



Mouth proximity influences perceived disgust of visual stimuli

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ABSTRACT

The emotion of disgust likely evolved to protect humans against oral contamination by pathogens. Accordingly, objects positioned in close proximity to body parts -where infection can easily invade the human body-should be perceived as more disgusting than objects positioned in more neutral places. In the present study, we experimentally altered the distance of various edible and non-edible stimuli from the human mouth and found that mouth proximity enhanced disgust ratings, and more particularly for non-food stimuli. Interestingly, stimuli that were shown near the foot, i.e., far away from the mouth, were also given high disgust ratings, probably due to different contextual integration of emotional conflict. These findings suggest that disgust is enhanced when the risk of oral contamination increases, and thus, that disgust is context-dependent.

1. Introduction

Disgust is a basic emotion with deep evolutionary roots, which most likely evolved to protect humans against contamination by pathogens (Darwin, 1872/1965; Rozin & Fallon, 1987). Most of the human body covers skin (Romanovsky, 2014), which is an effective barrier against pathogens (Niyonsaba & Ogawa, 2005). Indeed, the natural acidity of the skin provides a hostile environment for bacteria (Madison, 2003). Ingestion of many pathogens - such as viruses, bacteria, protozoa, fungi or nematodes - is the most common type of infection in humans (Loy-nachan, 2013). Therefore, it is reasonable to hypothesize that the evolutionary origin of disgust is primarily related to oral contamination (Darwin, 1872/1965; Fančovičová et al., 2022; Rozin et al., 2008; Rozin & Fallon, 1987). However, it is also possible that disgust evolved as a broader mechanism designed to protect ourselves against infectious diseases (Curtis et al., 2004; Oaten et al., 2009; Plutchik, 1980; Tybur et al., 2009). For instance, disgust sensitivity is specifically related to fear of certain groups of animals that evoke revulsion due to the presence of mucus (e.g., snails) and being sources of contamination and/or are associated with dirt (e.g., cockroaches, spiders) (Davey, 1991; Matchett & Davey, 1991). Likewise, humans perceive insects as similarly

disgusting as pathogens despite many species being harmless (Lorenz et al., 2014; Matchett & Davey, 1991; Prokop & Jančovičová, 2013; Rozin & Fallon, 1987). This superficial recognition of pathogens ultimately benefits the prevention of disease transmission because the costs of pathogen infection are higher than the avoidance of noninfectious animals (Nesse, 2001).

Because humans cannot survive without eating on a regular basis and do not eat the same type of food since we are an omnivorous species, they need to evaluate food quality by sensory organs and healthiness before ingestion (Rappaport et al., 1992; Rozin & Fallon, 1987). Rotten food and food susceptible to microbial contamination are perceived as more disgusting than still edible food (Becker et al., 2016; Calder et al., 2007; Curtis & Biran, 2001), but when the activation of disgust becomes miscalibrated it may cause dysfunctional eating behaviors (e.g., Aharoni & Hertz, 2011; Hildebrandt et al., 2015). In addition, heightened disgust is associated with specific phobias (Olatunji et al., 2007; Polák et al., 2021) and anxiety disorders (Cisler et al., 2009; Woody & Teachman, 2000). For instance, people diagnosed with blood-injury-injection phobia are more disgust sensitive people than non-phobic people (Kiss et al., 2022; Olatunji et al., 2007). Spider phobic people are more disgust sensitive than spider non-phobic people (Mulken et al., 1996; Polák

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et al., 2020, 2021).

Typically, food disgust is more pronounced in females than in males (Pellegrino et al., 2015) and females are generally more prone to pathogen disgust than males (for reviews see Al-Shawaf et al., 2018; Oaten et al., 2009). A common explanation for heightened disgust sensitivity in females is that females need to be more careful of potential pathogens because they protect not only their health but also the health of their offspring (Curtis et al., 2004; Polák et al., 2020; but see Prokop & Jančovičová, 2013; Prokop & Fančovičová, 2016). Alternatively, females are at a higher risk of contracting sexually transmitted infections (Al-Shawaf et al., 2018; Fleischman, 2014), which is costly in terms of impaired reproductive success, which could contribute to their heightened disgust sensitivity relative to males.

The activation of the emotion of disgust is crucial to ultimately protect the body from the risk of contamination (Pellegrino et al., 2016; Porzig-Drummond et al., 2009). However, disgust can be strongly context-dependent. Concerning food and disgust, Fančovičová et al. (2022) found that disgusting food stimuli triggered greater visual attention than disgusting non-food stimuli, suggesting that humans pay strong attention to the visual processing of contaminated food. However, we are not aware of a study that has investigated how disgust sensitivity varies concerning the direct risk of oral contamination. Our study was therefore aimed at addressing this important issue.

We hypothesize that if disgust primarily evolved to avoid oral contamination, then disgusting stimuli positioned near the mouth should be perceived as posing a greater risk of contamination than disgusting stimuli that are displayed far away from the mouth. Because disgusting stimuli displayed near the mouth should be perceived as emotionally conflicting, we further predicted that disgusting non-food stimuli positioned near the mouth should be perceived as being more disgusting than disgusting food stimuli, because the human body is not adapted to process the former type of stimuli. If these two predictions are true, then this would provide evidence for the hypothesis that disgust is context-dependent. Finally, in line with previous findings in the literature (Al-Shawaf et al., 2018), we anticipated that females should exhibit higher levels of disgust than males whatever the context in which disgusting stimuli are rated.

2. Methods

2.1. Participants and procedure

The participants were 287 Slovak volunteers (aged 18 to 73 years, $M = 26$, $SE = 0.09$) selected based on their age (older than 18). They were recruited online via the university website, similarly to other research in this field (e.g., Curtis et al., 2004; Fessler & Navarette, 2003; Prokop & Fančovičová, 2016). The language of the online questionnaire was Slovak, and it was administrated online using the Google docs form. Before undertaking the online questionnaire, the participants were provided with a brief overview of the research. They were informed that the main aim of the research was to investigate which visual stimuli are perceived by humans as disgusting. After providing informed consent, the participants were asked to provide their age and sex. The online questionnaire took approximately 5–7 min to complete. All the study procedure was approved by the Statutory Ethics Committee of Trnava University.

2.2. Visual stimuli

We developed 48 visual stimuli with the same confederate who helped us create various categories of objects close to the human body (see below). Visual objects were divided into disgusting (edible vs. inedible) and non-disgusting (edible vs. inedible) categories (Table 1). This categorization was based on previous research showing that rotten food (Curtis & Biran, 2001; Tybur et al., 2009), spiders, cockroaches, and caterpillars are considered disgusting (Matchett & Davey, 1991;

Table 1

Categories of visual stimuli used in the research.

	Food	Non-food
Disgusting	Rotten apple Rotten pizza Rotten schnitzel	Garden spider (<i>Araneus diadematus</i>) Oriental cockroach (<i>Blatta orientalis</i>) Turnip moth (<i>Agrotis segetum</i>) ^a
Non-disgusting	Apple Pizza Schnitzel	Lady beetle (<i>Coccinella septempunctata</i>) Firebug (<i>Pyrrhocoris apterus</i>) Western conifer seed bug (<i>Leptoglossus occidentalis</i>)

^a Caterpillar.

Prokop & Randler, 2018), whereas Lady beetles (Prokop et al., 2010) and probably other colourful insects (Prokop & Fančovičová, 2013) are not. Each object listed in Table 1 was photographed in four treatments: 1) close to mouth, 2) in hand, 3) separately 4) close to the foot (Fig. 1). Participants rated perceived disgust of each picture (e.g., How disgusting do you consider this food?) on a 7-point Likert scale (1 = not at all disgusting, 7 = extremely disgusting).

2.3. Statistical analyses

The data were analysed with a Linear Mixed Model (LMM). The disgust score was the dependent variable. Participant identity was introduced as a random effect. Treatment (i.e., positioning of the stimuli near the mouth, hand, foot, or separately), Edibility of stimuli (Food or Non-food), and Disgust (whether the stimuli was a priori considered disgusting or non-disgusting) were introduced as predictors. All analyses were run with the GENLINUX module of IBM SPSS (2019) ver. 26.

3. Results

Departures from normality of residuals and participants' random effects were checked graphically, considering skewness and kurtosis coefficients. Both appeared reasonably symmetrical (residuals: $G1 = 0.04$, random effects: $G1 = -0.32$), and their tails did not depart significantly from those of a normal distribution (residuals: $G2 = -0.18$, random effects: $G2 = -0.32$). Given LMMs appear relatively robust from departures from these assumptions (e.g. Schielzeth et al., 2020), the raw-data were used with no transformation in the model.

3.1. Main effects

The LMM model was significant (Table 2) with a variance of participant's random effect differing significantly from zero ($Z = 11.97$, $P < .001$). Older age was associated with lower disgust sensitivity (estimate = -0.018 , $P < .01$) and females ($M = 4.25$, $SE = 0.02$) were more disgust-sensitive than males ($M = 3.56$, $SE = 0.04$, $P < .001$). The main effect of treatment was significant ($P < .001$), with pairwise comparisons revealing that stimuli placed close to the mouth were rated as being more disgusting than stimuli positioned near the foot ($P < .001$), placed on the hand ($P < .001$) or shown in isolation ($P < .001$, Table 3). In addition, stimuli positioned near the foot were significantly more disgusting compared with those placed on the hand ($P < .001$) and with stimuli presented in isolation ($P < .001$, Table 3). If also significant, the difference between stimuli placed on hand and stimuli placed apart was less salient ($P = .026$). Not surprisingly, disgusting stimuli ($M = 5.02$, $SE = 0.02$) were rated as more disgusting than neutral stimuli ($M = 2.79$, $SE = 0.03$, $P < .001$). Finally, Food stimuli ($M = 3.9$, $SE = 0.03$) were rated similarly disgusting to non-food stimuli ($M = 3.91$, $SE = 0.03$, $P = .605$).

3.2. Interaction terms

Treatment \times Disgusting/Non-disgusting stimuli interaction ($P <$

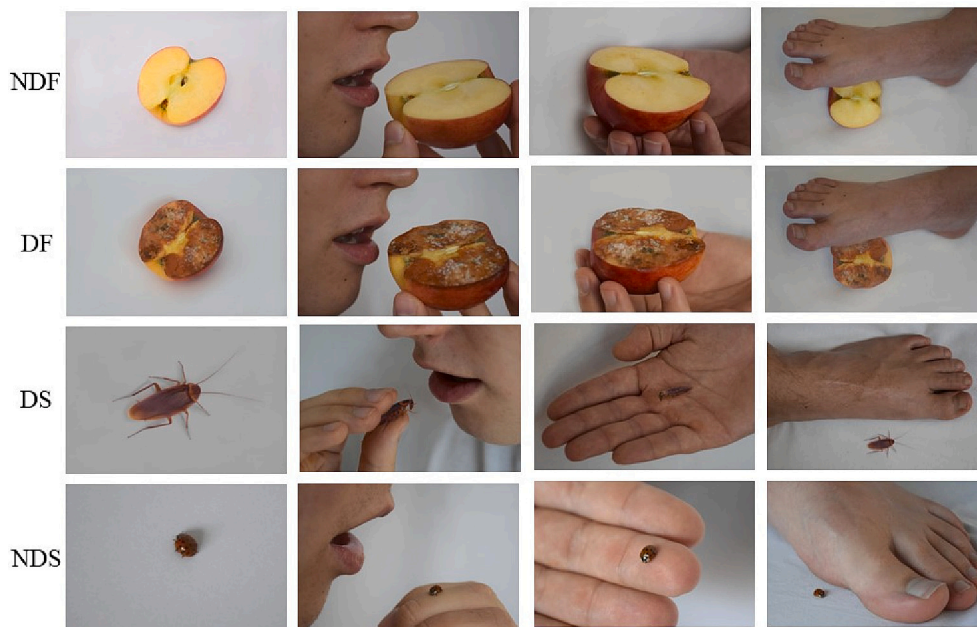


Fig. 1. A subset of the types of non-disgusting food (NDF), disgusting food (DF), disgusting non-food stimuli (DS) and non-disgusting stimuli (NDS) positioned separately, near the mouth, in hand and near the foot (from left to right).

Table 2
LMM on disgust ratings.

	F	df1	df2	P
Age	10.31	1	13,755	.001
Gender	26.47	1	13,755	<.0001
Disgust	4685.04	1	13,755	<.0001
Treatment	244.9	3	13,755	<.0001
Food/non-food	0.268	1	13,755	.61
Gender × disgusting/non-disgusting	12.4	1	13,755	.001
Gender × treatment	6.17	3	13,755	<.0001
Gender × food/non-food	48.09	1	13,755	<.0001
Disgust × treatment	102.49	3	13,755	<.0001
Disgust × food/non-food	826.01	1	13,755	<.0001

Table 3
Disgust ratings of all stimuli (a priori considered disgusting or non-disgusting) positioned near different body parts.

	Mouth	Hand	In isolation	Foot
Mean	4.67	3.66	3.58	4.41
SE	0.04	0.04	0.04	0.04

.001) suggests that disgusting objects were rated as most disgusting when seen near the mouth compared with the other places: hands, feet, or in isolation (all $P_s < .001$) while the differences between these last were reduced (P_s between 0.002 and 0.244). Non-disgusting objects, however, were rated as most disgusting when positioned near the foot (Fig. 2), with a relative low observed difference with those near the mouth ($P < .001$) relatively to the differences appearing with stimuli positioned alone or placed on the hand (both $P_s < .001$).

Treatment × Food/Non-food ($P < .001$) suggests that food stimuli were most disgusting when positioned near the foot ($P < .001$), while non-food stimuli were most disgusting when positioned near the mouth ($P < .001$). One exception was the difference between the Hand and In isolation levels for food stimuli ($P = .661$), but all differences were significant at $P < .001$ (Fig. 3).

Food/Non-food × Disgusting/Non-disgusting stimuli interaction term ($P < .001$) suggests that disgusting food-related stimuli were rated

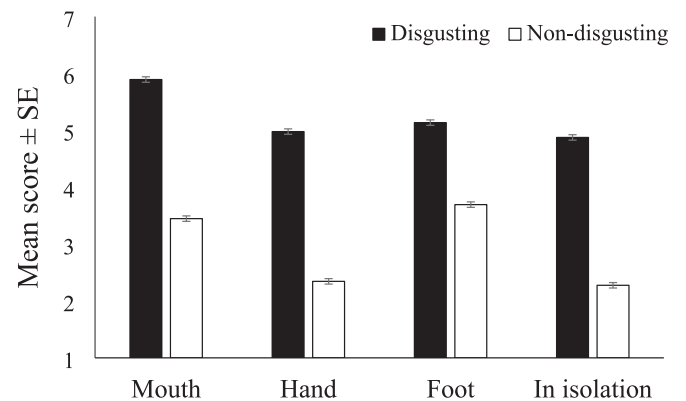


Fig. 2. Disgust ratings of stimuli a priori considered disgusting and non-disgusting across treatments.

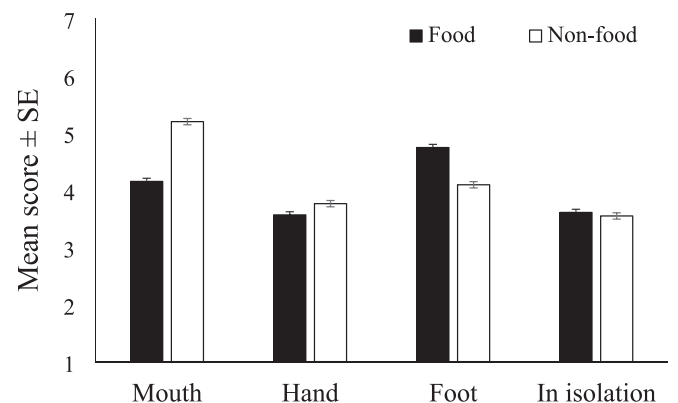


Fig. 3. Disgust ratings of food and non-food stimuli with respect to treatment.

higher than disgusting non-food stimuli ($P < .001$), but the reverse was true for non-disgusting stimuli ($P < .001$): food was rated less disgusting than non-food (Fig. 4).

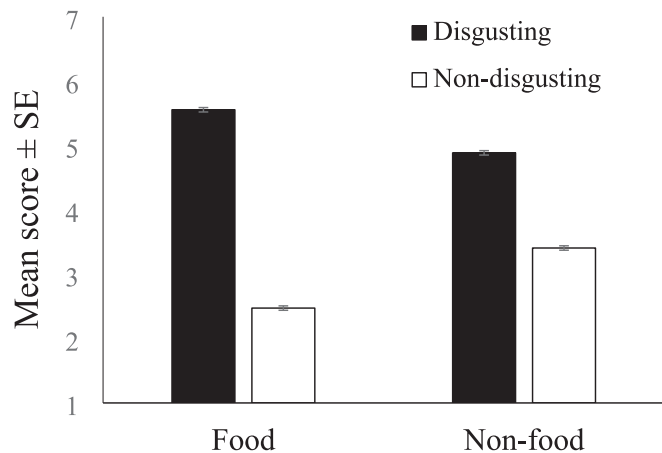


Fig. 4. Disgust ratings of stimuli a priori considered disgusting and non-disgusting with respect to their relatedness to edibility (food vs. non-food).

Gender \times Disgusting stimuli interaction ($P < .0001$) suggests that females rated both disgusting ($M = 5.42$, $SE = 1.34$) and non-disgusting stimuli ($M = 3.08$, $SE = 1.34$) as more disgusting than males (disgusting vs. non-disgusting stimuli, $M = 4.62$, $SE = 1.34$ vs. $M = 2.51$, $SE = 1.34$) (both P s < 0.001), but this gender difference was somewhat more pronounced for disgusting stimuli.

Gender \times Treatment interaction term ($P < .001$) suggests that although females rated all stimuli more disgusting than males (all P s < 0.001), compared to males, the differences between the stimuli positioned near the mouth and foot with the other stimuli were somewhat more pronounced for females.

Gender \times Food/Non-food stimuli ($P < .001$) suggests that females rated non-food stimuli ($M = 4.37$, $SE = 1.34$) more disgusting than food stimuli ($M = 4.13$, $SE = 1.34$), but that the reverse was true for males (non-food stimuli vs food stimuli, $M = 3.46$, $SE = 1.34$ vs. $M = 3.66$, $SE = 1.34$, both P s < 0.001).

4. Discussion

In the present study, we were mainly concerned with the issue of avoidance of oral contamination. Using edible (versus non-edible) stimuli that were disgusting or not (control stimuli), we found that both disgusting and control stimuli positioned near the mouth were perceived as more disgusting than the same stimuli positioned away from the mouth (i.e., presented apart or near the hand). This finding supports the idea that the evolutionary origin of disgust is primarily related to oral contamination (Darwin, 1872/1965; Fančovičová et al., 2022; Rozin et al., 2008; Rozin & Fallon, 1987). Disgusting food items were given higher disgust ratings overall than disgusting non-food stimuli, further supporting the superiority of disgusting food in perceived risk of contamination compared with non-food stimuli (Fančovičová et al., 2022). Interestingly, disgusting non-food stimuli positioned near the mouth were perceived as more disgusting than disgusting food stimuli which also supports the avoidance of oral contamination. Conflicting visual stimuli create a mental association between an emotional distractor (disgusting stimuli) and a neutral target (mouth representing the entrance to the body) (Zimmer et al., 2014) that capture visual attention (Vuilleumier, 2005). Therefore, heightened attention could be responsible for high disgust ratings of potentially invasive disgusting stimuli positioned near the mouth. Taken as a whole, the present findings strongly support the idea that disgust is context-dependent (Elad-Strenger et al., 2020).

One surprising, but interesting, finding is the observation that stimuli positioned near the foot, i.e., furthest from the mouth, were rated almost as disgusting as stimuli shown near the mouth. One significant difference between stimuli positioned near the mouth and foot was that food

stimuli were more disgusting near the foot, and non-food stimuli were more disgusting near the mouth. Foot odour is caused by bacterial metabolism (Caroprese et al., 2009; Tachibana, 1976), thus, an emotional conflict could be contextually integrated differently as it is the case with the mouth. Visual association with the foot can interact with individual experiences with foot odour, and objects positioned near the foot would be considered at risk of being contaminated with foot bacteria. Furthermore, pictures of feet could be easily associated with hygienic disgust (Haberkamp et al., 2017). Food stimuli near the foot were perceived as more disgusting than non-food stimuli, perhaps because their edibility would be reduced after contact with the foot. This phenomenon can be illustrated by the law of contagion (Rozin et al., 1986). Once in contact with a potential source of contamination, a stimulus acquires its (contaminating) properties.

As expected, females had higher levels of disgust than males (Al-Shawaf et al., 2018; Oaten et al., 2009). Recent studies have shown that females are generally more concerned with food-related risks (Niewczas-Dobrowolska, 2022; van der Vossen-Wijmenga et al., 2022), and engage more in food hygiene behaviour than males (Ammann et al., 2019). It worth noticing, however, that our data showed no specific food-related disgust but a greater disgust sensitivity in females, particularly with emotionally conflicting stimuli (objects positioned near the mouth and foot). Overall, these findings support gender-specific concerns about disease contamination (Al-Shawaf et al., 2018; Curtis et al., 2004; Oaten et al., 2009; Tybur et al., 2009). Perhaps using emotionally conflicting stimuli in future research, rather than conventional disgusting stimuli, would be more beneficial for examining evolutionary hypotheses of gender differences in disgust sensitivity.

In conclusion, our study makes a strong theoretical contribution by showing that disgust sensitivity is context-dependent. Inedible stimuli positioned near the mouth—where the risk of pathogen invasion to the body is high—are perceived as more disgusting than disgusting stimuli positioned in places with a low risk of pathogen contamination (on hands or in isolation). In contrast, edible stimuli placed near odour-producing feet are at risk of contamination and are therefore considered more disgusting than inedible stimuli or stimuli positioned in a neutral place.

Informed consent

Informed consent was obtained from all individual participants included in this study.

CRedit authorship contribution statement

Pavol Prokop: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Jana Fančovičová:** Investigation, Resources. **Dominika Šramelová:** Investigation. **Gaëtan Thiebaut:** Conceptualization, Writing – review & editing. **Alain Méot:** Software, Formal analysis. **Patrick Bonin:** Conceptualization, Writing – review & editing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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