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ARTICLE

Does food play a prominent role in visual attention to disgusting stimuli?

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Abstract
Disgust is a basic emotion which protects individuals from potential contamination. It is hypothesized that disgust evolved primarily as a mechanism against oral contamination or as a strategy against disease infections in general. We investigated visual attention to disgusting oral (rotten food) and non-oral (e.g., a tick) and control (e.g., a gull), non-disgusting stimuli using a touch-screen paradigm with a sample of 60 adult participants in Slovakia. We found that disgusting pictures triggered visual attention more than control pictures and that visual attention was not related to an individual's sensitivity to pathogen disgust. Although participants identified disgusting food items quicker than non-disgusting food pictures, these differences did not reach statistical significance. Findings in this study suggest that the evolution of disgust could have been originally favoured by the repulsion of contaminated food, but the benefits from disease avoidance were soon extended to disgust sensitivity to pathogens that threaten our bodies using non-oral entry points.

Keywords Emotion · Evolution · Pathogens · Oral contamination · Food disgust · Visual attention

Introduction

Disgust is a basic emotion that evolved to protect individuals from sources of pathogens (Darwin 1872/1965; Ekman and Friesen 1986; Oaten et al. 2009). Facial expressions of disgust are cross-culturally universal (Ekman and Friesen 2003) and are characterized by movements around the mouth (Ekman & Friesen, 1975; Darwin, 1872/1965; Izard, 1971; Rozin & Fallon, 1987; Chapman et al., 2009; Hoefling et al., 2009). When the body is in in the presence of disgusting stimuli including repulsive tastes, activity of the *levator labii* (Vrana, 1994; Yartz & Hawk, 2002; Hu et al. 1999; Hoefling et al., 2009; Shenhav & Mendes, 2014) and the corrugator s*upercilii* muscles increase (De Jong et al., 2011), the wrinkling of the nose intensifies (Vrana, 1993), and the eye closure and pupil retraction become noticeable (De Jong et al., 2011).

Some researchers suggest that the evolutionary origin of disgust is primarily related to eating (Darwin, 1872/1965; Rozin & Fallon, 1987; Rozin et al., 2008) whereas others argue that disgust evolved as a defence mechanism against disease infection (Plutchik, 1980; Curtis et al., 2004; Tybur et al., 2009) or both (Miller, 2004). For information about the sexual and moral domains of disgust, see Tybur et al. (2009, 2013). The link between infectious diseases and disgust becomes stronger with a greater risk of the presence of pathogens, therefore experiencing disgust in situations involving disgusting stimuli can be interpreted as an indicator of pathogens (Troisi, 2020). Hypotheses put forward on the origin of disgust all have received some empirical support, in part because strong disgust elicitors are primarily bodily fluids and products, animals, poor hygiene, or

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decomposing and rotting organic matter (Tybur et al., 2013). This toxin-based food rejection system, is also called core disgust (Rozin et al., 2008) or pathogen disgust (Tybur et al., 2009, 2013).

Several lines of evidence support the idea that the origin of disgust is associated with food intake (Darwin, 1872/1965; Rozin et al., 2008). Physiological responses to disgust stimuli such as vomiting (Rozin & Fallon, 1987), increased salivation (Angyal, 1941), decreased gastric muscle contraction (Shenhav & Mendes, 2014), tongue muscle inhibition (Vicario et al., 2017) and nose wrinkle, function to get rid of the disgusting agent (Rozin et al., 1994). Moreover, disgust specifically reduces food preferences (Motoki & Sugiura, 2018) and subjective disgust feelings concerning food are stronger than feelings associated with disease (Rohrmann & Hopp, 2008); it is also known that disgust sensitivity is influenced by hunger (Hoefling et al., 2009; Randler et al., 2017) rather than by health status (Prokop et al., 2010; Tybur et al., 2020, but see Cepon-Robins et al., 2021). In general, this posture suggests that individuals should be primarily concerned with food because it is associated with oral intake rather than with non-food objects.

Disgust stimuli capture automatic visual attention (Knowles et al., 2019; Schienle et al. 2016, 2021). For instance, eye-tracking research found that fixations of disgusting pictures were followed by an "hyperscanning pattern," which is characterized by more frequent and shorter fixations as compared to patterns observed with neutral or frightening pictures (Schienle et al. 2016, 2021). Previous research have also reported longer reaction time (resulting from greater attentional fixation) with the detection of a line on disgusting pictures than with fearful and neutral images (Chapman et al., 2013). Stronger attention to disgusting stimuli would therefore favour the ability to remember better disgust elicitors, and as a result, avoid them in the future to prevent contamination (Schienle et al. 2021). It is unclear, however, whether stimuli related to oral contamination (and, thus potentially more harmful for an individual) receive greater attention than disgusting stimuli unrelated to oral contamination.

In this study, we used a touch-screen paradigm, which is commonly used to examine threat detection in children, adults, and even non-human primates (reviewed by LoBue & Matthews, 2014) to determine disgust sensitivity by means of visual attention. We predicted that if disgust is primarily related to eating, then the detection time for disgusting food products should be shorter than the detection time for non-disgusting food products. Alternatively, it is possible that disgust inhibits visual contact, which could ultimately promote behavioural avoidance and prevent contamination (Garcia-Burgos et al., 2017; Armstrong et al., 2020). Under this scenario, we expect attentional bias toward less threatening, non-food stimuli.

Materials and methods

Ethical approval was obtained from the Institutional Board of the Trnava University in conformity with the principles of the Declaration of Helsinki. All participants were advised of the study's aims and provided informed consent before completing the survey.

Participants

The research was carried out in January and February 2020 at a university in Slovakia. Participants included 42 women and 18 men aged 18 to 63 years ($M = 30$, $SE = 1.56$). The participants were recruited online through the university website. Prior to the study, they were informed that their participation was unpaid and voluntary. All participants were Caucasian. Upon the completion of the study, the participants were debriefed on the research goals and purpose.

Research instruments

Paper-and-pencil questionnaires

The researchers contacted the participants by e-mail to give them a schedule for them to choose the date to meet with the research team in the laboratory for testing. Each participant filled out a printed questionnaire dealing with demographic information (gender, age). Next, the participants were instructed to respond to a 14-item, paper and pencil questionnaire measuring pathogen and moral disgust (Tybur et al., 2009). Pathogen disgust (PD) refers to disgust elicitors caused by the sources of various pathogens (e.g., seeing a cockroach). Moral disgust (MD) refers to disgust pertaining to social transgressions (e.g., intentional lying). Answers to the questions were scored using a Likert scale (1 [not at all disgusting] to 5 [extremely disgusting]). Although we were primarily concerned with pathogen disgust (actual Cronbach $\alpha = 0.71$), we also used moral disgust (actual Cronbach $\alpha = 0.74$) to investigate whether visual attention correlates exclusively with pathogen disgust and not with moral disgust (Prokop et al., 2016).

Pictures

A touch-screen method (LoBue & Matthews, 2014) was used to examine visual attention to disgust-generating pictures. Participants were instructed to find the disgusting target among eight threat-irrelevant, neutral distractors (e.g., spoiled food among non-spoiled foods). Following Haberkamp et al., (2017), disgusting targets were colourful objects belonging to six categories of disgusting

stimuli: food, animals, injuries/infections, death, body products, and hygiene. Each category was represented by ten randomly disgusting and ten randomly neutral colourful selected pictures from Haberkamp et al. (2017) (Fig. 1). The list of the items used in the experiment is provided in the electronic supplement.

Procedure

After completing the paper-and-pencil questionnaire, each participant was invited to sit in front of a touch-screen monitor (approximately 40 cm from the base of the screen) and told to place his or her hands on the keyboard. Each participant was then asked to identify and touch as quickly as possible one disgusting object among the five distractors (Fig. 2). Each category had six replications. This means that the participant was asked to find the disgusting animals

Fig. 1 A subset of the types of disgusting (upper row) and neutral (lower row) images used for food (F), animals (A), injuries/infections (I/I), death (D), body products (BP), and hygiene (H) categories

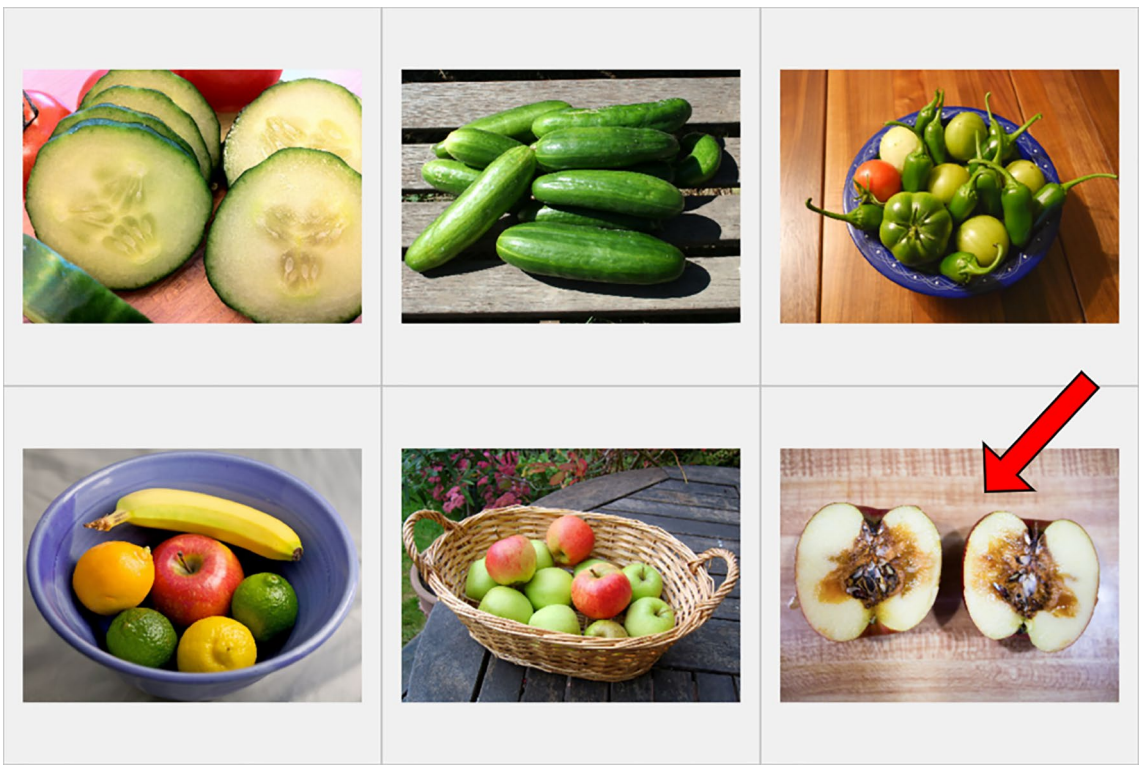

Fig. 2 An example of the single disgusting food (marked with red arrow) item among five neutral foods

Table 1 Results of LMM on reaction time

	F	df1	df2	*p*
Treatment	10.47	5	295	< 0.0001
Sex	1.20	1	55	0.28
Age	3.55	1	55	0.07
PD	1.30	1	55	0.26
MD	2.05	1	55	0.16

Table 2 Results of pairwise contrasts for the food category compared with remaining five categories

	Death	Injuries/infections	Hygiene	Body products	Animals
Food	0.066	0.14	< 0.001	< 0.001	< 0.001

Numbers are *p* values

among 6 trials, which made 36 replicates in total. Further details about the procedure can be found in LoBue and DeLoache (2008). In this phase of the data gathering process, we examined the latency (in seconds) to touch the disgusting stimuli (mean value). We found out that participants correctly recognized disgusting stimuli among distractors at M = 87%, SE = 3.34, therefore we did not further analyse non-correct responses.

Statistical Analyses

Mean of correct latencies to touch disgusting stimuli (mean values from six categories defined as the dependent variable) were analysed with the Linear Mixed Model (LMM). These data were not normally distributed and therefore were Box-Cox transformed to achieve normality. Categorical predictors in the model included (a) treatment, which consisted of disgusting picture categories: food, animals, injuries/infections, death, body products and hygiene, (b) gender, and (c) age and the mean scores from PD and MD as continuous predictors. Participant identification was treated as a random factor. Note that PD and MD did not correlate (Pearson r = 0.15, $p = 0.26$, N = 60) and running the model without one of these measures did not influence the results. Pairwise comparisons between means were done with contrast analysis. All interaction terms were non-significant and therefore removed from the model, at which time the analysis was run again. Note that the model with raw, non-transformed data yielded almost identical results.

Results

The LMM model, with the reaction time as the dependent variable was significant ($F(9,99) = 6.59$, $p < 0.0001$, Tab. 1). Food pictures were identified sooner than other pictures, however the differences were not significant with infection and only marginally significant with death (Tab. 2). With the exception of hygiene pictures, animal pictures were identified significantly later than other disgusting pictures; hygiene and body pictures did not differ significantly (Tab. 2, Fig. 3). Other effects were not significant (Table 1).

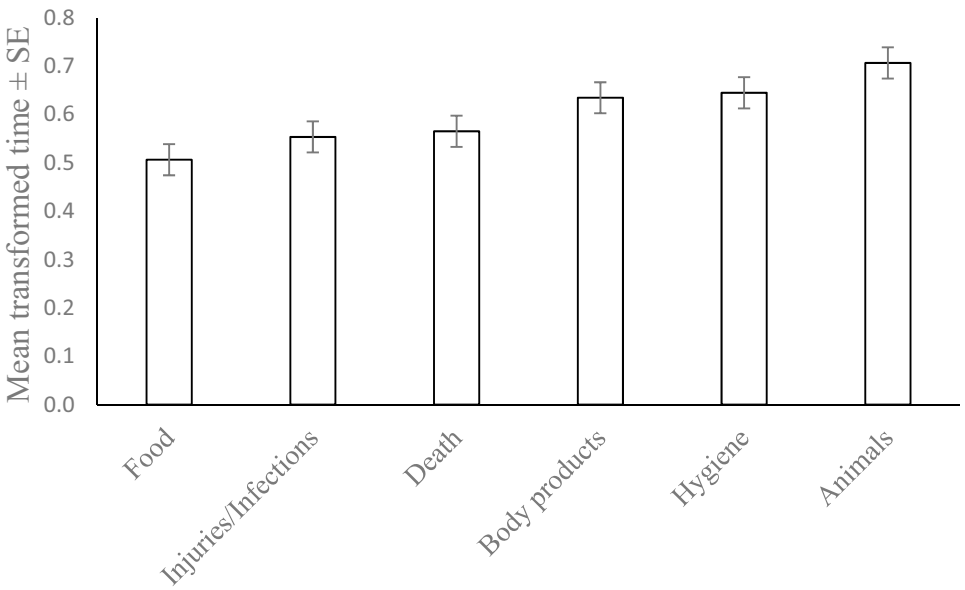

Fig. 3 Average latency in the identification of disgusting stimuli (Box-Cox transformed data)

Discussion

The main contribution this present study makes to the literature is by serving as a mechanism to determine whether oral contamination captures visual attention more than non-disgusting food stimuli and whether these processes are influenced by pathogen avoidance. In line with previous research, we confirmed that disgusting pictures attract visual attention more than neutral stimuli (Ciesielski et al., 2010; van Hooff et al., 2013; Perone et al., 2020). Thus far, there are no other studies in the literature examining the expected superiority of oral contaminants with the use of the touch-screen paradigm.

If disgust evolved as an adaptation to protect the body against oral contaminants (Darwin, 1872/1965; Rozin & Fallon, 1987; Rozin et al., 2008), disgusting foods should capture visual attention more than non-disgusting food stimuli. The rationale for this assumption stems from a high risk of being contaminated orally as compared with other body parts. However, pathogens also use other entry points to our body (skin, anus, and genitals) (Tybur et al., 2013) which suggests that our evolved psychological mechanisms focused on disease avoidance should respond to disease-connoting cues in a hypersensitive way to avoid risk of being contaminated (Schaller & Duncan, 2007; Schaller & Park, 2011). Because the lower energetic costs of prolonged attention to disgusting stimuli apparently outweigh possible benefits such as information regarding the presence of pathogens or edibility of food, it is not surprising that all disgust-generating pictures captured participants' attention more than the control pictures. Furthermore, visual attention to disgusting stimuli was unrelated to sensitivity to pathogen disgust. In their recent study, Perone et al. (2020) also showed that bias toward disgust-eliciting stimuli was stable regardless of an individual's pathogen disgust score or the presence of disgusting olfactory cues.

Although the superiority of visual attention to food disgusting pictures was not reliable, it is notable that these disgusting pictures were descriptively recognized more quickly than pictures from other categories. Additionally, apparent similarities exist between our findings and self-reported disgust of the same categories in the study by Haberkamp et al. (2017). While participants in the Haberkamp's et al. (2017) study reported food pictures as the most disgusting, followed by death, body products, injuries/infection, hygiene, and animals, we found similar visual attention scores (food, followed by injuries/infection, death, body products, hygiene and animals) in our study. Contaminated food seems to be an exceptional trigger of greater fears about oral contamination as compared to contamination through other entry points; this feature may reflect a purposeful ancestral origin of disgust (i.e., oral expulsion of food) (Darwin, 1872/1965; Rozin & Fallon, 1987; Rozin et al., 2008; Vicario et al., 2017). Future research might investigate whether a variety of disgusting stimuli placed near the mouth are thought to be more disgusting than the same stimuli placed on other body parts.

Our alternative hypothesis assumed that disgust motivates avoidance of stimuli associated with potential contamination (Garcia-Burgos et al. 2017; Armstrong et al. 2020). Although our data suggest that contaminated food received stronger attention than other disgusting stimuli, this does not mean that we should discard the alternative hypothesis. Unusual disgusting stimuli capture automatic attention and later repel visual attention with a continued or repeated exposure (Bradley et al., 2015; Armstrong et al. 2020). For instance, Armstrong et al. (2020) reported a strong tendency in the first 2 seconds of the response to visually approach disgusting images, but disgusting stimuli were visually tracked less if the exposure was prolonged and/or repeated. It is suggested that increased attention to disgusting stimuli is motivated by threat detection, and subsequently by avoidance due to increased risk of contamination (Mulckhuyse & Dalmaijer, 2016). Rodents, similarly, initially explore a threatening situation and avoid it only after repeated exposure (Kron et al., 2014). Whether disgusting or non-disgusting stimuli associated with oral contamination are avoided during a prolonged exposure remains to be examined. In the current study, animal pictures received the lowest disgust (cf. Haberkamp et al., 2017) and delayed visual attention scores. This finding can be explained by the relatively lower risk of contamination compared to other disgusting stimuli. Pathogens survive better in environments that provide a source of nutrients (e.g., rotten food, open wounds) rather than in live, albeit disgusting animals (Tybur et al., 2013).

Limitation.

Three limitations of this study include: First, although Haberkamp et al. (2017) selected pictures according to their quality (i.e., sharpness, noise, luminance, contrast, distortion, etc.), their selection did not control for picture brightness, familiarity and complexity. For instance, food category might have been brighter than the other categories and this factor might influence the results (Motoki et al., 2018). Future research should control for these potential confounding factors. Second, visual attention examined with eye-tracking might be a more sensitive measure than touch-screen technique. More accurate and insightful measures for visual attention would be provided by more direct and ecologically valid eye-tracking techniques. The results of the touch-screen method used in this study, however, are still informative, given that they provide support for the superiority of food disgust despite its possible lower sensitiveness as compared to the eye-tracking technique. Third, certain psychologists have suggested that facial expressions are not

universally recognized as originally suggested (Gendron et al., 2014). Further, cross-cultural research is therefore needed to investigate whether the superiority of oral disgust is universal.

To conclude, we found that disgusting stimuli capture visual attention more than control stimuli, however these biases were unrelated to pathogen-avoidance purposes. Although disgusting pictures associated with oral contamination (food) captured visual attention more than non-disgusting food pictures, this difference did not reach statistical significance. Thus, we submit that the evolution of disgust could be originally favoured by the avoidance of contaminated food, and that it was soon extended as a defence mechanism against pathogen infection threatening our bodies from other entry points.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10164-021-00722-1.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no conflict of interest.

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