviorally, disgust is manifested through withdrawal and rejection responses from offensive stimuli as well as a distinct facial expression: wrinkling of the nose and raising of the upper lip (Haidt, Rozin, McCauley, & Imada, 1997). Although this basic emotion was largely ignored during the affective revolution in psychological research in the 1980s, disgust has become a significant emotion of interest due to its wide range of influences upon human cognition and social interaction (Chapman & Anderson, 2012). Specifically, its evolutionary origin (distaste), various types of elicitors (ranging from concrete physical stimuli to moral violations), and suggested role(s) in human social behaviors highlight the multifaceted nature of disgust. The aim of this thesis, therefore, is to investigate the potential three-tier relationships between distaste, disgust sensitivity assessed by facial disgust recognition measures, and moral responsivity.

1.1. Distaste

Distaste is identified as a form of motivated food rejection after the ingestion of unpleasant-tasting substances, particularly ones that are bitter (Chapman, Kim, Susskind, & Anderson, 2009; Rozin, Haidt, & McCauley, 1999). The behavioral response of distaste is normally oral rejection of the unpleasant substance in addition to the visceral responses of nausea and gagging (Chapman & Anderson, 2012). This ancient oral response is rooted in chemical sensory rejection: a type of rejection dependent upon sensory properties such as taste, smell, and texture of a substance (Chapman & Anderson, 2012; Chapman et al., 2009; Rozin et al., 1999). Distaste is thought to be an innate quality in human beings as this food rejection impulse has been shown very early in human ontogeny. Rosenstein and Oster (1988), for instance, found that infants only two hours after birth produce the distinct facial grimace in response to bitter tastes. As bitter tastes often signal poisonous or toxic substances, distaste provides an adaptive and protective mechanism to reject potentially harmful food items (Chapman & Anderson, 2013).

1.1.1. Measure of Taste: PROP

Empirical studies of taste sensitivity primarily use measures involving bitter tasting substances – thereby inherently measuring distaste sensitivity – such as chemically infused materials (e.g. solutions,

paper strips) of phenylthiocarbamide (PTC) or of its chemical relative, 6-*n*-propylthiouracil (PROP). Due to the sulfurous odor and toxicity of PTC, however, PROP has been the predominant method of choice to measure taste sensitivity in humans (Herbert, Platte, Wiemer, Macht, & Blumenthal, 2014). Responses to PROP have been shown to vary on several factors. The ability to taste PROP, for example, declines with age (Stevens, Cruz, Hoffman, & Patterson, 1995) and is enhanced in females more so than males (Bartoshuk, Duffy, & Miller, 1994). Notably, furthermore, there is evidence for genetic and anatomical influences upon varying levels of perceived bitterness of PROP.

1.1.2. Anatomy of PROP Bitter Taste Sensitivity

Research has indicated that taste sensitivity to PROP is genetically determined (Herbert et al., 2014). Specifically, the alleles of the human TAS2R38 gene are primarily considered to be responsible for the variation in bitter taste sensitivity to PROP. Two common alleles associated with PROP taste sensitivity are PAV the dominant variant and AVI the recessive variant (Calo et al., 2011). Heritability research suggests that three phenotypes of the TAS2R38 gene result in three different levels of tasters: "super-tasters" who are homozygous dominants (PAV/PAV) and have high sensitivity to PROP at low concentrations, "medium-tasters" who are heterozygous (PAV/AVI) at the TAS2R38 gene locus and are able to taste moderate levels of PROP, and "non-tasters" who are homozygous recessives (AVI/AVI) and have low sensitivity to the bitter taste of PROP at low concentrations (Herbert et al., 2014; Herz, 2014). To date, more than 25 genes have been identified to influence bitter taste perception, but the TAS2R38 genotype has been found to predict the majority of the variance in the PROP taste sensitivity (Calo et al., 2011; Herbert et al., 2014). PROP-determined taster levels are also reflected in other primary taste compounds, including things that are sour, sweet, and salty, in that super-tasters will perceive them more intensely (e.g. sucrose is sweeter to super-tasters) than medium-tasters and non-tasters (Lucchina et al., 1998).

In addition to the genetic basis of PROP taste sensitivity, anatomical differences in the fungiform papillae of the tongue have been found amongst the three groups of PROP-tasters. Fungiform papillae are raised protrusions on the tongue (primarily on the tip of the tongue) upon which taste buds lie. Individual papillae consist of anywhere between 0 to 20 taste pores, which are located on the apical surface of the papillae and are the taste bud portions that open onto the tongue surface (Miller & Reedy, 1990). Research

has shown that super-tasters have a high density of fungiform papillae that are smaller, have more taste pores, and also have rings of tissue around them that are not seen on the fungiform papillae of non-tasters (Bartoshuk et al., 1994). Additionally, Miller and Reedy (1990) found that individuals with the highest densities of taste buds had the greatest densities of fungiform papillae on their tongue tips and rated PROP taste intensity higher than participants with lower taste bud/fungiform papillae densities. The densities of taste buds and fungiform papillae, therefore, seem to have a significant impact on taste perception. In the case of distaste or bitter taste sensitivity, taste perception of substances that elicit distaste is important to prevent ingestion of potentially poisonous substances. Therefore, it is likely that PROP sensitivity reflects individual differences in defensive and emotional reactivity as those who are more sensitive to bitter tastes may exhibit stronger responses to avoid items posing a threat to their survival (Herbert et al., 2014). The defensive and emotional response that has been most linked with distaste is disgust due to its prominent avoidance and withdrawal responses.

1.1.3. Overlap of Distaste and Disgust: Definition, Anterior Insula, and Facial Expression

The emotion of disgust has been proposed to be a preadaptation – "the use and modification of an already existing structure that had evolved for a different purpose" - of distaste (Rozin et al., 1999). This evolutionary relationship was proposed primarily due to the response similarities of distaste and disgust: oral rejection, nausea, and distinct facial expression (Rozin & Fallon, 1987). Thus, researchers initially defined disgust very closely to distaste. In fact, the word "dis-gust" etymologically means "bad taste" (Rozin et al., 1999). Darwin (1872) first identified disgust as an emotion related primarily to sources that are offensive to the sense of taste while Ekman and Friesen (1975) described disgust as a rejection response centered on eating. Rozin and Fallon (1987), furthermore, defined disgust as a food-related emotion that causes revulsion at the idea of coming into physical contact (e.g. orally) with the offensive object(s). The evolutionary advantage of disgust, moreover, is thought to be the prevention of ingesting or coming into contact with diseases, toxins, or parasites through withdrawal responses from the source(s) of disease, particularly food sources (Haidt et al., 1997).

Recent research has expanded upon the taste-centered definitions of disgust by indicating an overlap between disgust and distaste at the neural level. Specifically, studies have implied that the anterior insula is the main area for disgust processing as well as the primary gustatory cortex (Chapman &

Anderson, 2012; Herz, 2014; D. M. Small, 2010; Wicker et al., 2003). Small and colleagues (2003), furthermore, suggest that the human gustatory system is functionally segregated as they found that unpleasant tastes (representation of distaste) resulted in increased anterior insular activity in comparison to pleasant tastes. Additionally, Jabbi and colleagues (2008) recently investigated the neural responses to the tasting of unpleasant bitter solutions, reading disgusting scenarios, and viewing of disgusted facial expressions of others. Notably, they found that all three tasks resulted in anterior insular activity, indicating that distaste – which reflects a taste-induced disgust experience in their study – and imagination as well as social perception of disgust share a common neurological site. These findings further emphasize the close relationship of the distaste and disgust experiences.

One of the most prominent similarities between distaste and disgust is the distinct facial expression response to both. Researchers have indicated that the characteristic disgust facial expression is also elicited by distasteful stimuli, which fueled the proposition that disgust evolutionarily originated from distaste (Ekman & Friesen, 1975; Rozin & Fallon, 1987). Three major areas of the face are involved in the so-called disgust face: the gape (lowering of the lower jaw – with or without tongue extrusion), the nose wrinkle, and the upper lip raise (Rozin et al., 1999). The gape and nose wrinkle, in particular, are suggested to be most associated with disgust situations related to food, such as food detection and rejection (Rozin & Fallon, 1987; Rozin et al., 1999). Functionally, this facial expression response provides a means to prevent the ingestion of potentially harmful substances – a core overlapping function between distaste and disgust. For example, the gape functions to expel mouth contents, the nose wrinkle helps cut off odor inhalation, and the upper lip raise may also help impede an odor input (Rozin & Fallon, 1987; Rozin, Markwith, & McCauley, 1994). Thus, this characteristic facial grimace represents a method of food rejection, which prompted the idea that disgust originated in distaste (Rozin & Fallon, 1987). Despite these strong overlaps between the neural and facial underpinnings of distaste and disgust, key differences exist between the two – especially in terms of the wide repertoire of elicitors for the emotion of disgust in comparison to the sensory elicitors for distaste.

1.2. Disgust: From Food to Ideations

Disgust has been identified as a basic emotion since the time of Darwin due to its characteristic facial expression (disgust face/grimace), appropriate action (withdrawal/avoidance from disgust source),

physiological manifestation (nausea), and feeling state (revulsion) (Phillips, M. L., Senior, C., Fahy, T., & David A. S., 1998; Rozin & Fallon, 1987). Compared with distaste, disgust is less reliant on the sense of taste and is elicited by a variety of modalities (Chapman & Anderson, 2012). Disgusting sources, furthermore, are much more contaminating and offensive than distasteful substances (Chapman & Anderson, 2012). A case reflecting this "contagion effect" of disgusting sources occurred in a children's hospital where nurses were inappropriately drinking the glasses of juice meant for the children (Rozin & Fallon, 1987). To solve this issue, the juice was placed in new urine-collection bottles. The fact that the nurses stopped drinking the juice despite the lack of physical trace of urine in the bottles highlights the ideational sources of disgust – that a disgusting source (e.g. urine) can contaminate another object, situation, or even person just by association. Surprisingly, disgust has been the subject of relatively fewer empirical studies than other basic emotions such as fear and anger (Chapman & Anderson, 2012; Rozin & Fallon, 1987). This could possibly be due to the initial consideration of disgust as primarily a primitive and food-related emotion. Over the past decades, however, research on disgust has gained momentum as the range of disgust elicitors have grown from concrete objects to abstract social constructs. For instance, modern theorists have suggested that disgust functions to reject threats to the integrity of self and also maintain distance from such threats (Phillips et al., 1997). The emotion of disgust has therefore evolved in research as a basic emotion with various domains due to its wide array of stimuli that range from the traditional physical sources of disease and poison to ideational sources of social and (arguably) moral threats to the human self. Though, the question of whether these varied sources elicit the same behavioral and physiological manifestation of disgust remains.

Two domains of disgust will be the focus of the present study: *physical disgust* (disgust experienced when exposed to concrete, external, and offensive stimuli such as feces, vomit, and etc.) and *moral disgust* (disgust elicited by exposure to behaviors that violate social and moral norms).

1.2.1. Physical Disgust: Types and Measures

Within the domain of physical disgust, there are several subdomains that reflect the changes in the interpretation of the functions of disgust and its types of elicitors. As mentioned previously, disgust was initially defined very closely to distaste as evolutionary theories conceptualized the food system as the phylogenetic and ontogenetic origin of disgust (Rozin et al., 1999). These definitions of disgust represent

the subdomain *core disgust*, which is believed to focus on defending against infection via the oral route (Chapman & Anderson, 2012). In particular, Rozin and Fallon's (1987) definition of disgust of it being the revulsion at the idea of potentially incorporating offensive substances provided the basis for this subdomain (Haidt et al., 1997). Core disgust is physically signified by nausea (a gastro-intestinal and often food-related sensation) that discourages ingestion of a substance and may induce ejection (e.g. vomiting) of something already ingested (Rozin et al., 1999). From this subdomain, other disgust subdomains were acknowledged to guard contact and/or association with other types of threats. *Animal-nature disgust*, for example, reflects the rejection/avoidance of aspects that remind humans of their animal natures: poor hygiene, inappropriate sex, body violations such as blood and injuries, and contact with death or decay (Chapman & Anderson, 2012; Rozin et al., 1999). This type of disgust highlights the role of disgust in civilization and socialization by preventing humans from engaging in activities that involve the aforementioned elicitors (Rozin et al., 1999). Additionally, *interpersonal disgust* encompasses a form of disease-avoidance by functioning to prevent contact with unfamiliar, unhygienic, or diseased conspecifics (Chapman & Anderson, 2012). At a social level, animal-nature and interpersonal disgust highlight the contamination property or "contagion effect" of disgust. These subdomains of disgust, for instance, function to avoid interaction with other people that have been involved in something disgusting whether it is something unfamiliar to being diseased (Chapman & Anderson, 2012; Rozin et al., 1994). Past research has shown that participants were less willing to wear washed sweaters worn by people who had a history of misfortune (e.g. limb amputation) and infectious diseases (Rozin et al., 1994). These forms of disgust, therefore, further emphasize the social nature of disgust by influencing humans to be selective and critical of other humans in addition to objects that normally elicit disgust (Rozin et al., 1999).

Many current theoretical accounts of emotion stipulate that emotional changes occur in three interrelated experiences: subjective experience of emotion, physiological and somatic changes, and central nervous system changes (Lang, Bradley, & Cuthbert, 1998). Studies on disgust, therefore, have investigated its correlates in all three domains respectively through self-report measures such as the Disgust Scale (Haidt et al., 1994) and the Three Domain Disgust Scale (TDDS) (Tybur, Lieberman, & Griskevicius, 2009) in addition to taste and smell-induced disgust experiences, disgust facial expression production (primarily measured by the levator labii muscle region of the face) as well as observation, and disgust

neural markers such as the anterior insula. Wicker and colleagues (2003), for instance, recently conducted a study to investigate these three domains. Specifically, they compared whether the disgust experience and observation of disgust in others resulted in common neural activity. Wicker and colleagues (2003) found that when participants were induced with disgust by inhaling unpleasant odorants and when participants passively viewed movies of individuals expressing facial disgust, the anterior insula was commonly activated. As disgust is becoming more widely perceived to have a role in a variety of human social behaviors, there is much speculation whether these types of emotional changes in relation to disgust are seen in response to more abstract social contexts. In particular, a proposed subdomain of disgust that is not associated with the common physical disgust stimuli and disease is moral disgust.

1.2.2. Moral Disgust

A consensus has yet to be reached regarding whether moral disgust is an actual disgust subdomain. The main elicitors of moral disgust are suggested to be sociomoral transgressions, which are generally categorized as thoughts and behaviors that violate social and moral norms (Kelly, 2011). Rozin and colleagues (1999) indicate that moral disgust is reflected across a broad range of cultures and functions to "…reject certain classes of violators who are beyond redemption" (p. 436). In America, for instance, moral disgust has been described as a type of character judgment of individuals who jeopardize the dignity of others, such as criminals (Haidt et al., 1997). Several researchers and theorists, however, have argued that moral disgust is metaphorical in that it reflects other negative emotions like anger rather than disgust (Chapman et al., 2009). Terms such as "revolting," "disgusting," and "rotten," for instance, are often used to describe criminal and moral offenses; it is questioned, therefore, whether disgust is fundamentally similar to the basic emotion of disgust or if the link between moral transgressions and disgust only exists at the semantic level (Kelly, 2011).

Recently, a wide range of studies have addressed the issue of moral disgust by investigating whether moral transgressions elicit similar behavioral responses as physical disgust stimuli. Studies have found, for instance, that participants with higher disgust sensitivity tended to find suspects in crime vignettes culpable more frequently than participants with lower disgust sensitivity (Jones & Fitness, 2008) and that greater self-reported feelings of disgust towards purity violations predicted stronger moral condemnation of behaviors violating purity (Horberg, Oveis, Keltner, & Cohen, 2009). Facial disgust response measures,

primarily measured by levator labii (LL) facial muscle activity, have also been used to gauge the existence of moral disgust. Chapman and colleagues (2009), for example, found that LL activity was evoked when participants experienced unfairness (e.g. lack of fair monetary offers made by a partner) during the Ultimatum Game. They also found that self-reported disgust was positively correlated with the decision to reject unfair offers. Cannon and colleagues (2010), furthermore, assessed LL activity in response to specific types of moral transgressions as outlined by the Moral Foundation Theory (MFT) (Haidt & Joseph 2004). The MFT divides moral behaviors into five foundations: (1) harm/care, (2) fairness/reciprocity, (3) ingroup/loyalty, (4) authority/respect, and (5) purity/sanctity. Cannon and colleagues (2010) found that facial disgust (LL activity) was evoked significantly greater for purity and fairness violations compared to the other foundations. Purity violations are primarily linked with spiritual and internal hygiene and physical contamination (i.e. keeping the body and mind "clean"), which arguably reflect physical disgust more so than the other moral foundations in the MFT (Kelly, 2011). Fairness violations, on the other hand, tend to primarily involve lying, cheating, and other unfair behaviors that do not usually reflect physically disgusting behaviors (Chapman & Anderson, 2012). Experiments on disgust facial affect responses to unfair treatment provide interesting insight into whether disgust is a contender for the emotion felt during moral transgressions that do not reflect physically disgusting stimuli.

1.3. Social Communication of Disgust: Facial Emotion Recognition

Alongside the emotions of fear, anger, happy, sad, and surprise, disgust has been considered to be pan-cultural and a basic universal emotion with a universal facial expression that can be recognized as disgust (Ekman et al., 1987; Kelly, 2011). Emotional facial expressions provide insight into an otherwise internal state that cannot be directly seen by others (Kelly, 2011). In other words, facial expressions represent a type of emotional behavior, which encompass outward cues that accompany an emotional experience (Elfenbein & Ambady, 2002). The disgust facial expression, furthermore, is thought to be automatically and involuntarily produced whenever the emotion is elicited and particularly difficult to fake (Kelly, 2011). Kelly (2011) notes that it is difficult to produce the disgust face without entering the emotional state of being disgusted. Expressing facial disgust, therefore, is considered to be a reliable and salient indicator of feeling disgust – recognizing disgust then reflects the capability to receive and understand (to a certain extent) the disgust in others.

Currently, studies have investigated the commonalities underlying the ability to produce and recognize disgust. One source of evidence reflecting the relationship between production and recognition of disgust is the common neural substrate for these two qualities of the disgust emotional experience: the anterior insula. Phillips and colleagues (1997), for instance, found that the anterior insula was selectively activated when participants viewed images of individuals expressing facial disgust at varying levels. Interestingly, Matais-Colx and colleagues (2008) also found that disgust sensitivity mediated insular responses to the viewing of facial disgust: those with greater disgust sensitivity (as measured by the Disgust Scale) exhibited greater insular activity when observing facial disgust. On the flip side, researchers have additionally found that there is a deficit in producing the emotion of disgust as well as recognizing facial disgust in others when the insula is impaired (Sprengelmeyer et al., 1996; Sprengelmeyer et al., 2003). These findings further highlight the close foundational link between disgust production and recognition and their significant roles in conveying emotional messages.

Recognition of disgust is considered to be a form of mental-state imitation (Kelly, 2011). Recognizing disgust in others, for example, puts the observer into the similar mental state as the producer of the disgust signal (Goldman & Sripada, 2005; Sato, Fujimura, Kochiyama, & Suzuki, 2013). This notion, furthermore, provides potential explanations for the behavioral relationships between disgust and its evolutionary origin in distaste as well as its link to more abstract social concepts such as morality. In relation to distaste, as the anterior insula is considered to be part of the primary gustatory cortex, it has been suggested that the ability to recognize disgust in others is closely linked to the appraisal of distasteful stimuli (Phillips et al., 1997; Wicker et al., 2003). For example, the processing of the disgust face in another individual eating something distasteful would lead to a propositional representation of the inferred state of disgust thereby leading to the rejection of the distasteful food item (Wicker et al., 2003). Recognition of disgust, moreover, is also considered to be a form of empathy. It is proposed that disgust recognition in normal mature human beings is automatic and also causes the recognizers to enter a similar mental state (of disgust) as the expresser (Goldman & Sripada, 2005; Kelly, 2011). Consequently, those who have a decreased sense of empathy – often reflected by moral judgments and sensitivity – may have difficulty in recognizing disgust in others.

Empirically, emotion recognition of disgust and the other basic emotions has been assessed primarily by the frequencies of correctly ("hits") and incorrectly ("errors") identifying facial disgust in others. Few studies have investigated other dimensions of emotion recognition such as the bias for specific emotions, which may lead to a specific type of error (e.g. false positive error) made in recognizing facial expressions. Research in emotional bias has primarily been conducted in psychiatric populations such as individuals diagnosed with depression and social phobia. Depressed patients, for instance, have shown predominant biases away from recognizing and labeling happy expressions as happy and a bias towards labeling neutral expressions as sad or angry (Joormann & Gotlib, 2006; Surguladze et al., 2004). Disgust bias and false positive error tendencies, however, have not been extensively investigated. One study showed that schizophrenic patients tended to mislabel neutral expressions and also over-attributed disgust to neutral expressions – indicating that the patients made disgust false positive errors specifically for neutral expressions (Kohler et al., 2003). There is also conjecture that people with obsessive-compulsive disorder have attention biases for disgust cues, but there is still a significant lack of studies investigating biases specifically for disgust facial expressions in both normal and clinical populations (Olatunji & Sawchuk, 2005). A focus of the present study, therefore, is to explore these dimensions in addition to accuracy in recognizing disgust.

1.4. Aims and Hypotheses: Exploration of Distaste, Disgust Expression Recognition, and Moral Responsivity

The objective of the present study is to investigate the three-tier relationships of the evolutionary origin of disgust, disgust sensitivity in the form of recognizing facial disgust, and a potential non-visceral branch of disgust through the assessment of moral responsivity with the following hypotheses:

Hypotheses 1: Individuals with higher bitter sensitivity to PROP will have greater accuracy in facial disgust recognition (hits). There is a lack of empirical studies investigating the relationship between distaste and disgust, and to our knowledge, there have not been studies on the influence of bitter taste sensitivity on disgust expression recognition tendencies. By assessing distaste (bitter taste) through PROP sensitivity and the dimensions of disgust recognition, this will provide further insight into the nature of the evolutionary link between distaste and disgust in a social context.

Hypothesis 2: Individuals with greater bitter taste sensitivity have increased moral responsivity. Despite the current debate regarding whether moral disgust is a disgust subdomain (in that it elicits key disgust behavioral responses), there have been very few studies investigating the relationship between moral disgust and distaste. Recently, Herz (2011) found that taste sensitivity, measured by PROP, was positively correlated with disgust sensitivity (assessed by the Disgust Scale, the Three Domain Disgust Scale (TDDS), and two other disgust subscales) but not to responses concerning moral disgust. Another study conducted by Herz (2014) showed that verbal priming through the evaluative term "grossed-out" resulted in more PROP taste-sensitive participants reporting being more "grossed-out" by moral transgressions. These studies, however, are quite preliminary and past studies have provided evidence suggesting a relationship between disgust responses, commonly evaluated by disgust facial muscle activity, and moral responsivity (Cannon et al., 2010; Chapman et al., 2009). Thus, as an exploratory aim, we investigated whether distaste sensitivity was heightened in individuals who found moral transgressions of fairness more morally inappropriate (or were more grossed out by fairness transgressions) and showed greater moral disgust sensitivity through TDDS. A relationship between distaste and morality would provide support for moral disgust as a representative subdomain of disgust as well as support for the idea that the human moral sense, to a certain extent, draws upon evolutionarily ancient precursors (Chapman & Anderson, 2013).

Hypothesis 3: Individuals with greater disgust recognition accuracy will have greater moral responsivity. As facial emotion recognition is suggested to be a form of empathy, it is perceivable that individuals with higher moral sensitivity (measured in this study through the moral judgments of fairness violations) will have increased capabilities to recognize disgust in others. To date, the Three-Domain Disgust Scale (TDDS) is the only disgust sensitivity measure that specifically measures moral disgust; this particular subscale assesses moral disgust of fairness violations (Herz, 2014; Tybur et al., 2009). Thus, the moral subscale of the TDDS was used in this study to measure disgust responsivity to behaviors lacking physically disgusting components. Investigating the relationship between disgust facial recognition and moral responsivity will reflect whether moral disgust is a strong contender as a disgust subdomain that incorporates a characteristic physical disgust response of perceiving facial disgust.

2. Methods

The study was composed of three phases: (i) an emotion recognition task, (ii) completion of self-report questionnaires for demographics, moral judgments, and disgust sensitivities, and (iii) PROP-taste sensitivity test. The present study was approved by the University Teaching and Research Ethics Committee (UTREC) at the University of St Andrews and carried out in accordance with the guidelines provided by UTREC (Appendix 1).

2.1. Participants

Overall, one hundred and ten participants (90 females, 20 males; mean age: 19.99 years, SD = 1.95) consented to complete this experiment. Seventy-seven participants were recruited through the University of St Andrew's SONA system and were compensated with £3 for their time. The remaining participants were recruited from a lecture practical in the School of Psychology and Neuroscience at the University of St Andrews. In this case, participation was voluntary, students completed the experiment on their own time, and no incentive or compensation was given. Participants recruited from the practical were given the PROP bitter sensitivity taste test with specific instructions on how to administer the test and rate their taste sensitivities after completing the other tasks online on their own. Inclusion criteria included age (25 years and younger), ethnicity (Caucasian only), and completion of the questionnaires (N = 110; 90 females and 20 males).

2.2. Materials

2.2.1. Emotion Recognition Task (ERT)

Subjects were asked to observe grey-scale pictures of faces on a computer screen displaying one of six emotions at different intensities: anger, happy, sad, surprise, fear, or disgust. Two Caucasian male and two Caucasian female faces expressing each emotion at three levels of intensity (20%, 40%, 60% within the range of 0% being neutral and 100% being posed intensity) from a standard and computer-transformed set (Young et al., 1997) were presented in a randomized order (Figure 1). There were a total of 72 trials: four facial identities, each displaying six emotions at the three intensities. Participants were instructed to observe and indicate which emotion was being expressed for each trial by clicking one of the six options (anger, happy, sad, surprise, fear, disgust) presented on the screen underneath the each face. Trial duration was unlimited.

Figure 1. Disgust facial expressions in increasing intensity (left to right: 20%, 40%, 60%) of two of the four facial identities from a standard and computer-transformed set of faces (Young et al., 1997) presented in the Emotion Recognition Task (ERT).

2.3. Questionnaires

2.3.1. Demographics

Participants were asked to indicate their age, gender, ethnic group, and country of origin.

2.3.2. Moral and Visceral Disgust Judgments of Moral Vignettes

To assess moral judgments, fifteen moral vignettes (see Appendix 1) describing fairness-related behaviors were selected from a standardized set compiled by Knutson and colleagues (2010). The vignettes were chosen from this particular set (Knutson et al., 2010) because of their ecological validity as they are based upon real-life situations and were rated for familiarity by young adults (mean age = 26.7). Thirteen of the vignettes chosen involved fairness transgressions (i.e. cheating, lying, etc.) while two vignettes involved morally fair behaviors (Appendix 2). A fairness transgression, for example, would be "I used to work as a legal assistant. I lied to clients all of the time, the attorney I worked for lied all the time, too. We

just lie to our clients so things will work out the best for us." An example of a fair behavior, on the other hand, would be "One summer I had a job on the beach picking up trash. I found a wallet on the beach and it had $60 in it. So I picked it up and turned it into my supervisor." Participants were asked to rate these vignettes on how morally appropriate they found each behavior on a 1-8 scale: 1 being extremely inappropriate and 8 being extremely appropriate. For analyses purposes, however, the scores were all reverse coded so that a person with high moral sensitivity (finding transgressions inappropriate) would score highly and to have consistency with the scoring of the other questionnaires described below. The moral vignettes used in this study did not reflect behaviors with visceral disgust components.

In addition, Herz (2014) recently showed that participants who had more intense reactions to the PROP taste sensitivity test also indicated that they were more "grossed out" by moral transgressions. To further explore Herz's (2014) finding of PROP sensitivity relating to the visceral reaction (measured by "grossed out" ratings) to moral transgressions, participants were also asked to rate how "grossed out" they were by the same fairness transgressions they previously rated on moral appropriateness in the present study.

2.2.3. Tybur Moral Disgust Scale

The moral subscale of the TDDS was used in this study to measure disgust sensitivity to behaviors lacking physically disgusting components (Appendix 3). For example, an item in this moral disgust subscale is "A student cheating to get good grades." Participants were instructed to rate how disgusting they found each item on a 1-7 category scale (1 being "not at all disgusting" and 7 being "extremely disgusting"). This subscale consists of seven items.

2.2.4. PROP: Bitter Taste Sensitivity Test

To measure bitter taste sensitivity, the standard biological assay 6-*n*-propylthiouracil (PROP) was administered. PROP was administered as 2.0 mg/mL saturated on rectangular filter paper strips (Supertaster Labs, New York). Sensitivity to PROP was assessed with the General Labeled Magnitude Scale (gLMS; Bartoshuk et al., 2004). The gLMS is a line scale partitioned into evenly distributed numerical increments of 0-100 with six semantic labels fixed at empirically determined points on the scale: barely detectable, weak, moderate, strong, very strong, strongest imaginable sensation of any kind (Figure 2) (Bartoshuk et al., 2004; Herz, 2014).

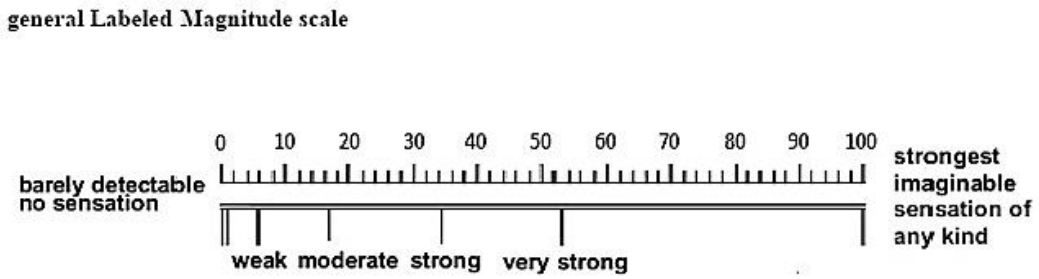


Figure 2. general Labeled Magnitude Scale (gLMS) administered to measure PROP bitter taste sensitivity (Bartoshuk et al., 2004).

2.4. Procedure

The experiment, other than the administration of PROP, was computerized. Each participant provided informed consent prior to participating in the experiment. Participants were told that they would observe a series of faces and be asked to indicate what kind of emotion they were expressing, answer questionnaires gauging into different personality constructs, and complete a taste test at the end of the tasks. The tasks were completed in the following order: (1) emotion recognition task, (2) demographic questions, (3) moral judgments of the moral vignettes, (4) "grossed-out" ratings of the moral vignettes, (5) TDDS moral subscale, and (6) the PROP bitter taste sensitivity test. In order to control for the potential of PROP inducing a negative taste sensation in participants and thereby confounding responses to the other questionnaires, it was administered at the end of the experiment. Participants were instructed to place the paper strip on their tongue for several seconds and then to indicate on the gLMS scale how strong of a taste sensation they had from the strip. Participants were informed that they may find the taste bitter and thus were advised to have a glass of water ready. Small chocolates were also offered for relief after the PROP test.

2.5. Analyses

To assess the relationships between bitter taste sensitivity and three measures of disgust facial recognition (hits, bias, and false positive errors), correlational as well as categorical analyses were conducted. Correlational analyses were performed in order to measure taste sensitivity as a continuous variable and categorical analyses were conducted to assess taste sensitivity in three taster levels: non-taster,

medium-taster, and super-taster. Although the inclusion of both types of analyses is somewhat redundant, there are advantages in including both. Categorical analyses, for example, allow for comparison with prior work (e.g. Herz, 2011) and also addresses the possibility that the relationship between taste sensitivity and expression sensitivity might not be linear (e.g. it could be that only super-tasters, or only non-tasters, differ from others). Correlational analyses also allow for comparison with prior work (e.g. Herz, 2014) and provide plots that may reveal outliers.

The relationships between taste sensitivity and moral sensitivity (measured by fairness transgression judgments, "grossed out" ratings of the fairness transgressions, and moral disgust scores from the TDDS) were assessed through correlational analyses since the moral sensitivity measures were scored as continuous variables.

Correlational analyses were also conducted to investigate the relationships between the three measures of disgust recognition and judgments of fairness transgressions as well as moral disgust (collectively referred to as moral responsivity in the present study).

3. Results

3.1. Disgust Recognition x PROP Bitter Taste Sensitivity

3.1.1. PROP Bitter Taste Sensitivity

PROP Bitter Taste Sensitivity scores of all participants were normalized by square-root transformations. Thus, the gLMS scores reported in this study fall within a range of 0-10 rather than the collected scores that fall between 0-100 in the gLMS scale. In past research conducted by Herz (2011), taster levels were categorized into 3 levels based on their untransformed gLMS scores: participants who rated their experiences of PROP between 0 and 15 (barely detectable – weak) were categorized as non-tasters, between 15 and 50 as medium-tasters, and between 50 and 100 (very strong – strongest imaginable sensation) as super-tasters. In the present study, these ranges were square-rooted to be consistent with the square-root transformed gLMS scores and thus were separated along these ranges: between 0 and 3.87 as non-tasters (N = 31; 26 females, 5 males), 3.87 and 7.07 as medium-tasters (N = 52; 41 females, 11 males), 7.07 and 10 as super-tasters (N = 27; 23 females, 4 males). Square-root transformed gLMS responses were also analyzed as a continuous variable to address the fact that PROP sensitivity is not a direct measurement of fungiform papillae and because there is greater sensitivity with a continuous scale (Herz, 2014).

Due to the large difference in the sample size of males (N = 20) in comparison to females (N = 90), gender was not analyzed in this study. Furthermore, additional analyses showed no qualitative differences between males and females in taster levels and emotion task performance.

3.1.2. Disgust Hits

The proportion or rate of correct disgust expression recognition ("disgust hits") was computed for each participant. This rate was computed by dividing the number of correct disgust responses when disgust was displayed by 12, as there were 12 disgust stimuli trials in the ERT. To assess whether taster level (non-taster, medium-taster, super-taster) would have a statistically significant effect on disgust hit rates in ERT, a one-way ANOVA was conducted. There was not a main effect of taster level ($p = .547$) on disgust hits. No significant differences between the proportions of disgust hits were found amongst the non-tasters ($M = .489$, $SD = .185$), medium-tasters ($M = .497$, $SD = .211$), and super-tasters ($M = .540$, $SD = .191$) (Figure 3A).

Correlational analyses between the gLMS scores and disgust hits were conducted to assess whether those with higher bitter taste sensitivity would more accurately identify disgust expressions in the ERT. There was not a significant association between bitter taste sensitivity and disgust hits, $r(108) = .126$, $p = .189$ (Figure 4A).

3.1.3. Disgust Bias

As the focus of the present study is the emotion of disgust, the disgust bias rate was calculated for each participant. Disgust bias was identified as the frequency of identifying emotional expressions as disgust, regardless of accuracy, throughout the ERT. A one-way ANOVA was performed to test for the effects of taster level on disgust bias. A main effect of taster level upon disgust bias was shown, $F(2, 107) = 3.68$, $p < .05$, eta=.25. Post hoc Bonferroni tests indicate that non-tasters ($M = .121$, $SD = .053$) and medium-tasters ($M = .125$, $SD = .051$) did not differ significantly in their disgust bias ($p = 1.00$) while super-tasters ($M = .158$, $SD = .059$) had significantly greater rates of disgust bias than non-tasters ($p = .048$) and a trend towards a significantly greater rate of disgust bias than medium-tasters ($p = .055$) (Figure 3B).

Further correlational analyses were done between disgust bias rates and bitter sensitivity as a continuous variable. Pearson correlations showed that increasing bitter taste sensitivity was significantly associated with increasing rates of disgust bias, $r(108) = .216$, $p = .023$ (Figure 4B).

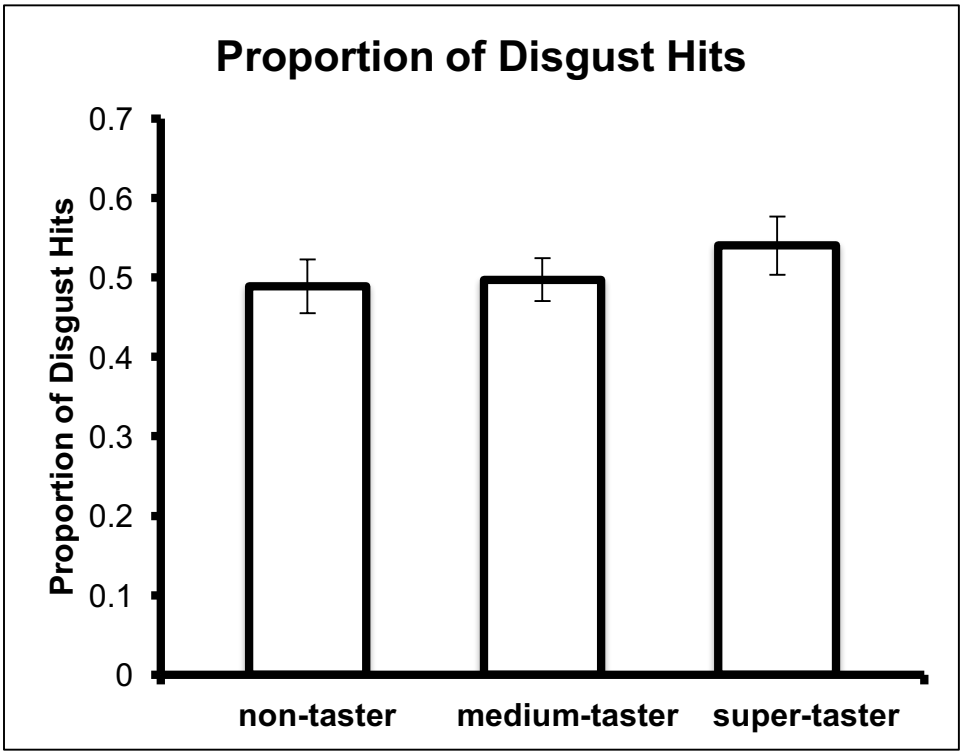
3.1.4. Disgust False Positive Errors

There is a lack of research in emotion recognition studies investigating the tendency to identify faces with a certain emotion when that emotion is actually not present (false positive error). Therefore, this study investigated the tendency of participants to make disgust false positive errors: identifying faces shown during the ERT as disgust when those faces are expressing non-disgust emotions. Disgust false positive errors were computed as such: dividing the number of total error trials made where a participant used the 'disgust' label but no disgust stimulus was presented by the total number of trials with opportunity for such errors (n=60).

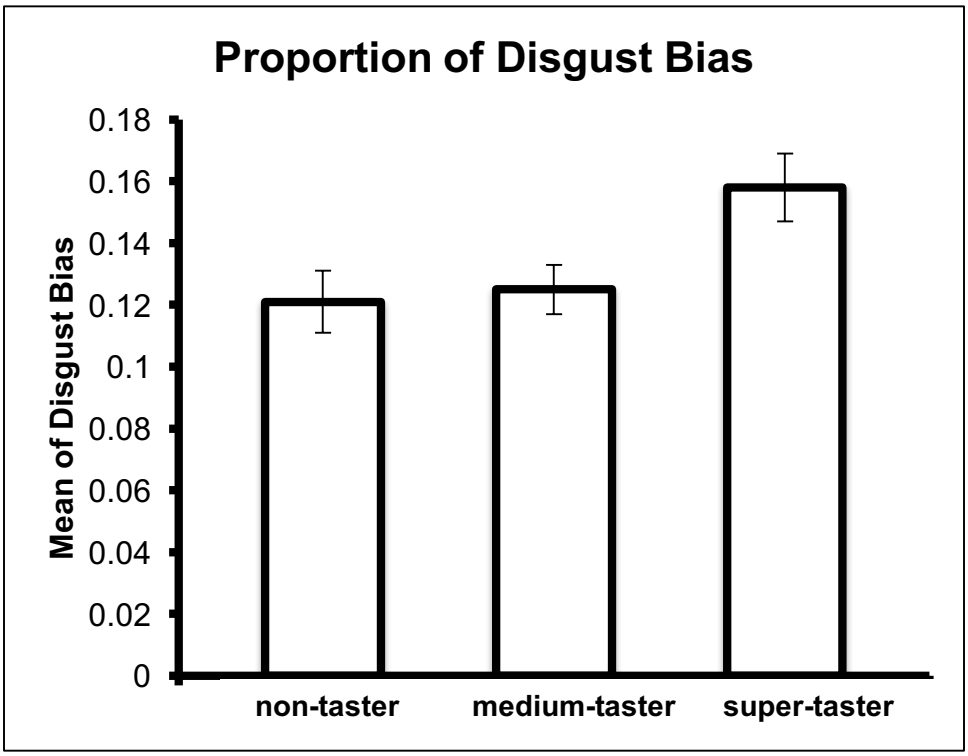
To explore whether taster level had statistically significant effects on the tendency to make disgust false positive errors, a one-way ANOVA was performed. Due to the skewness of the data, the Welch's adjusted ratio was obtained. There was a non-significant trend for a main effect of taster level, Welch's $F(2, 56.3) = 2.42$, $p = .098$. No significant differences were seen amongst the non-tasters ($M = .047$, $SD = .040$) and medium-tasters ($M = .051$, $SD = .047$) in their proportion for making false positive errors (Figure 3C). However, post hoc Games-Howell tests showed a trend towards a significant difference in false positive error rates between non-tasters and super-tasters ($M = .082$, $SD = .054$), $p = .087$ (Figure 3C).

Spearman's correlation was computed to address the skewness of the data. A trend towards significance between bitter taste sensitivity as a continuous variable and false positive error rates was found, $r_s(108) = .167$, $p = .082$ (Figure 4C).

A)


Proportion of Disgust Hits
Proportion of Disgust Hits
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
non-taster
medium-taster
super-taster

B)


Proportion of Disgust Bias
Mean of Disgust Bias
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
non-taster
medium-taster
super-taster

C)

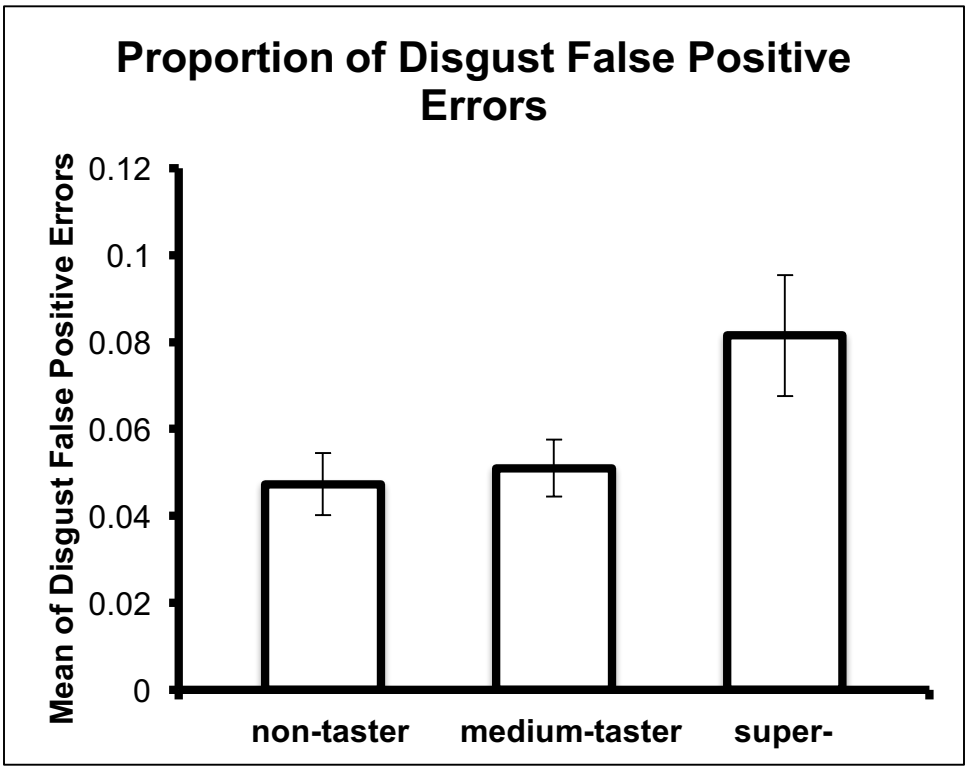
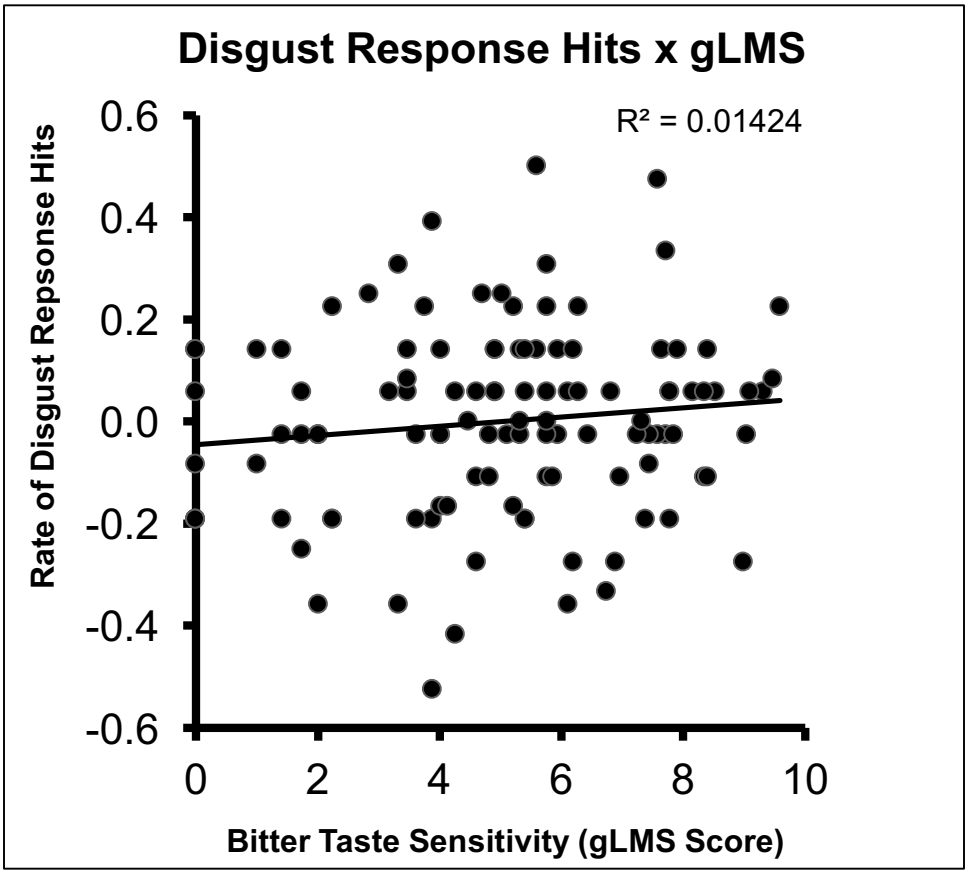
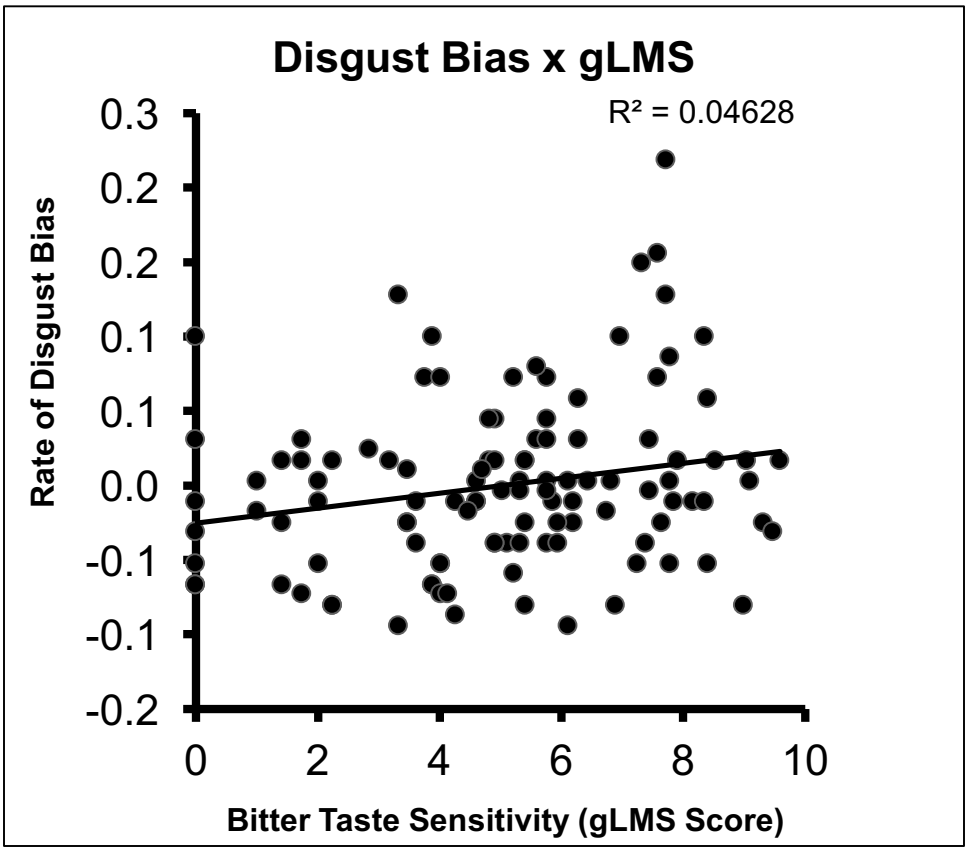


Figure 3. Bar graphs of three measures of disgust facial expression recognition for each taster level. **A)** No significant differences were found amongst non-tasters (M = .489, SD = .851), medium-tasters (M = .497, SD = .211), and super-tasters (M = .540, SD = .191) in their proportions of disgust hits. **B)** Super-tasters (M = .158, SD = .059) showed a significantly greater proportion of disgust bias than non-tasters (M = .121, SD = .053; $p < .05$) but neither group showed significant differences from medium-tasters (M = .125, SD = .051). **C)** Proportions of false positive errors also did not show significant differences amongst non-tasters (M = .047, SD = .040), medium-tasters (M = .051, SD = .047), and super-tasters (M = .082, SD = .054); though a trend towards a significant difference was shown between non-tasters and super-tasters, p = .087

A)


Disgust Response Hits x gLMS
R² = 0.01424
Rate of Disgust Repsonse Hits
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
0
2
4
6
8
10
Bitter Taste Sensitivity (gLMS Score)

B)


Disgust Bias x gLMS
R² = 0.04628
Rate of Disgust Bias
0.3
0.2
0.2
0.1
0.1
0.0
-0.1
-0.1
-0.2
0
2
4
6
8
10
Bitter Taste Sensitivity (gLMS Score)

C)

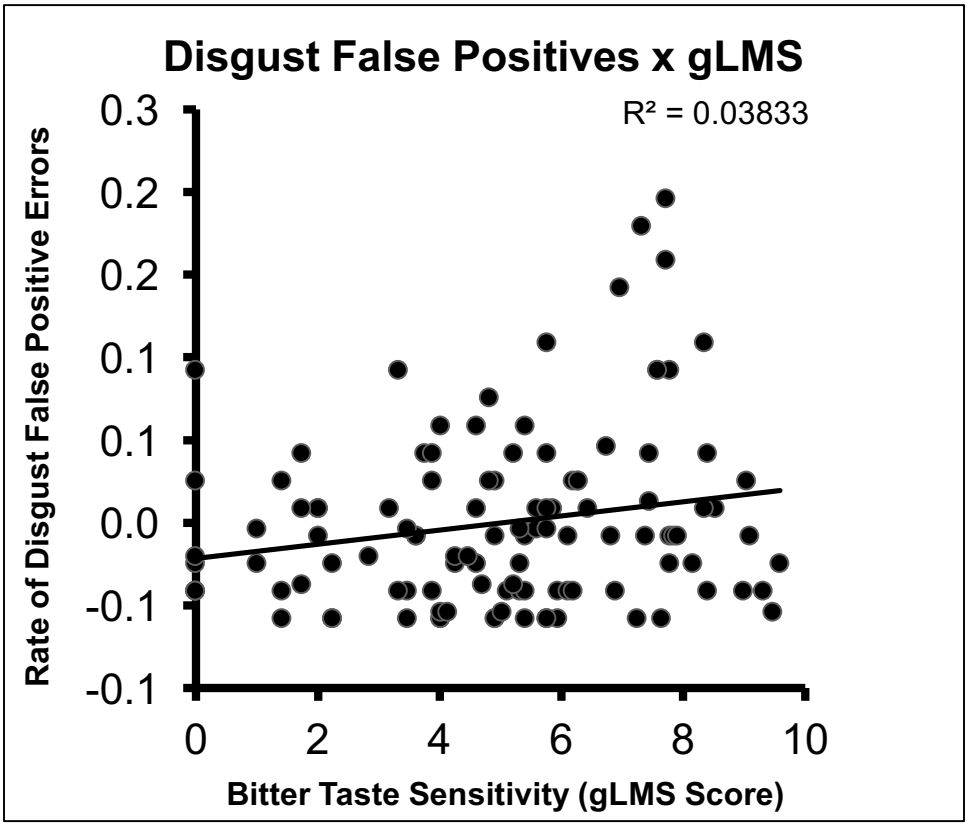


Figure 4. The relationship between bitter taste sensitivity and the dimensions of disgust expression recognition. Scatterplots showing the significant positive relationship between bitter taste sensitivity to PROP (square-rooted transformed gLMS) score and **B)** rate of disgust bias ($r = .219$, $p < .05$) but not with the **A)** rate of disgust hits ($r = .126$, $p = .189$) or **C)** rate of disgust false positive errors ($r_s = .167$, $p = .082$). Lines record the best-fit linear regression together with proportion of variance explained by regression line.

3.2. Taster Level x Moral Responsivity

3.2.1. Fairness

To investigate whether individuals with higher bitter taste sensitivity found the fairness transgressions overall to be more morally inappropriate, Pearson's correlation was used to analyze this relationship. No significant relationship, however, was found ($r(108) = -.023$, $p = .834$), suggesting that individuals who are more sensitive to bitter tastes are not necessarily more critical towards fairness transgressions.

3.2.2. Visceral Disgust – "grossed out" judgments

Pearson's correlation was run between bitter taste sensitivity as a continuous variable and overall "grossed out" ratings of the fairness transgressions to further explore Herz's (2014) findings on the

relationship between visceral disgust responses to moral transgressions. No significant relationship was shown ($r(108) = -.106$, $p = .270$) in this study.

3.2.3. TDDS Moral Disgust Subscale

The relationship between moral disgust sensitivity, measured by the TDDS moral disgust subscale, and bitter taste sensitivity was investigated. Pearson's correlational analyses showed that there was a statistical trend towards a significant negative association between bitter taste sensitivity and moral disgust sensitivity, $r(108) = -.158$, $p = .099$.

3.3. Disgust Recognition x Moral Disgust and Judgments

3.3.1. Disgust Hits

Correlational analyses were performed to investigate whether individuals with higher moral disgust sensitivity (as measured by the TDDS moral subscale) and moral judgments had greater disgust expression hits. Pearson's correlations showed that rates of disgust hits did not significantly relate with moral disgust sensitivity ($r(108) = .001$, $p = .995$) or moral judgments of fairness transgressions ($r(108) = -.022$, $p = .820$).

3.3.2. Disgust Bias

To assess whether disgust bias rates were higher in individuals with greater moral disgust and sensitivity to the fairness transgressions, correlational analyses were conducted. No significant relationships, however, were found between disgust bias rates and moral disgust sensitivity ($r(108) = -.034$, $p = .723$) or moral judgments ($r(108) = -.136$, $p = .156$).

3.3.3. Disgust False Positive Errors

Spearman's rho correlations were conducted to investigate whether rates of disgust false positive errors increased with individuals who scored higher in moral disgust and sensitivity to the fairness transgressions. No significant relationship was found between disgust false positive errors and moral disgust scores, $r_s(108) = -.063$, $p = .512$. An unexpected significant negative relationship was found between moral judgments of fairness transgressions and rates of disgust false positive errors, $r_s(108) = -.247$, $p = .009$. This negative relationship suggests that individuals who were more sensitive to the fairness transgressions tended to make less disgust false positive errors.

3.4. Moral Disgust x Ratings of Moral (Fairness) Transgressions

To investigate whether those with higher moral disgust sensitivity as measured by the TDDS moral subscale were more sensitive to the moral fairness transgressions, Pearson's correlations were performed. A significant positive correlation was found between moral disgust scores and moral judgments of the fairness transgressions, $r(108) = .372$, $p < .001$, which indicates that individuals with higher moral disgust sensitivity found the fairness transgressions more morally inappropriate. A significant positive correlation was found between moral disgust scores and "grossed out" ratings of the fairness transgressions, $r(108) = .717$, $p < .001$, which suggests that individuals with higher moral disgust sensitivity were more grossed out (sick to the stomach, nauseated) by the fairness transgressions that do not involve viscerally disgusting components. Moral judgments and grossed out ratings of the fairness transgressions were significantly correlated, $r(108) = .421$, $p < .001$, indicating that individuals who found the fairness transgressions to be more morally inappropriate were also more grossed out by the behaviors.

4. Discussion

The primary focus of the present study was to investigate the relationships between distaste, measured in the form of bitter taste sensitivity, and three different measures of facial disgust expression recognition: hits, bias, and false positive errors. Although no significant relationships with disgust hits were found, distaste sensitivity showed a positive relationship with rates of disgust bias (tendency to report disgust throughout the emotion recognition task (ERT) in response to whatever facial expression was presented) as well as a trending association with rates of disgust false positive errors (tendency to report disgust to facial expressions that are not expressing disgust in the ERT). This suggests that distaste sensitivity may not necessarily enhance one's accuracy in recognizing disgust but rather bias one to *see* disgust more often. Additionally, the relationships between distaste and moral disgust as well as moral judgments of fairness transgressions (collectively referred to as moral responsivity in the present study) were explored. No significant relationships were found, implying that distaste – although considered the evolutionary origin of disgust – does not directly affect moral responsivity. A third focus of the study was to explore interrelations between disgust emotion recognition and judgments of fairness transgressions. Of the three expression recognition measures, disgust false positive error rates increased with individuals who found the fairness violations less morally inappropriate. This unexpected finding provides insight into a

potential dimension in the disgust experience of individuals who have a higher tolerance for fairness transgressions.

4.1. Hypothesis 1, Individuals with Higher Bitter Sensitivity to PROP will have Grater Accuracy in Facial Disgust Recognition

The initial hypothesis that individuals with higher bitter taste sensitivity would have greater disgust expression recognition accuracy or "hits" was not supported, as it was not found that an individual's bitter taste sensitivity was related to increased rates of disgust hits. As implied by Elfenbein and Ambady (2002), research on expression recognition predominantly focuses on accuracy (hits) – typically measured by the frequency at which participants correctly identify the emotion being portrayed by the stimulus – and errors – commonly measured by the frequency at which participants mislabel the facial emotion being expressed (e.g. Blair et al., 2004; Sprengelmeyer et al., 1996; Sprengelemeyer et al., 2003). Yet, an issue with only focusing on accuracy in emotion recognition is that correct hits do not necessarily account for biases or tendencies to report particular emotions. For instance, an individual could hypothetically choose disgust for all 72 trials in the ERT of this study and obtain 12 disgust hits, which would translate to 100% disgust accuracy with respect to hits. Computing false positive error rates for the recognition of a certain emotion (e.g. disgust) *in addition* to computation of hit rates, furthermore, provides a more specific perspective as to the type of error being made rather than just general inaccuracy in recognizing certain emotional expressions (e.g. Buhlmann, Etcoff, & Wihelm, 2006; Kohler et al., 2003). In the present study, therefore, the bias and false positive error rates for disgust were investigated in addition to hit rates.

Individuals with greater bitter taste sensitivity, as reported by the PROP paper strip test ratings, showed higher rates of disgust bias in the ERT. Taster level was also found to have a medium effect size (eta of .25; Cohen, 1988) upon disgust bias rates with super-tasters having the greatest disgust bias, in comparison to non- and medium-tasters. Additionally, increased bitter taste sensitivity showed a trending association with increased disgust false positive error rates – more sensitive tasters tended to identify non-disgust emotional expressions as disgust. These findings indicate that individuals with greater bitter taste sensitivity (e.g. super-tasters) have a tendency to *see* disgust more often than less sensitive tasters, which may be an underlying reason for their compromised accuracy in recognizing disgust facial expressions. We suggest that "seeing" an emotion should be differentiated from "recognizing" an emotion since seeing an

emotion does not imply accuracy. In other words, an emotional bias in regards to expression recognition would be a type of "seeing" that involves both accurate and inaccurate recognition of that particular emotion (Elfbein & Ambady, 2002).

A potential explanation as to why more sensitive bitter tasters (e.g. super-tasters) see disgust more often begins at the neurobiological level. In particular, the anterior insula has been shown to be the neurological site for the primary taste cortex and disgust response (Phillips et al., 1997; D.M. Small, 2010; Wicker et al., 2003). Furthermore, the taste and perceived intensity of unpleasant foods (most commonly measured by salt (NaCl concentrations) have been linked with anterior insular activity (Small et al., 2003; Spetter, Smeets, de Graaf, & Viergever, 2010). Small and colleagues (2003), for instance, found that the anterior insula preferentially responded to unpleasant tastes in comparison to pleasant tastes. Spetter and colleagues (2010) also found that anterior insula activity increased more with increasing NaCl concentrations than with sucrose, once again showing preferential responses to unpleasant tastes. Thus, as super-tasters have enhanced taste perceptions and overall taste experiences, it is likely that they exhibit greater anterior insular activation than other tasters when ingesting unpleasant bitter foods. Damage to the insula results in impaired recognition and experience of disgust (Adolphs, Tranel, & Damasio, 2003; Calder, Keane, Manes, Antoun, & Young, 2000). The anterior insula, specifically, has been shown to be involved with observation and feeling of disgust (Wicker et al., 2003). Therefore, although it has yet to be studied directly, it is perceivable that super-tasters have overactive or over-responsive anterior insula, which would enhance not only the taste perception of unpleasant tastes but also the disgust *experience*. Importantly, however, the findings in the present study suggest that this increased distaste and disgust emotional experience does not necessarily lead to accuracy in recognizing disgust emotion in others.

The fact that individuals with increasing bitter taste sensitivity chose disgust most frequently in this study poses several behavioral implications. As mentioned before, the distaste and disgust experience have many overlapping behaviors and qualities such as nausea (including retching), bodily reactions, and facial expression (Herz, 2014). It is possible, therefore, that those with greater distaste sensitivity inherently have more frequent disgust experiences. Experiencing disgust more often, furthermore, could cloud an individual's social perception in that the personal emotional experience (e.g. frequency of feeling disgust) is projected onto the experiencer's social surroundings to cause him or her to see disgust more often in

others through a reduced “mirroring” effect. This effect is reflected in the Hebbian associating learning theory regarding mirroring whereby the emotions of others (e.g. represented by facial emotion expressions) are associated to emotions experienced by the observer (Keysers & Perrett, 2004). For example, we often learn to recognize disgust from the coincidence of experiencing our own disgust and associating our experience with other people’s disgust facial expressions due to common environmental causes of the emotion, such as a bad smell (Keysers & Perrett, 2004). Super-tasters, however, may have a reduced quality of Hebbian associative learning in that the coincidence of associating personal disgust experiences with disgust expressions of others is *less* frequent due to their high frequency of feeling disgust. In other words, super-tasters or more sensitive bitter tasters may feel disgust more often than others and thus acquire the tendency to be over-inclusive in the classification of disgust in others, causing super-tasters to be more inaccurate at recognizing disgust.

As there are a lack of studies investigating specific types of emotional biases and false positive errors in facial expression recognition, future studies are necessary to further explore these dimensions of facial expression recognition. For example, more sensitive statistical analyses should be done to investigate the effects of taste upon disgust deriving signal detection measures of sensitivity that are independent of bias or criterion such as d’ (“d-prime”) statistics. In addition, confusion matrices for facial disgust misidentification (the percentage of disgust response to each of the five other basic emotional expressions; e.g. Kohler et al., 2003) would provide further insight into the type of bias and false positive errors made by high bitter tasters in comparison to low bitter tasters. It is possible, for instance, that high bitter tasters have a greater tendency to confuse anger expressions with disgust, which are two commonly confused facial emotion expressions in comparison to disgust confusions with the other basic emotional expressions (Ekman & Friesen, 1975). Another test would be to analyze the performance of tasters on disgust recognition measures based upon the intensities at which the disgust expression is presented. Furthermore, as the ERT of this study used static faces, a future improvement could be to use dynamic stimuli since facial expressions are intrinsically dynamic stimuli (Wicker et al., 2003). Lastly, it is important to investigate whether there is differential insular activity across taste sensitivity levels to have a better understanding of the neurobiological underpinnings of taste perception.

4.2. Hypothesis 2, Individuals with Greater Bitter Taste Sensitivity have Increased Moral Responsivity

An exploratory aim of the present study was to investigate the relationship between distaste (as it is considered to be the evolutionary origin of disgust) and moral responsivity. There is still much speculation in regards to whether moral disgust produces the visceral responses of physical disgust such as nausea, gagging, and the disgust facial expression (Chapman & Anderson, 2013; Herz, 2014; Kelly, 2011). There were no significant correlations between distaste as measured by PROP and moral disgust (TDDS) or moral judgments of fairness transgressions, supporting Herz's (2014) finding that moral responsivity does not reflect taste sensitivity. Furthermore, we investigated whether participants with more intense reactions to PROP would be more "grossed-out" by the fairness transgressions as was found in Herz's (2014) study. No significant relationship was shown between ratings of "grossed-out" and bitter taste sensitivity, indicating that "grossed-out" did not have the same semantic effect of inducing more sensitive bitter-tasting participants to feel visceral disgust and thus view moral transgressions as viscerally repulsive events (Herz, 2014). These findings suggest that distaste sensitivity does not directly affect levels of moral disgust or judgments of transgressions of fairness.

It is important to note that the participant sample in this study is primarily composed of Caucasian individuals from Europe. Thus, the phrase "grossed-out" may not have had the same visceral disgust impact that it does in the United States, which is where Herz (2014) conducted her study. A future study could be one that investigates the relationship between bitter taste sensitivity and facial disgust recognition in specific ethnic and/or cultural groups. An additional future direction would be to conduct mediation analyses to test whether rates of disgust hits, biases, or false positive errors mediate a relationship between distaste and moral responsivity.

4.3. Hypothesis 3, Individuals with Greater Disgust Recognition Accuracy will have Greater Moral Responsivity

A third aim of the present study was to further explore the domain of moral disgust. Research on the subdomain of moral disgust has been inconclusive; some researchers argue for the experience of disgust in response to moral violations while others claim moral disgust is simply a metaphor that is used to describe other basic emotions in the face of moral violations (Chapman & Anderson, 2013; Chapman et al.,

2009). Fairness violations, in particular, have been a topic of interest in relation to moral disgust since several studies suggest that these non-physical violations elicit disgust responses – often measured by facial levator labii muscle activity (Cannon et al., 2010; Chapman et al., 2009). The items of the moral violations as well as the moral subscale from the Three Domain Disgust Scale (TDDS) that we examined here, therefore, consisted of only fairness-related behaviors to further investigate whether this specific moral domain is related to disgust facial expression recognition.

In the present study, there were no significant relationships between disgust hits or disgust bias with moral responsivity (collectively referring to moral judgments and reports of disgust reactions) to fairness violations. The hypothesis that accuracy in facial disgust emotion recognition would positively relate to moral responsivity was therefore not supported as these findings suggest that greater moral responsivity does not relate to improved recognition of disgust.

One unexpected finding was that those who were less sensitive in their moral judgments of the fairness transgressions made significantly greater numbers of disgust false positive errors. In other words, the emotion most often chosen when incorrectly identifying the emotional expressions by individuals who did not find the fairness transgressions as morally inappropriate was disgust. It is not immediately apparent why moral responsivity would be negatively correlated with disgust false positive error rates. One possibility lies in the area of antisocial behaviors, which is often manifested by moral insensitivity. Moral insensitivity is characterized by a variety of factors, ranging from indifference towards to the willingness to commit moral transgressions against others (Harenski, Harenski, Shane, & Kiehl, 2010). In the present study, albeit a narrow focus, moral insensitivity was assessed by less critical moral judgments of fairness violations and scores that indicate low levels of disgust towards behaviors in the TDDS moral disgust subscale.

Moral insensitivity is a primary characteristic of individuals with antisocial and, on the extreme end, psychopathic tendencies (Glenn, Iyer, Graham, Koleva, & Haidt, 2009). Psychopathic individuals have been suggested to suffer deficits in the moral domains of harm and fairness, such as lack of empathy for others receiving harm or unfair treatment (Glenn et al., 2009), reduced autonomic nervous system responding to distress cues in others (R. J. Blair, 1999), and impairments in recognizing sad and fearful facial expressions (Blair, Colledge, Murray, & Mitchell 2001; Blair et al., 2004). The disgust-processing

network, on the other hand, is suggested to be intact in psychopaths (R. J. Blair, 2007; Glenn et al., 2009). For instance, Blair and colleagues (2004) found that psychopaths were not worse in disgust facial recognition hits in comparison to a control group, and according to Glenn and colleagues (2009), the insula is not generally found to be impaired in psychopaths. Similar to the Hebbian associative learning theory proposed by Keysers and Perrett (2004), Blair (2007) advocates the notion that disgust expressions of others initiate a form of emotional learning mediated by the insula, in that people learn disgust reactions to particular situations (e.g. moral transgressions) by observing and recognizing the display of facial disgust expressions towards the constituents (e.g. perpetrator of transgressions) of those situations. Interestingly, psychopaths seem to have a neural foundation to experience and learn the disgust response. Though, with the Hebbian associative learning theory in mind, it is possible that psychopaths do not feel disgust due to a timing mishap in sharing the disgust experience. In other words, psychopaths may *see* the disgust facial expression from others very often due to their actions and views but do not always personally experience disgust during situations that elicit disgust in others. Thus, they miss a key part in the learning process of associating their own personal disgust with the disgust expressions of others. Individuals with antisocial/psychopathic tendencies may therefore reflect a very similar scenario we proposed for super-tasters but in the opposite direction: also reduced association of personal disgust with disgust expressions of others but due to *less* frequency in personally experiencing disgust while receiving disgust facial expressions from others at a high frequency. With this hypothetical situation as well as previous research on disgust and antisocial/psychopathic tendencies in mind, it is possible that the individuals who did not find the fairness transgressions as morally inappropriate in the present study often receive facial disgust responses by their peers due to their morally insensitive views and behaviors. Although these individuals are able to recognize the disgust expression, they do not over-attribute it to all emotional contexts and instead use disgust as a fallback response when they are unsure of the emotional expression being presented – resulting in more disgust false positive errors.

These explanations, nevertheless, are hypothetical and thus require much investigation to assess the possibility of using these theories as explanations for morally insensitive individuals and their social learning and recognition processes of disgust. Moreover, further research is necessary as the relationship between disgust and antisocial behaviors/psychopathy is still unclear (Glenn et al., 2009). For instance, a

future test would be to compare insular activity in morally insensitive individuals to a control group when observing disgust in others and when induced with a disgust state, similar to the study conducted by Wicker and colleagues (2003). Another direction would be to expand upon our finding of more morally insensitive individuals making more disgust false positive errors by incorporating direct measures of antisocial and/or psychopathic tendencies.

5. Conclusion

Disgust is a complex basic emotion that encompasses a wide range of subdomains that reflect its suggested primal origin in distaste as well as its social role in human interactions and behaviors. The present results suggest a unique relationship between distaste sensitivity and facial disgust recognition (an important form of social communication and learning) in that more sensitive bitter tasters, particularly super-tasters, had greater disgust bias and false positive error rates when identifying facial emotion expressions. Although bitter taste sensitivity did not appear to have a relationship with moral responsivity, participants who did not find the fairness transgressions as morally inappropriate tended to make more facial disgust false positive errors. These findings imply that within the three-tier relationship of distaste, disgust, and moral responsivity, there are different levels at which the tiers are interconnected. Further exploring these relationships at the neural, cognitive, and behavioral levels will thus provide a better understanding of the various defensive as well as social and cultural roles of disgust in human perceptions and behaviors.

Appendix 1. UTREC Approval

SONA Participants

- Ethics Approval Code PS11218

Lecture Practical Participants

- Ethics Approval Code PS11378

Appendix 2. Fairness Transgressions

1. I was thirteen years old and I went into the grocery store where I lived. There was a comb that I wanted in the store, so I just took it. I didn't really need it, but I just wanted the thrill of stealing it and nobody catching me.
2. I used to work as a legal assistant. I lied to clients all of the time, the attorney I worked for lied all the time too. We just lie to our clients so things will work out the best for us.
3. Sometimes I go to the movies, pay to see one movie and then go to a second movie afterwards. I wait until the people at the snack bar aren't looking and sneak into a second movie. I've done it with my daughter a couple of times too and haven't gotten caught.
4. I put a poster that I had on eBay. There was a man who bid on it and paid with a system that sent the money directly to me. He was kind of a jerk during the whole transaction, so I decided not to send the poster and just keep the money.
5. One summer I had a job on the beach picking up trash. I found a wallet on the beach and it had $60 in it. So I picked it up and turned it into my supervisor.
6. Years ago, I shoplifted lipstick from a drugstore. No matter what I did with the lipstick after I stole it, I just wasn't able to enjoy it. I never took it back though or told anyone.
7. When I was eleven or twelve, I called someone a racial name. The person I'd called the name was a sort of a friend of my sister's. It got back to her and she was humiliated.
8. I bought a pair of shoes and the lady was busy, so she charged me a lower price for the shoes. I told her this and she corrected the price then thanked me.

9. I was taking a vocabulary test in class, and usually I am great at vocabulary. But, as I was passing my paper forward I realized that the girl behind me had one different answer than I did. So I changed my answer to the same as her answer.
10. I was responsible for the financial wellbeing of the women members in my family. They really needed all the money that they had and could get. So, through a bit of "creative reporting" on their taxes, I ended up cheating the government out of about $100,000.
11. When I was in high school, this old man died. Some guys and I went into his house and I took a pair of old work boots.
12. When my first husband and I split up, I was seventeen years old with a six-month-old baby and working in a grocery store. Sometimes I would just take things I needed. I remember taking cans of tuna, milk, and loaves of bread.
13. When I was a scriptwriter in Hollywood, I was in a writer's group and sold a TV show and got an agent. My friend asked if I could send his stuff to my agent. I didn't send his stuff to my agent; instead, I told my friend that my agent didn't like his work.
14. At the gym, a few years back, there was this jacket that was hanging on a hook. I had seen it hanging there for a few weeks and no one claimed it. So I just took the jacket.
15. There have been several times when I have been walking down the street and a homeless person has asked me for money. I have never given him or her money. I just walk by him or her.

Appendix 3. TTDS Moral Disgust Subscale

1. Shoplifting a candy bar from a convenience store
2. Stealing from a neighbor
3. A student cheating to get good grades
4. Deceiving a friend
5. Forging someone's signature on a legal document
6. Cutting to the front of a line to purchase the last few tickets to a show
7. Intentionally lying during a business transaction

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