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# Evidence that disgust evolved to protect from risk of disease

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**Disgust is a powerful human emotion that has been little studied until recently. Current theories do not coherently explain the purpose of disgust, nor why a wide range of stimuli can provoke a similar emotional response. Over 40 000 individuals completed a web-based survey using photo stimuli. Images of objects holding a potential disease threat were reported as significantly more disgusting than similar images with little or no disease relevance. This pattern of response was found across all regions of the world. Females reported higher disgust sensitivity than males; there was a constant decline in disgust sensitivity over the life course; and the bodily fluids of strangers were found more disgusting than those of close relatives. These data provide evidence that the human disgust emotion may be an evolved response to objects in the environment that represent threats of infectious disease.**

**Keywords:** disgust; disease avoidance; adaptation; web survey; sex differences; life-history variation

## 1. INTRODUCTION

Humans feel disgust for items including faeces, vomit, sweat, spit, blood, pus, sexual fluids, wounds, corpses, toenail clippings, rotting meat, slime, maggots, lice, worms, rats and people who are ill; and events such as theft, tyranny and incest (Curtis & Biran 2001; Rozin *et al.* 2000). Disgust is thought to be universal in humans and has an associated facial expression that is recognizable across cultures (Darwin 1872; Ekman & Friesen 1986; Mesquita & Frijda 1992). Its physiological manifestations include lowered blood pressure and galvanic skin response, nausea and actions including stopping, dropping the object of disgust and shuddering or saying 'Eugh!' (Rozin *et al.* 1993, 1994). MRI studies have located a neurological substrate for perceiving facial expressions of disgust in the anterior insula cortex (Phillips *et al.* 1997).

Rozin *et al.* (2000) argue that 'core disgust' relates to the oral ingestion of substances that might cause illness, such as rotten meat. They explain disgust for such things as defecation, corpses, violations of the body envelope and sexual behaviour as symbolic extensions to core disgust. These remind us of our animal nature, and hence of our mortality, and thus cause anxiety.

Some have argued that although disgust evolved to prevent oral ingestion of potentially noxious materials, it also operates to prevent infection from certain animals such as worms and rats (Davey *et al.* 1998) or to prevent non-adaptive sexual pairings (Fessler & Navarette 2003). We have proposed that disgust is an adaptation serving to bias behaviour away from risks of infectious disease in general, not just via the oral route (Curtis & Biran 2001). For example, the bodily excretions and secretions of others are avoided because they can contain high concentrations of bacterial and viral pathogens. These parasitic agents enter the host's body through the nose, skin or sexual organs, as well as by the mouth. All schools of thought agree that disgust has also been extended into the social domain, where it may be elicited by immoral and unjust acts.

The hypothesis that disgust is an adaptation that serves to prevent disease has never, to our knowledge, been quantitatively demonstrated. If disgust did arise to prevent disease then it should: (i) be felt more strongly when faced with a disease-salient stimulus than with a similar stimulus with less salience; (ii) operate similarly across cultures; (iii) be more pronounced in females, since they play a double role in protecting both self and offspring from disease; (iv) become less potent as an individual's reproductive potential declines; and (v) be more strongly evoked by contact with strangers than close relatives, because strangers may carry novel pathogens. We report a test of these predictions using data provided by almost 40 000 participants in an international Web site experiment employing visual stimuli. We argue that the results are consistent with disgust being primarily an adaptation for disease avoidance.

## 2. MATERIAL AND METHODS

A survey instrument was placed on the BBC science Web site (www.bbc.co.uk/science/humanbody/mind/disgust) and advertised at the end of the first part of the documentary on 'Human Instincts' shown on BBC1 on 23 October 2002 in the UK. By 1 March 2003 the test had been completed by over 77 000 people from 165 countries. Those logging-in first answered demographic questions in English concerning their age and sex, the country in which they had spent most of the first 10 years of their life, their occupation and whether they had watched the television programme. Respondents were then asked to rate 20 photographs, which appeared one-by-one on separate web pages, for disgust on a Likert scale of 1–5. All photographs were prepared in collaboration with BBC designers for use with this survey. Randomly placed among the 20 photographs were seven pairs; one depicting a disease-salient stimulus and another matched to be as similar as possible, but without disease relevance.

Data cleaning removed implausible data values (e.g. values of age under 5 or age over 80), duplicate observations (determined by exact matches for all variables), and observations in which all disgust stimuli were coded as 1s (the minimum value) or 5s (the maximum value). This left 71 048 observations. Those who had seen the programme were excluded because they had been exposed to the study hypothesis, which left 39 829 valid responses. (Owing to a computer problem at the BBC, the data concerning sharing a toothbrush were restricted to 30 839 cases tallied by 4 July 2003.) Slightly more females than males took the test (50.3%); 78% of respondents were from Europe (mainly UK), 13% from North America and Canada, 5% from Asia, 2% from Oceania, 2% from Africa and 1% from South America. The majority of participants were aged 17–45 years (75%), while 16% were 16 years and under and 10% were over 45 years. There was a wide spread of occupations; 25% were students, 5% were retired or unemployed, 12% worked in information technology and 8% in healthcare or science. Ethical approval for the study was given by the LSHTM ethics panel.

## 3. RESULTS

Figure 1 shows the seven pairs of photo stimuli with the test population average disgust scores ($\bar{x}$) inset. Figure 1*a* shows the same photograph of a plate of viscous liquid colour-morphed in two ways; one looked like bodily fluids, the other a blue chemical dye. The plate of 'bodily fluid' was scored as 61% more disgusting than the plate of blue slime ($t = 176$; $p < 0.000\,01$). When the person in figure 1*b* was sprayed with a water mist and photo-morphed to


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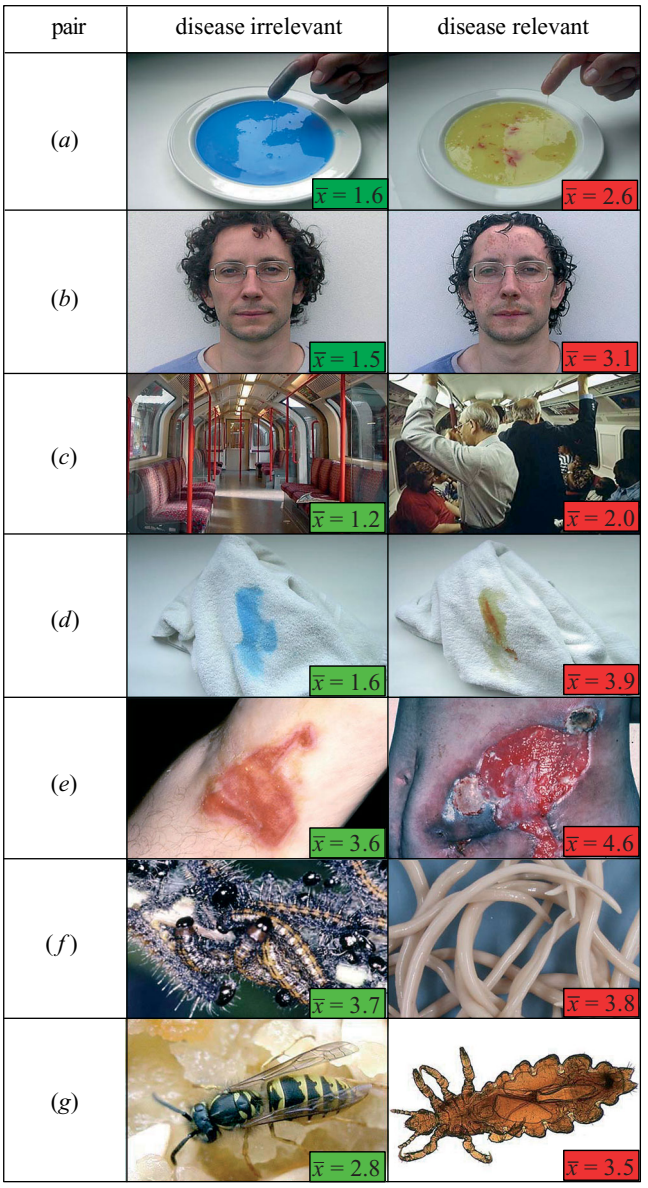


Figure 1. Paired disgust sensitivity stimuli. $\bar{x}$, average disgust scores.

look feverish and spotty-faced, the respondent average disgust score more than doubled, from 1.5 to 3.1 ($t = 248$; $p < 0.000\,01$). In figure 1*c* the addition of people to the empty underground train carriage changed the average disgust scale score from 1.2 to 2.0 ($t = 128$; $p < 0.0001$). The white towel with a blue coloured stain in figure 1*d* was scored half as disgusting, on average, as the same towel with the stain depicted in reddish-yellow, to represent blood and bodily secretions ($t = 365$; $p < 0.000\,01$). Both skin lesions in figure 1*e* were found to be disgusting, but the lesion depicting pus and inflammation was judged significantly more so than the clean burn ($t = 189$; $p < 0.0001$). Figure 1*f* and 1*g* show macroscopic endo- and ectoparasites juxtaposed with similar, non-disease-salient insects. The stimulus matching is less effective in this case, because these species are different with respect to many biologically relevant characteristics, such as dangerousness (Davey *et al.* 1998), and not just disease salience. We nevertheless found the expected pattern, with the louse rated as more disgusting than the wasp and the *Ascaris* worms as more disgusting than the caterpillars ($t = 92$, $p < 0.0001$; $t = 11$, $p < 0.0001$, respectively). Overall, more than 98% of people found the disease-relevant pictures equally, or more disgusting, than their pairs.

When the same pairwise comparisons were made for nine different cultural regions (sub-Saharan Africa; the Middle East and North Africa; Far East; North America; Latin America; Europe; Australasia; the Slavic/Eastern Bloc countries, and the Indian subcontinent), the disease-relevant stimulus was found to be significantly more disgusting than its non-threatening counterpart, with one exception. For six out of the seven pairings in all nine regions, the disease-salient stimulus was rated significantly more disgusting. For the *Ascaris*/caterpillar pair, the *Ascaris* was found significantly more disgusting in Europe and North America, but the relationship was reversed in the Far East, Middle East, Latin America and India, and for sub-Saharan Africa and Australia the difference was not significant. Insects that evoke both disgust and fear have proven difficult to classify in other studies (Davey *et al.* 1998; Fessler & Navarette 2003). Further work should reveal whether the response pattern to disgust-relevant insects varies with the exposure that people have had to different species in different ecological zones. It is also possible that the photograph of the *Ascaris* was simply not recognized for what it was in some countries.

All seven of the disease-salient images were rated as more disgusting by females than males (mean sensitivity: female = 3.5, male = 3.2; two-sample *t*-test with equal variances; $t = 48$, $p < 0.0001$). The difference in score for the disease threat compared with its paired stimulus was also significantly greater for females than males ($t = 26.4$; $p < 0.0001$), suggesting that females are responding more sensitively specifically to disease threats than males. Similar results have been found in previous studies (Haidt *et al.* 1994; Fessler & Navarette 2003). This result is consistent with women's enhanced evolutionary role in protecting the next generation.

Figure 2 illustrates the average ratings of the seven disease-salient pictures by age and sex of respondent. There is a small, but significant, downward trend in the data, corroborating the age-based declines in disgust sensitivity seen in earlier studies (Quigley *et al.* 1997; Fessler *et al.* 2003). The common slope of the sensitivity decrease between sexes (males: $y = -0.0123x + 4.28$; $r^2 = 0.85$; females: $y = -0.012x + 3.99$; $r^2 = 0.86$) is consistent with the general decline in brain reactivity with age as reproductive value diminishes (Harkins 1996; DiGiovanna 2000; Fessler *et al.* 2003).

A final question on the Web site asked respondents to choose with whom they would least like to share a toothbrush. Least acceptable was the postman (59.3%), followed by the boss at work (24.7%), the weatherman (8.9%), a sibling (3.3%), a best friend (1.9%) and the spouse/partner (1.8%). Sharing a person's bodily fluids becomes more disgusting as that person becomes less familiar because strangers are more likely to carry novel pathogens and hence present a greater disease threat to a naive immune system (Anderson & May 1991).

The hypothesis that disgust is an adaptation designed to prevent the acquisition of infectious diseases was thus supported by all of the tests.

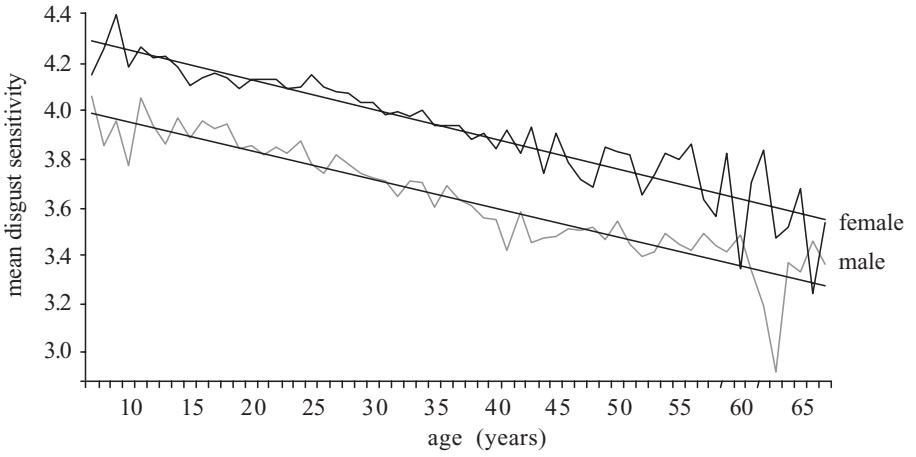


Figure 2. Disgust sensitivity by age and gender.

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