

Review

Why disgust matters

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The new synthesis about disgust is that it is a system that evolved to motivate infectious disease avoidance. There are vital practical and intellectual reasons why we need to understand disgust better. Practically, disgust can be harnessed to combat the behavioural causes of infectious and chronic disease such as diarrhoeal disease, pandemic flu and smoking. Disgust is also a source of much human suffering; it plays an underappreciated role in anxieties and phobias such as obsessive compulsive disorder, social phobia and post-traumatic stress syndromes; it is a hidden cost of many occupations such as caring for the sick and dealing with wastes, and self-directed disgust afflicts the lives of many, such as the obese and fistula patients. Disgust is used and abused in society, being both a force for social cohesion and a cause of prejudice and stigmatization of out-groups. This paper argues that a better understanding of disgust, using the new synthesis, offers practical lessons that can enhance human flourishing. Disgust also provides a model system for the study of emotion, one of the most important issues facing the brain and behavioural sciences today.

Keywords: disgust; obsessive compulsive disorder; disease; behaviour; evolution

1. INTRODUCTION

The premise of the new synthesis about disgust is that it is an adaptive system that evolved to motivate disease-avoidance behaviour [1–7]. It arose in our animal ancestors to facilitate the recognition of objects and situations associated with risk of infection and to drive hygienic behaviour, thus reducing micro- and macro-parasite contact. Sometime in our evolution towards human ultrasociality, disgust took on an extended role—providing a motive to punish antisocial behaviour and to shun the breakers of social rules [8,9]. Disgust is an adaptive system whereby individual responses vary according to an individual's personality and learning experience, as well as by local cultural effects such as norms about manners and the symbolism of pollution and purity [7]. This new synthesis replaces previous conceptions of disgust as, for example, a Freudian means of repudiating desired objects, such as the mother's breast or faeces [10], a psychodynamic balancing mechanism to refuse reminders of our animal nature [6,11,12] or as a social and cultural construction [13,14].

But why, in the end, does it matter that we understand how and why disgust evolved? Disgust impacts on many aspects of our lives, from our individual, domestic, everyday hygiene habits, through our moral choices as members of society, to public policy on issues such as health, justice, social exclusion and warfare. However, possibly because it is the part of our nature that deals with repulsion, disgust has

received scant scientific attention until recently [10]. This special issue demonstrates how disgust is now proving a fertile ground for study by psychologists, zoologists and evolutionary biologists. Beyond the life sciences, it also provides rich matter for the humanities—in the social sciences, in history and classical studies, in politics, jurisprudence and marketing, as well as in the arts.

Clearly, the better we understand how and why disgust evolved and the part that it plays in our natures and in our societies, the better we will advance in all of these fields of intellectual endeavour. Such advances are important in themselves, but they also have practical repercussions. In this paper, I argue that there are three principal practical reasons why we need to better understand the biology of this 'dark side' of our nature.

First, as one of our principal defences against infection, disgust can be harnessed to efforts at improving health. It can be employed in programmes to prevent diarrhoeal diseases, pandemic flu and to aid smoking cessation, for example. Second, disgust has important implications for psychological welfare. It plays a role in obsessive compulsive and post-traumatic stress disorders (OCD and PTSD) and it is part of the emotional cost of caring for the sick, elderly and infirm. Stigmatization and self-directed disgust cause suffering in conditions such as obesity and fistula. Thirdly, disgust is a moral emotion that influences social behaviours. Its role in religion, justice, technological progress, caste, class, xenophobia and the politics of exclusion needs to be better understood if we are to create healthier and more humane societies.

Here I tackle each of these issues in turn and then draw out some of the questions that remain to

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be answered about this powerful but, still poorly understood emotion.

2. DISGUST AND DISEASE CONTROL

The proper domain [15] of disgust is the avoidance of infectious disease [1]. Despite major recent improvements in our understanding of the transmission, prevention and treatment of infectious disease, the problem is still with us. Table 1 presents the major current and recent infectious disease threats to humans. Six conditions cause most deaths: diarrhoeal diseases, acute respiratory tract infections, malaria, measles, HIV and tuberculosis. Parasitic worms including schistosomes, hookworm, ascaris and the nematodes that cause lymphatic filariasis and oncocerciasis still infect one-third of the world's population [16]. Leprosy, polio, smallpox, plague and guinea worm were major causes of death and disability in previous centuries; they are now rare or eradicated, thanks to recent control efforts [17]. Measles, diphtheria and meningitis also cause far less mortality owing to recent advances in vaccination. Newly emerging or re-emerging infections such as Ebola, SARS, West Nile and Rift Valley fevers and pandemic influenza are a major cause for concern, as is the emergence of resistance to antibiotics and antimalarials. Not included in the table are the infections that have also been shown to play a role in many chronic diseases, including cancer, stroke, multiple sclerosis and cardiovascular disease [18].

While medical effort and attention has focused on the pathology of disease, and the search for vaccines and cures, measures to prevent the acquisition of infection in the first place have received less attention. Yet, as the table shows, avoidance behaviour is essential to prevent the spread of all of these conditions [17]. If hygiene is defined as disease-avoidance behaviour [19], then hygienic measures help to defend all of the principal portals of entry to the body. Safe excreta disposal, hand, food and water hygiene prevent the faecal–oral transmission of the diarrhoeal diseases including cholera, salmonellosis, as well as hepatitis A and E, polio and various worm infections. Avoiding sex with infected others helps prevent the transmission of HIV, syphilis and hepatitis B and C. Diseases that use the respiratory route such as tuberculosis, measles, influenza leprosy, diphtheria and respiratory tract infections are harder to prevent, but reducing proximity and contact with the sick hinders airborne transmission and the avoidance of contaminated fomites can help reduce infection risk [20]. Staphylococcal, streptococcal and tetanus infections can be prevented through body surface hygiene, especially by avoiding fluid transfer from and to skin lesions and from fomites. The body surface is also the route of injection of the infectious diseases that are carried by insect vectors, including malaria, onchocerciasis, leishmaniasis, typhus and yellow fever. Here, disease prevention means avoiding insect bites. Other vector-borne infections including rabies and toxoplasmosis can be prevented by avoiding contact with bats, rats, dogs and cats. A number of these infections have multiple routes of infection, especially the diseases of crowding (measles and tuberculosis).

The final column of table 1 picks out items that have been cited as disgusting in various studies [1,2]. There are a variety of disgust elicitors that relate to almost every infectious condition. For the faecal–oral infections, these include faeces, dirty water and contaminated foods; for the skin contact infections, skin lesions; for sexually transmitted diseases, ulcerated genitals and individuals who may be at high risk such as sex workers; for the respiratory infections, respiratory secretions and contaminated materials. Sick people and bodily secretions/excretions occasion disgust as the source of multiple possible infections. We have suggested elsewhere that most disgust elicitors can be incriminated in the transmission of infection from source to host and that this explains why they are found to be disgusting [2]. Those with lower disgust sensitivity are known to suffer from more infectious disease [21], and selective partner choice is an important, but underappreciated, factor in the spread of sexually transmitted infections [22].

Of course, the diseases of recent centuries may not be a perfect proxy for the diseases that shaped the disgust response in our pre-human and human evolutionary history. Diseases with their origins in the domestication of animals or in high-density urban settlement, for example, are thought to be more prevalent now than in ancestral times [23]. Nevertheless, the table shows a general pattern whereby hygienic behaviour with respect to disgust elicitors plays an essential role in the prevention of infection. These behaviours are ancient and ubiquitous, many of them are shared with our animal ancestors [24] and are not contingent on recent scientific knowledge about the behaviour of the agents of infectious disease. Indeed, the idea of contacting or consuming infectious substances such as saliva, faeces or vomit, or of intimate contact with those known to be carrying infection is deeply uncomfortable to even contemplate. Self-limitation of such behaviour is so automatic and intuitive that it is often ignored as the front-line in our defence against disease.

Without disgust and the hygienic behaviours it elicits, then, infectious diseases would cause far more morbidity and mortality in our own—and in all free-living animal—species. (There is one notable exception to this pattern. No disgust elicitor is involved in the insect-vector infections such as malaria and oncocerciasis. Perhaps the adaptive response to a bite is not disgust, but to slap away the offending insect, or, alternatively, perhaps ancestral conditions were such that it was impossible to gain an adaptive advantage from insect bite-avoidance behaviour [1].)

Disgust therefore plays a major role in public health. How can this knowledge be exploited in programmes to control disease? Where disgust reactions are appropriate to modern conditions they can be elicited. In cases where they are inappropriate, efforts can be made at redirection. Further, disgust can also be employed to help improve health beyond the domain of infectious disease.

Take, for example, the diseases that are transmitted via the faecal–oral route. Though the situation is improving, diarrhoeal diseases still kill an estimated 1.5 million children every year [25]. Human faeces are the main source of infection [26]. Evidence suggests

Table 1. Disgust, behaviour and the major causes of infectious disease.

disease	infectious agent	preventive behaviour	disgust elicitor
AIDS	human immunodeficiency virus	safe sex, avoid needle sharing	sexual fluids, body fluids, sickly person
acute respiratory tract infections	<i>Streptococcus pneumoniae</i> , <i>Haemophilus influenzae</i> , <i>Mycoplasma pneumoniae</i>	hand hygiene, respiratory hygiene, surface hygiene, proximity avoidance	nasal mucous, spittle, droplets, coughing, proximity and contact, contaminated fomites
diarrhoeal diseases	over 20 bacterial and viral agents including: <i>Vibrio cholerae</i> , <i>Shigella</i> spp., <i>Salmonella</i> spp., <i>Campylobacter enteritis</i> , <i>Cryptosporidium</i> , <i>Escherichia coli</i>	avoid faecal–oral transmission through hand hygiene, safe water consumption, safe disposal of faeces, safe food hygiene, surface hygiene, restrict animal contact	faeces, spoilt food, dirty water, vomitus, contaminated fomites, contaminated food
diphtheria	<i>Corynebacterium diphtheriae</i>	avoid contact, fabric hygiene	sick person, soiled materials, nasal discharges
lymphatic filariasis	<i>Wucheraria bancrofti</i> , <i>Brugia malayi</i>	avoid being bitten by infected mosquitoes	signs of deformity
hepatitis (viral)	hepatitis A, E virus hepatitis B, C virus	faecal–oral: see diarrhoeal diseases safe sex, avoid close physical contact, avoid shared needles	faeces, dirty water, vomitus, contaminated food and fomites blood, saliva, body fluids
leishmaniasis	<i>Leishmania tropica</i> , <i>Leishmania braziliensis</i> , <i>Leishmania</i> spp.	avoid sandfly bite, destroy vector breeding sites	rubbish heaps
leprosy	<i>Mycobacterium leprae</i>	contentious—avoid direct contact and nasal secretions	sick others, skin lesions, deformity, nasal mucous
malaria	<i>Plasmodium falciparum</i> , <i>Plasmodium ovale</i> , <i>Plasmodium malariae</i> and <i>Plasmodium</i> spp.	avoid being bitten by infected mosquitoes, destroy breeding sites	—
measles	measles virus	isolation	rash, sores, nasal and throat secretions, and soiled items
meningitis	<i>Neisseria meningitides</i> , <i>Streptococcus pneumoniae</i> , <i>Haemophilus influenzae</i> type b (Hib)	avoid direct contact, nasal secretions	contact, nose and throat secretions
onchocerciasis (river blindness)	<i>Oncocerca volvulus</i>	avoid bite of <i>Simulium</i> blackfly, destroy breeding sites	flies
plague	<i>Yersinia pestis</i>	domestic hygiene, clothes hygiene, avoid sick animals	pustules, sick people, exudates, refuse, rats, fleas, sick animals
poliomyelitis	polio virus	faecal–oral: see diarrhoeal disease	faeces, throat secretions, soiled articles
rabies	rabies virus	avoid bite or scratch from infected animal	saliva, infected animal, dog, bat
schistosomiasis	<i>Schistosoma mansoni</i> , <i>Schistosoma haematobium</i> , <i>Schistosoma japonicum</i>	avoid wading into water, urinating in or defaecating near water	snails, stagnant water
smallpox	variola virus	case isolation, contact avoidance	pustules, rash, blood, droplets
staphylococcal skin infections (impetigo, carbuncles, abscesses etc.)	<i>Staphylococcus aureus</i>	skin hygiene, hand hygiene, clothes and toilet items hygiene	skin lesions, weeping sores, nasal discharges, soiled toilet articles
streptococcal infections (tonsillitis, scarlet fever, impetigo, septicaemia, otitis, wound infections, toxic shock, rheumatic heart disease)	<i>Streptococcus pyogenes</i>	hand hygiene, food hygiene, avoid skin contact, lesions	rash, fever, skin lesions, discharges, necrosis, vaginal secretions, respiratory droplets, skin contact, milk, meat

(Continued.)

Table 1. (Continued.)

disease	infectious agent	preventive behaviour	disgust elicitor
syphilis	<i>Treponema pallidum</i>	safe sex	rash, skin lesions, chancre, especially on genitals, exudates, insanity, prostitution
taenia (tape worm)	<i>Taenia solium</i> , <i>Taenia saginata</i>	avoid undercooked beef and pork, sanitation, handwashing	pig, cow, human faeces, worm eggs in meat
tetanus	<i>Clostridium tetani</i>	wound hygiene, safe childbirth practice	soil, dust, human and animal faeces
toxoplasmosis	<i>Toxoplasma gondii</i>	cook meat, wash vegetables, wash hands, avoid cat faeces	cat faeces, soil, dirt on food
tuberculosis	<i>Mycobacterium tuberculosis</i>	respiratory hygiene, minimize close contact, ventilation	nasal mucous, spittle, droplets, stale air, homeless

that handwashing with soap, were it practised globally, could save over a million lives a year, mainly from the infectious enteric diseases [27]. It can also prevent respiratory infections [28], including pandemic flu [20], infectious blinding trachoma [29], AIDS-associated infections [30] and potentially reduce malnutrition [31]. Handwashing with soap is, however, a rare practice. Direct observation showed that only 3 per cent of mothers in Ghana, 4 per cent in Madagascar, 12–14% in China, Tanzania and Uganda and 18 per cent in Kyrgyzstan [32] were washing their hands with soap after using the toilet. In the UK, we found that only 43 per cent of mothers washed their hands with soap after changing a dirty nappy [33] and electronic sensors showed that only 32 per cent of men and 64 per cent of women washed their hands with soap after using a public toilet [34]. Formative research studies into the reasons why people washed their hands found motives that included comfort, nurture, status and attraction. However, disgust at the idea that faecal material might be present on hands was consistently reported as the most powerful motivator of handwashing with soap after going to the toilet [32]. This information was employed in the development of a national handwashing campaign in Ghana. TV and radio commercials were designed to graphically highlight the contamination of hands and to show how invisible matter could be transferred to foods that were being eaten by children [35]. The campaign improved nationally reported rates of handwashing with soap by 13 per cent after the toilet and by 41 per cent before eating [36]. Similar improvements in hand hygiene were achieved in a social marketing campaign in Burkina Faso that used disgust-based messages, amongst others [37]. An image of a bacteria-ridden hand used as a screen saver in a Los Angeles hospital reportedly improved staff handwashing practices dramatically [38].

Disgust has been evoked to promote handwashing in more controlled conditions. Porzig-Drummond *et al.* showed that adding disgust-relevant images to educational films and posters improved handwashing rates above the effect of education alone both in the laboratory and in the public washrooms [39]. Judah *et al.* displayed a variety of messages at the entrance

to a public toilet and found that disgust-based messages such as ‘soap it off or eat it later’ were among the most effective in increasing soap use, especially in men [34].

Disgust featured in the UK Government response to the threat of a pandemic of H1N1 influenza in 2009/2010. The cover image of an information leaflet delivered to every household in the UK (see http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_098680.pdf; [41]) to raise awareness of hand and respiratory hygiene explicitly depicts the aerosol spread of bodily secretions in a sneeze coming directly towards the viewer. Exposure to the campaign material was associated with increases in hygienic behaviour, such as the purchase of antibacterial hand gel, though the specific effect of the disgust component was not explicitly evaluated [29].

Mass media is, of course, not the only source of individual learning about disgust and hygiene. Children throughout the world are socialized into hygiene rules at an early age by parents, family, school and the wider community [7,41]. Children learn to bathe and groom themselves, especially before social interaction, to avoid sharing toilet articles, to avoid wearing night clothes in public, where (and where not) to defecate, to use a handkerchief and to eat ‘politely’ without exchange of bodily fluids. Individuals who do not display continence with their own emanations are regarded as having ‘bad manners’ and are denied the benefits of social interaction [42]. Having well-mannered children is an important aspiration for mothers in most societies [32]. Though the subject has been little investigated, it appears that mothers recruit disgust to teach their children how to behave, pulling disgust faces and making appropriate ‘yuk’ noises as children ‘make messes’. The process is aided by a predisposition or preparedness [43–45] to learn disgust of bodily fluids. The fact that failing to display continence with bodily fluids is socially unacceptable was exploited in a graphic television commercial for the Florida Department of Health, where one character sneezes over food, surface, hands and workmates, causing colleagues to demonstrate their disgust at these lapses in respiratory

manners [46]. In our public toilet study using unobtrusive sensors, we found that rates of handwashing decreased when there were few people in the facility, and the message that had the biggest positive effect was: 'Is the person next to you washing hands with soap?' [34]. Manners are a subject about which almost nothing has been written in the academic press, yet understanding them better might prove fruitful in the quest to prevent the person-to-person spread of infection.

Whilst disgust of nasal emanations and of people who spread them is probably an appropriate and adaptive reaction to the threat of pandemic influenza [47], disgust responses can sometimes be unhelpful to public health. The disgust system operates by the precautionary principle whereby it is better to miss one meal than to run the risk of contracting a life-threatening disease [48,49]. Hence responses can be disproportionate to actual risk. The food industry is regularly affected by contamination scares that can lead to huge, but temporary shifts away from purchasing meat products, eggs or chocolate, for example [50]. The French public reduced their consumption of beef in response to emotive stories in the press about what could happen if you ate 'mad cow' [51]. A study of public reactions to a hypothetical outbreak of pneumonic plague found that people were likely to want to avoid health centres, when attending would have been beneficial to their health [52]. In California, public protestations of disgust have derailed projects for converting wastewater into drinking water [53].

While disgust's proper domain is that of infectious disease, it has also been employed in efforts to tackle other public health problems, most notably smoking. Cessation campaigns have used disgust freely. For example, the British Heart Foundation's most successful media campaign entitled 'Give up before you clog up' graphically depicted the impact of smoking on arteries by showing cigarettes apparently dripping globs of fat [54]. The World Health Organization now recommends the use of graphic images of diseased organs on cigarette packs. A Canadian study showed that the greater the disgust reported at such pictures, the greater the likelihood that participants would have attempted to, or succeeded in, quitting [55].

Disgust appears to have played a role in what Rozin calls the 'moralization' of smoking, which has become disgusting because it has been linked to contamination and disease. Individuals then display strong aversion to even minimal contact with the offensive substance (refusing smokers hotel rooms, for example). Rozin notes, 'when disgust becomes linked to an entity or activity, rejection or avoidance of that activity becomes highly motivated and internalized'. He found that moral reactions to smoking depended more on how disgusting than on how unhealthy it was perceived to be [56]. The modern practice of relegating smokers to the outside of public buildings reinforces the rejection of the disgusting practice and the stigmatization of the individual as antisocial.

Food-related disgust can be employed to combat obesity. In a UK TV show, all of the snack and junk food typically eaten by one school class was piled into one huge disgusting heap to highlight the poor quality

of children's diets [57]. This helped to spur the UK government to improve the quality of school dinners. Variations on this idea, such as graphic displays of the fat and sugar content of common food items, could help to harness disgust to healthy eating campaigns. One could imagine further uses of disgust targeted at obesity or at unsafe sex, for example. However, disgust has to be employed responsibly, as it can encourage moralization and stigmatization, as we have seen.

3. DISGUST AND PSYCHOLOGICAL WELFARE

Disgust is a strong and visceral emotion that can arouse powerful affective and behavioural responses. While the emotion arose to defend against infectious disease, it can also cause maladaptive behaviour, interfering with the ability to lead a normal life. Some problems are associated with pathologies of the disgust system. Others may be due to disgust's 'normal' functioning in the context of an abnormal or novel environment. Further, some professions require the suppression of disgust, which could be regarded as a psychological cost that has to be borne by those individuals—and by society as a whole.

Disgust sensitivity varies from one individual to another along a continuum [58]. We might expect then that individuals at the very high, or very low ends of the spectrum might manifest behavioural problems associated with being too easily or too little disgusted. Those who are too easily disgusted might be predicted to manifest phobias associated with potential disease sources such as other people, body products, sexual organs and by-products, certain foodstuffs and disease-related animals. Those who are, on the contrary, too little disgusted might find difficulty in being accepted into society and in maintaining bodily and domestic hygiene, with implications for their own health and that of their dependants. Unfortunate disgust experiences might also leave unpleasant or debilitating sequelae including post traumatic stress disorder (PTSD).

How far does the evidence bear out these predictions? A number of studies suggest that some forms of obsessive compulsive disorder (OCD) can best be understood as disorders of the disgust system [59]. Up to 50 per cent of OCD patients present with contamination fears [60]. They suffer from intrusive thoughts of contamination and impurity and reduce their distress by excessive sanitation and disinfection of the self and the environment [61]. These patients tend to rate contaminated objects as 'disgusting' rather than 'frightening' [62]. In one memorable experiment, Tolin and colleagues created a chain of contagion where a pencil was touched to a toilet bowl and then wiped on another pencil, and that one onto another in sequence. 'Normal' participants, and those with chronic anxiety, reported diminishing contamination that had largely disappeared by the fourth pencil. However, the OCD patients reported appreciable contamination even beyond the tenth pencil. They described a world of spreading, looming vulnerability where they cannot control the threat of contagion [62]. As OCD occurs along a continuum of severity, it is likely that for every individual who

seeks help, there will be many more borderline individuals who suffer from some form of debilitating contamination anxiety.

It might be expected that contamination anxiety would become more severe when disease reminders become more prevalent, for example, during epidemics [63]. Indeed, contamination fears and washing rituals were exacerbated in OCD patients during the recent H1N1 swine flu pandemic [64]. Planners need to bear in mind the possible social costs of pandemic awareness campaigns and consider the need for additional support services.

As ultrasocial beings, humans depend on others for survival, yet others are also the main source of infectious disease. Overactive disgust responses may play a role in some forms of social phobia. Though most goes unreported, at any one time 4.5 per cent of Americans may be suffering from social phobias and 2.3 per cent from agoraphobia [65]. Symptoms of both include an abnormal unwillingness to venture into crowds and to contact other people. The evidence is equivocal as to whether disgust plays a role—while agoraphobics have heightened disgust sensitivity [66] and agoraphobia is twice as common in women than it is in men (consistent with female disgust sensitivity being higher on average than it is for men [2]), one study found no heightened disgust sensitivity in social phobia (possibly because an instrument measuring only food-related disgust was employed) [66].

A variety of other debilitating specific phobias are also candidates for pathologies of the disgust system. Blood-injection-injury phobia is characterized by extreme aversion to the sight of blood, injuries, or surgical procedures including injections. Sufferers have higher disgust sensitivity, rate disgusting images as more disgusting than controls and display stronger facial expressions of disgust [67]. A variety of small animal and insect phobias are also potentially disgust-related. Animals that have connections with disease and dirt are much more likely candidates for phobias and childhood fears than those that do not (e.g. spiders, rats, worms, maggots, cockroaches and teeming insects [68]). Recent research also suggests that disgust is a stronger predictor than anxiety of spider avoidance [69]. Trichotillomania may also be disgust-related; pulling out skin hairs may be an exaggerated response to the possible presence of ectoparasites in skin—a hypothesis that has some support in the literature [70].

Clinical observation suggests that disgust is a primary feature of eating disorders such as anorexia and bulimia [10]. While some studies have shown correlations between measures of disgust sensitivity and of eating disorders [71,72]), others have failed to find such associations [66,73]. Disgust with the shape of one's own body is often a feature of eating disorders, and indeed obesity does tend to be seen as disgusting [74,75]. Meat is one of the most likely sources of pathogens in food and is also a particular focus of food-related disgust. It is therefore unsurprising that most cultures have taboos about what meats are suitable to eat and many cultures and sub-cultures such as Hindus and vegetarians/vegans reject it entirely [76].

As sexual acts, body parts and products are a focus of disgust, one might expect pathologies of the disgust

system to affect sexual function. Though the problem has been little studied, several authors report that disgust is implicated in undermining sexual arousal and desire [77,78]. De Jong *et al.* [77] present case studies of women who had turned disgust on themselves; associating dirt, disease, fistula and defaecation problems with their vagina which led to an inability to face intercourse.

Disgust may also play a role in the decision to remain celibate. The problem is described by one ex-celibate, the UK broadcaster Stephen Fry:

‘I would be greatly in the debt of the man who could tell me what would ever be appealing about those damp, dark, foul-smelling and revoltingly tufted areas of the body that constitute the main dishes in the banquet of love... .Once under the influence of the drugs supplied by one's own body, there is no limit to the indignities, indecencies, and bestialities to which the most usually rational and graceful of us will sink’ [79].

If the psychological problems we have discussed above are pathologies of the disgust system, then comorbidities are also to be expected. Monteiro *et al.* [80] found that 24 per cent of patients with untreated OCD were virgins and another 9 per cent had not been sexually active for years. Of their 25 patients, seven who reported sexual problems also suffered from extreme shyness, suggesting possible social phobia comorbidity with OCD.

If sexual, social, contamination, blood injury and food-related phobias may, at least partly, be explained as maladaptive disorders of an evolved disease-avoidance system, another class of disgust-related psychological disorders can be classed as adaptive responses to a hostile environment. In particular, it seems that one class of PTSD may result from extreme experiences associated with disgust. Olatunji *et al.* [81] showed that rape victims with PTSD suffer from feelings of dirtiness associated with mental pollution. Victims of childhood sexual abuse and survivors of torture may suffer in similar ways. Dalgleish and Power provide case histories where extremely disgusting events such as encounters with decomposed corpses in war or at work, or biological contaminants in food lead to intrusive thoughts, flashbacks, recurrent nausea, feelings of dirtiness that cannot be removed by washing and other manifestations that can leave patients unable to lead a normal life [82].

If the clinical and subclinical conditions that I have described are indeed disgust system disorders, then practical implications follow. First of all, accurate diagnosis is required, and seeing such problems as potentially disgust-related can help to hone the instruments of diagnosis. Secondly, many of these conditions occur on a sliding scale in the population, and many are associated with shame and an extreme reluctance to disclose or present to health services; hence much suffering goes undiagnosed and unaided. Health workers need to be well-briefed to detect hints of these conditions and to look for comorbidities, for example, for sexual dysfunction in those presenting with OCD. Internet-based support for such conditions may be more acceptable to many than face-to-face interaction [77].

Thirdly, there are many approaches to treatment both through behavioural and drug therapies. A systematic

look at what has worked in each of these conditions through the lens of disgust might reveal effective therapies. For example, we know that cognitive reappraisal is possible. Just as rotting milk can be relabelled as yoghurt and so becomes palatable, de Jong suggests that exercises aimed at reconstructing sexual organs, not as smelly and dirty, but as examples of exquisite design could be effective in reducing sexual phobias [83]. Work is needed to determine whether behavioural therapies such as Exposure with Response Prevention and microbiological experiments demonstrating the lack of organisms on objects perceived to be contaminated [62] are effective. Cognitive behavioural therapy involving habituation to disgust objects and extinction along with the formation of new and positive associations could be used across these phobias, possibly with the addition of cortisol, which has been shown to enhance the consolidation of newly learnt memories [77]. Drug therapies might also focus on the possible implication of serotonin pathways in disgust [84].

Finally, research suggests that the disgust system is made up of a series of components that relate to different types of disease threat (sexual, hygiene, blood-and-guts, food, sick people, animals/insects, etc.; [85]). It seems likely that each type of threat has its own type of phobia. The disgust scales in current use [86–88] are based on psychodynamic conceptions of disgust that predate the new evolutionary synthesis [89] or do not distinguish between types of organic disgust [6]. We are currently preparing a new scale based on the discrete disease-avoidance tasks of disgust which should have more power to help in distinguishing the discrete pathologies of disgust subsystems.

4. THE SOCIAL USES AND ABUSES OF DISGUST

While disgust is the primary means by which individual humans detect and avoid infectious pathogens, the problem is not just an individual one. Parasites tend to specialize in exploiting the particular biochemical and morphological features of their hosts, making parasite transmission most likely between biologically similar organisms. Social animals thus face a conundrum; sociality brings fitness benefits, but at the same time it carries an elevated risk of infectious disease. For an ultrasocial species, such as humans, the problem is more acute, as parasites adapt to take advantage of sustained social proximity and interaction. Individuals have to protect themselves and their kin from parasites that have evolved to take every transmission opportunity. Appropriate disease-avoidance strategies thus include preferring to mix with insiders (ethnocentrism), avoiding outsiders (xenophobia), excluding any individuals that show signs of infection (shunning) or punishing those that behave in ways that may threaten others with disease, by displaying poor hygiene, for example. So as not to be punished or excluded, individuals self-police their own hygiene and social contact behaviour, sometimes turning disgust on themselves (shame). Group norms of hygiene behaviour (manners) may emerge and groups may agree to cooperate on activities that protect the group as a whole (public health). Because disgust is ‘strong magic’ that recognizes an ability to

contaminate by association, it is used to marginalize outsiders to groups (stigmatization) and is employed in ritual and religion to demarcate what is pure and what is polluted. There is some evidence that disgust plays a role in morality, as much anti-social behaviour, as a form of social parasitism, is met with disgust. The workings of disgust as an adaptive system for disease avoidance in social groups have been discussed at length in a recent paper [7]. Here, I am concerned with the practical implications.

There is much evidence that humans tend to shun other individuals that display signs of disease, as do ants, fish [90,91], bullfrogs [92], mice [93], lobsters [94] and chimps [95]. Human faces made up to look sick are found to be more disgusting than healthy counterparts [2]. Individuals perceived to have disabilities or disfigurements automatically activate disease-relevant cognitions, even when perceivers are explicitly aware that these individuals do not harbour contagious diseases [96,97]. A hypervigilant disgust may be triggered implicitly by a range of conditions that may, or may not, be associated with risk of infection, such as epilepsy, mental illness, mental retardation, obesity, skin conditions such as psoriasis, cancer and HIV [98]. People who are more concerned with disease are less likely to have friends with disabilities [99], to dislike obese individuals more [75] and to display implicit ageism [100]. Having a psychology that is hypervigilant to cues as to who might be carrying an infectious illness means that we are particularly sensitive to socially acquired information about who is sick. Power-seeking individuals can exploit this fact. A common tactic for the playground bully, for example, is to label another child as infected or as having ‘cooties’; the victim then suffers shunning by their peer group.

Damaging as this can be to the individuals who are the subject of suspicion, stigmatization extends the problem of the labelling of individuals as diseased to whole groups. Out-groups, already a subject of suspicion because they could be carrying novel infections to which the in-group has not previously been exposed [1], can be especially easily labelled as disease carriers. A body of work has recently emerged that links parasite stress to assortative sociality (reviewed by Fincher & Thornhill [101]). Cultural groups that have historically faced high rates of parasite stress tend to be more xenophobic, have stronger family ties, and have more languages, ethnic groups and religions. There are a number of possible explanations for why this may be the case and confounding factors cannot be ruled out. However, it is clear that, throughout history, in-groups have been able to bolster groupishness by labelling members of out-groups as polluting, dirty, unhygienic, disease-carriers, so justifying caste and class divisions, cruelty, exploitation, pogroms, ethnic cleansing, genocide and war [102]. Such problems persist globally because the old tricks still work. The powerful continue to exploit our inherent tendencies to cleave to the in-group in the face of a disease threat from the outside. Intercommunal violence and discussion of immigration hence peak at election times [103,104].

Because access to social life is so fundamental to our species, we are predisposed to learn not to inflict our own infectious emanations on others. We learn ‘good

manners' early; covering our mouths when we cough and respecting designated defaecation locations, for example [7]. Failures in this department lead to a feeling of shame. Shame also leads those with conditions that they perceive as possibly infecting and hence repulsive to others to sequester themselves. Acne can cause shame and poor self image [105], and fistula can lead sufferers to remove themselves from the society for fear of causing offence [106]. Incontinence sufferers feel humiliated, as one doctor recounted from his own experience:

To lay in bed, and against all physical rules, and I may say psychological rules as well, and do what you normally do at the toilet was a humiliating experience of the helplessness patients feel when help with basic functions is needed. Why did I never question this part of caring when I worked as a doctor? For us, defaecation was only an abstract category in the patient's medical record [107].

A common fear among terminally ill people is that of losing control over their physical functions. Isaksen [108] suggests that this fear is based on becoming 'dirty' and hence 'untouchable' because of the fears that bodily fluids evoke in others. While the old, the frail, the sick and the disabled, who have to hand their body care to others, fear the disgust that they may occasion, overcoming revulsion of body products is one of the issues faced by carers. When the carer is a partner, this can put an extreme stress on the relationship [109] and is part of the, often unrecognized, emotional cost of caring [110].

Like the sick, carers face a double whammy, in having not just to deal with the products of sickness but with social stigmatization. Individuals whose work involves contact with body products, hair, feet, sewage, used clothes, wastes and dead bodies tend to be poorly rewarded and suffer low status, perhaps because the nature of the work is perceived to contaminate the individual. Though common throughout the world, it is in the Hindu caste system where such occupational pollution is most visible—and damaging—despite recurrent efforts at reform [111]. Those that campaign against abortion, homosexuality and genetically modified foods exploit the imagery and language of disgust and its ability to contaminate; they employ pictures of aborted foetuses, talk of 'dirty' sexual practices and raise the spectre of 'Frankenfoods'. By labelling the outsider as dirty and diseased, racists and nationalists find that they can also, to some extent, recruit morality to their side [112]. The best defence against such manipulative tactics is first, to understand what is happening, and second, to expose such strategies to the light of public revulsion.

Although disgust plays a key role in protecting us from disease, it is also responsible for much human suffering. Our evolved psychological defences against parasites are a double-edged sword. On the one hand, they provide the first line of defence against infection in social interaction. But at the same time they prevent social interaction, often at a time when it is most needed. Individuals who are sick or who have become contaminated by association, real or imagined, find themselves the subject of involuntary

disgust reactions from others, facing disdain, suspicion and sometimes exclusion. Unscrupulous individuals make political capital from blaming and stigmatizing victims and the groups to which they belong, and the victims often turn blame and disgust on themselves.

What can be done to prevent or reverse this unhappy cycle? The recent story of the response to the HIV pandemic holds lessons that give some cause for optimism. First, irrational fears of contamination were, in early days, recognized as a factor in the social response to the disease and the public was educated that victims were not contagious and did not pose a threat to the general population [113]. Groups that were particularly affected, such as homosexuals and sex workers, recognized that a process of stigmatization was underway and organized attempts to combat it. They refused collective stigma by declaring their individuality, for example through artistic productions such as plays, films, literature and events [114]. They supported one another to publicly refuse to accept shame and self-blame. Political activists, patients, academics and health professionals worked together to change public opinion about HIV and AIDS [115]. While the problem has not been fully solved—those living with HIV still suffer from stigma, exclusion and sometimes violence—the public debate and the political response did much to reduce the suffering of the affected and, beyond this, to raise general awareness of the social effects of infectious disease.

5. MORAL DISGUST

There are a number of lines of argument that link disgust to our implicit sense of morality. Antisocial acts and individuals are often labelled as disgusting [1], similar physiological and brain activation has been observed in moral and biological disgust [9,116] and a number of studies have suggested that physiological disgust can affect moral judgement [117–119], though doubt has been cast on some of these findings [120]. While the link between disgust and morality needs further exploration, disgust clearly plays a major and visceral role in our response to wrongdoing, exploitation and injustice. We asked teenagers at one UK school to list what they found to be morally disgusting; of several hundred examples the most common were rape, racism, killing, murder, torture, bullying, paedophilia, discrimination, necrophilia, genocide, exploitation, incest, theft, bestiality and cannibalism. Several authors have made a start on unpicking the nature of the relationship [1,6,121]—is it an exaptation of an ancient system designed to distance ourselves from parasites, turned to the function of ostracizing social parasites? Is it purely metaphorical? Or is disgust elicited because many of these offences involve bodily fluids? Whatever the explanation, there is no doubt that the emotion of disgust plays a major role in our decision-making about what is right and wrong. Nussbaum, for example, describes how the rhetoric of disgust influences judgement in the legal system. She argues that we should distrust our disgust responses, because they can lead to prejudice and discrimination [122]. While this may indeed be the case, Nussbaum fails to acknowledge that disgust also plays a

major part in our ability to distinguish right and wrong—an ability which underpins our ability to function in ultrasocial groups. To outlaw disgust in moral judgement would be akin to throwing the baby out with the bathwater. As Leon Kass [123] has argued, there is ‘wisdom in repugnance’. Moral disgust is one of the major positive forces that builds, maintains and polices the cooperative societies in which we have to live to thrive. Understanding disgust’s part in the morality puzzle remains a major task for social scientists—one that could offer important cues for the ways in which we make social policy.

6. CONCLUSIONS

Disgust is a powerful emotion that plays an underappreciated part in all of our lives, not just in our everyday hygiene habits and in our manners, but in our response to disease, to social hierarchy, to those who are different from ourselves and to immorality. Disgust is a double-edged sword that is both the first line of defence against disease, but also a cause of much human suffering. Throughout this paper, I have argued that it is vital that we shine a spotlight into this less-explored darker recess of our psychology. Doing so allows us to enhance our abilities at disease prevention, to deal with many of our commonest anxieties and phobias better and to combat the many prejudices that plague human social relations. It may even help us to understand how to build more cooperative societies.

Understanding disgust matters, both in itself, and for the practical consequences that stem from understanding. Understanding the function of the brain is possibly the most important intellectual challenge faced by scientists today. Emotions remain a contested subject in psychology with little agreement as to what they are, how they should be characterized, how they should be studied, even as to how many there are [124–126]. If disgust is an example of an emotion, then the new synthesis suggests that other emotions should have similar features. They should all have an adaptive purpose, an ancestral animal history, a set of cues that engage emotive processes and a set of typical behaviours, which may or may not be adaptive in the current environment [124]. Though they may have associated feelings, this is not definitive of an emotion. Disgust provides a rich test bed and a prototype for emotion studies.

On the practical side, we have seen that understanding disgust has many benefits. Understanding disgust as a disease-avoidance mechanism can help us to change the behaviours that cause infection and chronic disease. Understanding how disgust tends to err on the ‘safe side’ helps to explain why exclusion of the sick, the old, the lower caste and the different is still so common and shows us that social movements can refuse such prejudice—even labelling it disgusting—as witnessed by the fact that the kids of today now find racism and homophobia disgusting. Understanding how individuals exploit disgust’s ability to contaminate and spoil in their own quest for power can help us to expose such strategies.

If understanding is the key to action, then yet more understanding is needed. The new synthesis that

disgust is an adaptive system for infectious disease control has yet to be fully taken on board in the brain and behavioural sciences. Evolutionary theory offers a new means of integration of studies of brain architecture, neurochemistry and pathology, and of individual, social and cultural behaviour. The theory base for such work is vital—it provides both conceptual unity for prediction and a means for interpreting results. Theory should also inform the tools of such work—if psychological constructs are incorrectly conceived of, then the tools that are used to try to measure them will fail, giving false or misleading results. A key priority is the development of better measures of disgust. An early task for such tools is to use them to explore the relationship between subtypes of disgust and pathological phobias and anxieties.

Further work is needed to elucidate the developmental pathways of disgust and to explore how predispositions interact with social norms to create manners, the first line of defence against interpersonal infection and a possible evolutionary precursor of morality. The origins of the human ability to live in ultrasocial groups is one of the hottest topics in evolutionary biology today [127–129]. Disgust provides a key thread that may help us to unravel this problem.

Disgust studies, however, face the same problem of repulsion that they confront. Olatunji searched the published literature and found 10–20 times more papers per year on anger and fear than on disgust [67], perhaps owing to its lack of attractiveness when compared with other emotions. A similar problem afflicts public health. Though diarrhoeal diseases are the number two killer of children in the world today, they still attract only a fraction of the research funds that go to malaria or HIV, for example [16,130]. Lack of sanitation and hygiene are among the biggest culprits, yet it is hard to attract students to carry out studies of the faecal–oral transmission of infection, or on how to meet 40 per cent of the planet’s urgent need for sanitation. A recent review found that menstrual hygiene had been comprehensively ignored in health research. Our group is devoting efforts to finding ways of making sanitation sexy, setting-up events such as the ‘Golden Poo Awards’ for example. Artistic exploration of the disgusting such as the Wellcome Trust’s season on ‘Dirt’ and the ‘Grossology’ exhibitions that tour the world, help to attract interest and expose disgust to the light of day. Such efforts are beginning to pay off in terms of increased research funding.

Disgust is a voice in our heads, it is the voice of our ancestors telling us to avoid infectious disease and social parasites. The voice of emotion is there for a reason, it guides us to behave in ways that are good for our genes, or more precisely, to behave in ways that were good for the genes of our ancestors. But we no longer live in the environments in which we evolved, and emotion is not the only voice in our heads. We have also evolved an executive brain which can listen to reasoned argument, weigh outcomes, learn from experience in new environments, and from science, and which can override emotional responses when the long-term benefits may outweigh

the short-term gain [124]. Disgust is a vital force in our lives, we need to listen to it, to act on it and sometimes we need to over-ride it. Above all we need to understand it.

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REFERENCES

- Curtis, V. & Biran, A. 2001 Dirt, disgust, and disease: is hygiene in our genes? *Perspect. Biol. Med.* **44**, 17–31. (doi:10.1353/pbm.2001.0001)
- Curtis, V., Aunger, R. & Rabie, T. 2004 Evidence that disgust evolved to protect from risk of disease. *Proc. R. Soc. B* **271**(Suppl. 4), S131–S133. (doi:10.1098/rsbl.2003.0144)
- Fessler, D. M. T., Eng, S. J. & Navarrete, C. D. 2005 Elevated disgust sensitivity in the first trimester of pregnancy: evidence supporting the compensatory prophylaxis hypothesis. *Evol. Hum. Behav.* **26**, 344–351. (doi:10.1016/j.evolhumbehav.2004.12.001)
- Schaller, M. & Duncan, L. A. 2007 The behavioral immune system: its evolution and social psychological implications. In *Evolution of the social mind: evolutionary psychology and social cognition* (eds J. P. Forgas, M. G. Haselton & W. von Hippel), pp. 293–307. New York, NY: Psychological Press.
- Oaten, M., Stevenson, R. J. & Case, T. I. 2009 Disgust as a disease-avoidance mechanism. *Psychol. Bull.* **135**, 303–321. (doi:10.1037/a0014823)
- Tybur, J. M., Lieberman, D. & Griskevicius, V. 2009 Microbes, mating, and morality: individual differences in three functional domains of disgust. *J. Pers. Soc. Psychol.* **97**, 103. (doi:10.1037/a0015474)
- Curtis, V., de Barra, M. & Aunger, R. 2011 Disgust as an adaptive system for disease avoidance behaviour. *Phil. Trans. R. Soc. B* **366**, 389–401. (doi:10.1098/rstb.2010.0117)
- Haidt, J., Rozin, P., McCauley, C. & Imada, S. 1997 Body, psyche, and culture: the relationship of disgust to morality. *Psychol. Develop. Soc.* **9**, 107–131. (doi:10.1177/097133369700900105)
- Chapman, H., Kim, D., Susskind, J. & Anderson, A. 2009 In bad taste: evidence for the oral origins of moral disgust. *Science* **323**, 1222–1226. (doi:10.1126/science.1165565)
- Phillips, M. L., Senior, C., Fahy, T. & David, A. S. 1998 Disgust—the forgotten emotion of psychiatry. *Br. J. Psychiatry* **172**, 373–375. (doi:10.1192/bjp.172.5.373)
- Rozin, P., Haidt, J. & McCauley, C. 2008 Disgust. In *Handbook of emotions* (eds M. Lewis, J. Haviland Jones & L. Feldman-Barrett), pp. 757–776, 3rd edn. New York, NY: Guilford Press.
- Fessler, D. M. T. & Navarrete, C. D. 2005 The effect of age on death disgust: challenges to terror management perspectives. *Evol. Psychol.* **3**, 279–296.
- Douglas, M. 1966 *Purity and danger: an analysis of the concepts of pollution and taboo*. London, UK: Routledge and Kegan Paul.
- Miller, W. I. 1997 *The anatomy of disgust*. Cambridge, MA: Harvard University Press.
- Sperber, D. 1996 *Explaining culture: a naturalistic approach*. Oxford, UK: Blackwell.
- Hotez, P. J. *et al.* 2006 Helminth infections: soil-transmitted helminth infections and schistosomiasis. In *Disease control priorities in developing countries*, pp. 467–482, 2nd edn. New York, NY: Oxford University Press.
- Heymann, D. 2008 *Control of communicable diseases manual*, 19th edn. Washington, DC: American Public Health Association.
- Cochran, G. M., Ewald, P. W. & Cochran, K. D. 2000 Infectious causation of disease: an evolutionary perspective. *Perspect. Biol. Med.* **43**, 406–448.
- Curtis, V. 2007 Dirt, disgust and disease: a natural history of hygiene. *J. Epidemiol. Commun. Health* **61**, 660–664. (doi:10.1136/jech.2007.062380)
- Jefferson, T., Foxlee, R., Mar, C. D., Dooley, L., Ferroni, E., Hewak, B., Prabhala, A., Nair, S. & Rivetti, A. 2008 Physical interventions to interrupt or reduce the spread of respiratory viruses: systematic review. *Br. Med. J.* **336**, 77–80. (doi:10.1136/bmj.39393.510347.BE)
- Stevenson, R. J., Case, T. I. & Oaten, M. J. 2009 Frequency and recency of infection and their relationship with disgust and contamination sensitivity. *Evol. Hum. Behav.* **30**, 363–368. (doi:10.1016/j.evolhumbehav.2009.02.005)
- Donovan, B. 2000 The repertoire of human efforts to avoid sexually transmissible diseases: past and present. Part 1: strategies used before or instead of sex. *Sex. Transm. Infect.* **76**, 7–12. (doi:10.1136/sti.76.1.7)
- Diamond, J. 1997 *Guns, germs and steel*. London, UK: Jonathan Cape.
- Curtis, V. 2007 A natural history of hygiene. *Can. J. Infect. Dis. Med. Microbiol.* **18**, 11–14.
- Boschi-Pinto, C., Velebit, L. & Shibuya, K. 2008 Estimating child mortality due to diarrhoea in developing countries: a meta-analysis review. *Bull. WHO* **9**, 710–717.
- Curtis, V. A., Cairncross, S. & Yonli, R. 2000 Domestic hygiene and diarrhoea, pinpointing the problem. *Trop. Med. Int. Health* **5**, 22–32. (doi:10.1046/j.1365-3156.2000.00512.x)
- Curtis, V. & Cairncross, S. 2003 Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infect. Dis.* **3**, 275–281. (doi:10.1016/S1473-3099(03)00606-6)
- Rabie, T. & Curtis, V. 2006 Handwashing and risk of respiratory infections: a quantitative systematic review. *Trop. Med. Int. Health* **11**, 269–278. (doi:10.1111/j.1365-3156.2006.01568.x)
- Emerson, P. M., Cairncross, S., Bailey, R. L. & Mabey, D. C. W. 2000 A review of the evidence for the ‘F’ and ‘E’ components of the SAFE strategy for trachoma control. *Trop. Med. Int. Health* **5**, 515–527. (doi:10.1046/j.1365-3156.2000.00603.x)
- Huang, D. & Zhou, J. 2007 Effect of intensive handwashing in the prevention of diarrhoeal illness among patients with AIDS: a randomized controlled study. *J. Med. Microbiol.* **56**, 659–663. (doi:10.1099/jmm.0.46867-0)
- Humphrey, J. H. 2009 Child undernutrition, tropical enteropathy, toilets, and handwashing. *Lancet* **374**, 1032–1035. (doi:10.1016/S0140-6736(09)60950-8)
- Curtis, V., Danquah, L. & Aunger, R. 2009 Planned, motivated and habitual hygiene behaviour: an eleven country review. *Health Educ. Res.* **24**, 655–673. (doi:10.1093/her/cyp002)
- Curtis, V. A., Biran, A., Deverell, K., Hughes, C., Bellamy, K. & Drasar, B. 2003 Hygiene in the home: relating bugs to behaviour. *Soc. Sci. Med.* **57**, 657–672. (doi:10.1016/S0277-9536(02)00409-4)
- Judah, G., Aunger, R., Schmidt, W. P., Michie, S., Granger, S. & Curtis, V. 2009 Experimental pretesting of hand-washing interventions in a natural setting. *Am. J. Public Health* **99**, S405–S411. (doi:10.2105/AJPH.2009.164160)

- 35 Lintas, L. 2004 Truly clean—mothers. See <http://www.globalhandwashing.org/multimedia>.
- 36 Scott, B., Schmidt, W., Aunger, R., Garbrah-Aidoo, N. & Animashaun, R. 2007 Marketing hygiene behaviours: the impact of different communications channels on reported handwashing behaviour of women in Ghana. *Health Educ. Res.* **22**, 225–233.
- 37 Curtis, V., Kanki, B., Cousens, S., Diallo, I., Kpozehouen, A., Sangaré, M. & Nikiema, M. 2001 Evidence for behaviour change following a hygiene promotion programme in West Africa. *Bull. WHO* **79**, 518–526.
- 38 Dubner, S. J. & Levitt, S. D. 2006 Selling soap: the Petri-dish screen saver. *The New York Times*, 24 September 2004.
- 39 Drummond, R. P., Stevenson, R., Case, T. & Oaten, M. 2009 Can the emotion of disgust be harnessed to promote hand hygiene? Experimental and field-based tests. *Soc. Sci. Med.* **68**, 1006–1012. (doi:10.1016/j.socscimed.2009.01.013)
- 40 NHS 2009 *Important information about swine flu*. London, UK: NHS Scotland, NHS Wales, Department of Health, Social Services and Public Safety.
- 41 Stevenson, R. J., Oaten, M. J., Case, T. I., Repacholi, B. M. & Wagland, P. 2010 Children's response to adult disgust elicitors: development and acquisition. *Dev. Psychol.* **46**, 165–177. (doi:10.1037/a0016692)
- 42 Curtis, V., de Barra, M. & Aunger, R. 2011 Disgust as an adaptive system for disease avoidance behaviour. *Phil. Trans. R. Soc. B* **366**, 1320. (doi:10.1098/rstb.2010.0002)
- 43 McNally, R. J. 1987 Preparedness and phobias. *Psychol. Bull.* **29**, 91–94.
- 44 Ohman, A. & Mineka, S. 2001 Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychol. Rev.* **108**, 483–522. (doi:10.1037/0033-295X.108.3.483)
- 45 Seligman, M. E. P. 1971 Phobias and preparedness. *Behav. Ther.* **2**, 307–320. (doi:10.1016/S0005-7894(71)80064-3)
- 46 Florida Department of Health 2009 *Talk to the fifth guy*. See <http://www.5thguy.com/coveringcoughs.htm>
- 47 Schmidt, W. & Curtis, V. 2011 *Hand and respiratory hygiene for influenza control in the general population*. London, UK: London School of Hygiene and Tropical Medicine.
- 48 Nesse, R. M. 2005 Natural selection and the regulation of defenses: a signal detection analysis of the smoke detector principle. *Evol. Hum. Behav.* **26**, 88–105. (doi:10.1016/j.evolhumbehav.2004.08.002)
- 49 Haselton, M. G. & Nettle, D. 2006 The paranoid optimist: an integrative evolutionary model of cognitive biases. *Pers. Soc. Psychol. Rev.* **10**, 47–66. (doi:10.1207/s15327957pspr1001_3)
- 50 Knowles, T., Moody, R. & McEachern, M. G. 2007 European food scares and their impact on EU food policy. *Br. Food J.* **109**, 43–67. (doi:10.1108/00070700710718507)
- 51 Sinaceur, M., Heath, C. & Cole, S. 2005 Emotional and deliberative reactions to a public crisis mad cow disease in France. *Psychol. Sci.* **16**, 247–254. (doi:10.1111/j.0956-7976.2005.00811.x)
- 52 Rubin, G., Amlot, R., Rogers, M., Hall, I., Leach, S., Simpson, J. & Wessely, S. 2010 Perceptions and reactions with regard to pneumonic plague. *Emerg. Infect. Dis.* **16**, 120–122. (doi:10.3201/eid1601.081604)
- 53 Schmidt, C. 2008 The Yuck factor: where disgust meets discovery. *Environ. Health Perspect.* **116**, A524–A527. (doi:10.1289/ehp.116-a524)
- 54 British Heart Foundation 2003 See <http://www.youtube.com/watch?v=cDAN7Oie2e0>
- 55 Hammond, D., Fong, G. T., McDonald, P. W., Brown, S. & Cameron, R. 2004 Graphic Canadian cigarette warning labels and adverse outcomes: evidence from Canadian smokers. *Am. J. Public Health* **94**, 1442–1445. (doi:10.2105/AJPH.94.8.1442)
- 56 Rozin, P. & Singh, L. 1999 The moralization of cigarette smoking in America. *J. Consum. Behav.* **8**, 321–337.
- 57 Gilbert, G. 2005 *Jamie's school dinners*. UK (channel 4; p. 48 minutes).
- 58 Olatunji, B. O. & Broman-Fulks, J. J. 2007 A taxometric study of the latent structure of disgust sensitivity: converging evidence for dimensionality. *Psychol. Assess.* **19**, 437–448. (doi:10.1037/1040-3590.19.4.437)
- 59 Olatunji, B. O., Lohr, J. M., Sawchuk, C. N. & Tolin, D. F. 2007 Multimodal assessment of disgust in contamination-related obsessive-compulsive disorder. *Behav. Res. Ther.* **45**, 263–276. (doi:10.1016/j.brat.2006.03.004)
- 60 Rasmussen, S. & Eisen, J. 1988 Clinical and epidemiologic findings of significance to neuropharmacologic trials in OCD. *Psychopharmacol. Bull.* **24**, 466–470.
- 61 Rachman, S. 2004 Fear of contamination. *Behav. Res. Ther.* **42**, 1227–1255. (doi:10.1016/j.brat.2003.10.009)
- 62 Tolin, D. F., Worhunsky, P. & Maltby, N. 2004 Sympathetic magic in contamination-related OCD. *J. Behav. Ther. Exp. Psychiatry* **35**, 193–205. (doi:10.1016/j.jbtep.2004.04.009)
- 63 Rubin, G. J., Amlot, R., Page, L. & Wessely, S. 2009 Public perceptions, anxiety and behavioural change in relation to the swine flu outbreak: a cross-sectional telephone survey. *Br. Med. J.* **339**, b2651. (doi:10.1136/bmj.b2651)
- 64 Page, L., Seetharaman, S., Suhail, I., Wessely, S., Pereira, P. & Rubin, G. 2011 Using electronic patient records to assess the impact of swine flu (influenza H1N1) on mental health patients. *J. Ment. Health* **20**, 60–69. (doi:10.3109/09638237.2010.542787)
- 65 Magee, W., Eaton, W., Wittchen, H., McGonagle, K. & Kessler, R. 1996 Agoraphobia simple phobia social phobia in the National Comorbidity Survey. *Arch. Gen. Psychiatry* **53**, 159–168.
- 66 Muris, P., Merckelbach, H., Nederkoorn, S., Rassin, E., Candel, I. & Horselenberg, R. 2000 Disgust and psychopathological symptoms in a nonclinical sample. *Pers. Individ. Diff.* **29**, 1163–1167. (doi:10.1016/S0191-8869(99)00263-9)
- 67 Olatunji, B. O. & Sawchuk, C. N. 2005 Disgust: characteristic features, social manifestations and clinical implications. *J. Soc. Clin. Psychol.* **24**, 932–962. (doi:10.1521/jscp.2005.24.7.932)
- 68 Davey, G. *et al.* 1998 A cross-cultural study of animal fears. *Behav. Res. Ther.* **36**, 735–750. (doi:10.1016/S0005-7967(98)00059-X)
- 69 Woody, S. R., McLean, C. & Klassen, T. 2005 Disgust as a motivator of avoidance of spiders. *J. Anxiety Disord.* **19**, 461–475. (doi:10.1016/j.janxdis.2004.04.002)
- 70 Fleischman, D. & Fessler, D. 2011 Progesterone's effects on the psychology of disease avoidance: support for the compensatory behavioral prophylaxis hypothesis. *Horm. Behav.* **59**, 271–275. (doi:10.1016/j.yhbeh.2010.11.014)
- 71 Davey, G. C. L., Buckland, G., Tantow, B. & Dallos, R. 1998 Disgust and eating disorders. *Eur. Eat. Disord. Rev.* **6**, 201–211. (doi:10.1002/(SICI)1099-0968(199809)6:3<201::AID-ERV224>3.0.CO;2-E)
- 72 Troop, N. A., Treasure, J. L. & Serpell, L. 2002 A further exploration of disgust in eating disorders. *Eur. Eat. Disord. Rev.* **10**, 218–226. (doi:10.1002/erv.444)
- 73 Mayer, B., Bos, A. E. R., Muris, P., Huijding, J. & Vlieland, M. 2008 Does disgust enhance eating

- disorder symptoms. *Eat. Behav.* **9**, 124–127. (doi:10.1016/j.eatbeh.2007.07.003)
- 74 Stein, R. I. & Nemeroff, C. J. 1995 Moral overtones of food: judgments of others based on what they eat. *Pers. Soc. Psychol. Bull.* **21**, 480–490. (doi:10.1177/0146167295215006)
- 75 Park, J., Schaller, M. & Crandall, C. 2007 Pathogen-avoidance mechanisms and the stigmatization of obese people. *Evol. Hum. Behav.* **28**, 410–414. (doi:10.1016/j.evolhumbehav.2007.05.008)
- 76 Rozin, P., Markwith, M. & Stoess, C. 1997 Moralization and becoming a vegetarian: the transformation of preferences into values and the recruitment of disgust. *Psychol. Sci.* **8**, 67–73. (doi:10.1111/j.1467-9280.1997.tb00685.x)
- 77 de Jong, P. J., van Lankveld, J., Elgersma, H. J. & Borg, C. 2010 Disgust and sexual problems—theoretical conceptualization and case illustrations. *Int. J. Cogn. Ther.* **3**, 23–39. (doi:10.1521/ijct.2010.3.1.23)
- 78 Borg, C., De Jong, P. J. & Schultz, W. W. 2010 Vaginismus and dyspareunia: automatic vs. deliberate disgust responsivity. *J. Sex. Med.* **7**, 2149–2157. (doi:10.1111/j.1743-6109.2010.01800.x)
- 79 Fry, S. & Blumenbach, U. 2004 *Paperweight*, p. 84 London, UK: Arrow Books.
- 80 Monteiro, W. O., Noshirvani, H. F., Marks, I. M. & Lelliott, P. 1987 Anorgasmia from clomipramine in obsessive compulsive disorder: a controlled trial. *Br. J. Psychiatry* **151**, 107–112. (doi:10.1192/bjp.151.1.107)
- 81 Olatunji, B. O., Elwood, L., Williams, N. & Lohr, J. 2008 Mental pollution and PTSD symptoms in victims of sexual assault: a preliminary examination of the mediating role of trauma-related cognitions. *J. Cogn. Psychother.* **22**, 37–47. (doi:10.1891/0889.8391.22.1.37)
- 82 Dalgleish, T. & Power, M. 2004 Emotion-specific and emotion-non-specific components of posttraumatic stress disorder (PTSD): implications for a taxonomy of related psychopathology. *Behav. Res. Ther.* **42**, 1069–1088. (doi:10.1016/j.brat.2004.05.001)
- 83 De Jong, P. & Peters, M. 2009 Sex and the sexual dysfunctions: the role of disgust and contamination sensitivity. In *Disgust and its disorders: theory, assessment, and treatment* (eds B. Olatunji & D. McKay), pp. 253–270. Washington, DC: American Psychological Association.
- 84 Rubio-Godoy, M., Aunger, R. & Curtis, V. 2007 Serotonin—a link between disgust and immunity? *Med. Hypotheses* **68**, 61–66. (doi:10.1016/j.mehy.2006.06.036)
- 85 De Barra, M., Aunger, R., Flieshmann, D. & Curtis, V. Submitted. Disgust and disease: sensitivity patterns and infection cues. *J. Res. Personality*.
- 86 Haidt, J., McCauley, C. & Rozin, P. 1994 Individual-differences in sensitivity to disgust—a scale sampling 7 domains of disgust elicitors. *Pers. Individ. Diff.* **16**, 701–713. (doi:10.1016/0191-8869(94)90212-7)
- 87 Olatunji, B. O., Williams, N. L., Tolin, D. F., Abramowitz, J. S., Sawchuk, C. N., Lohr, J. M. & Elwood Lisa, S. 2007 The disgust scale: item analysis, factor structure, and suggestions for refinement. *Psychol. Assess.* **19**, 281–297. (doi:10.1037/1040-3590.19.3.281)
- 88 Rozin, P., Haidt, J., McCauley, C., Dunlop, L. & Ashmore, M. 1999 Individual differences in disgust sensitivity: comparisons and evaluations of paper-and-pencil versus behavioral measures. *J. Res. Pers.* **33**, 330–351. (doi:10.1006/jrpe.1999.2251)
- 89 Curtis, V. 2011 Disgust. In *The encyclopaedia of human behaviour* (ed. V. Ramachandranagrain), 2nd edn. Oxford, UK: Elsevier.
- 90 Karvonen, A., Seppala, O. & Valtonen, E. T. 2004 Parasite resistance and avoidance behaviour in preventing eye fluke infections in fish. *Parasitology* **129**, 159–164. (doi:10.1017/S0031182004005505)
- 91 Krause, J. & Godin, J.-G. J. 1994 Influence of parasitism on the shoaling behaviour of banded killifish, *Fundulus diaphanus*. *Can. J. Zool.* **72**, 1775–1779. (doi:10.1139/z94-240)
- 92 Keisecker, J., Skelly, D., Beard, K. & Preisser, E. 1999 Behavioral reduction of infection risk. *Proc. Natl Acad. Sci. USA* **96**, 9165–9168. (doi:10.1073/pnas.96.16.9165)
- 93 Kavaliers, M. & Colwell, D. D. 1995 Discrimination by female mice between the odours of parasitized and non-parasitized males. *Proc. R. Soc. Lond. B* **261**, 31–35. (doi:10.1098/rspb.1995.0113)
- 94 Behringer, D. C., Butler, M. J. & Shields, J. D. 2006 Avoidance of disease by social lobsters. *Nature* **441**, 421. (doi:10.1038/441421a)
- 95 Goodall, J. 1986 Social rejection, exclusion, and shunning among the Gombe chimpanzees. *Ethol. Sociobiol.* **7**, 227–236. (doi:10.1016/0162-3095(86)90050-6)
- 96 Park, J. H., Faulkner, J. & Schaller, M. 2003 Evolved disease-avoidance processes and contemporary anti-social behavior: prejudicial attitudes and avoidance of people with physical disabilities. *J. Nonverbal Behav.* **27**, 65–87. (doi:10.1023/A:1023910408854)
- 97 Park, J. H., Schaller, M. & Crandall, C. S. 2007 Pathogen-avoidance mechanisms and the stigmatization of obese people. *Evol. Hum. Behav.* **28**, 410–414. (doi:10.1016/j.evolhumbehav.2007.05.008)
- 98 Kurzban, R. & Leary, M. R. 2001 Evolutionary origins of stigmatization: the functions of social exclusion. *Psychol. Bull.* **127**, 187–208. (doi:10.1037/0033-2909.127.2.187)
- 99 Park, J. H., Faulkner, J. & Schaller, M. 2003 Evolved disease-avoidance processes and contemporary anti-social behavior: prejudicial attitudes and avoidance of people with physical disabilities. *J. Nonverbal Behav. Brain Sci.* **27**, 65–87. (doi:10.1023/A:1023910408854)
- 100 Duncan, L. A. & Schaller, M. 2009 Prejudicial attitudes toward older adults may be exaggerated when people feel vulnerable to infectious disease: evidence and implications. *Anal. Soc. Issues Public Policy* **9**, 97–115. (doi:10.1111/j.1530-2415.2009.01188.x)
- 101 Fincher, C. & Thornhill, R. In press. Parasite-stress promotes in-group assortative sociality: the cases of strong family ties and heightened religiosity. *Brain Behav. Sci.*
- 102 Taylor, K. E. 2009 *Cruelty: human evil and the human brain*. Oxford, UK: Oxford University Press.
- 103 Charteris-Black, J. 2006 Britain as a container: immigration metaphors in the 2005 election campaign. *Discourse Society* **17**, 563–581. (doi:10.1177/0957926506066345)
- 104 Wilkinson, S. I. 2006 *Votes and violence: electoral competition and ethnic riots in India*. Cambridge, UK: Cambridge University Press.
- 105 Magin, P., Adams, J., Heading, G., Pond, D. & Smith, W. 2006 Psychological sequelae of acne vulgaris: results of a qualitative study. *Can. Family Phys.* **52**, 978.
- 106 Alio, A. P., Merrell, L., Roxburgh, K., Clayton, H. B., Marty, P. J., Bomboka, L., Traorè, S. & Salihu, H. M. 2010 The psychosocial impact of vesico-vaginal fistula in Niger. *Arch. Gynecol. Obstet.* **284**, 1–8.
- 107 Dahle, R. 1999 Lukt, fukt og skam [Bodily smells, wetness and shame]. Paper presented at *Norsk Selskap for aldersforskning, Oslo, 9 September 1999*.
- 108 Isaksen, L. W. 2002 Toward a sociology of (gendered) disgust images of bodily decay and the social organization of care work. *J. Family Issues* **23**, 791–811. (doi:10.1177/019251302236595)

- 109 Wrubel, J. & Folkman, S. 1997 What informal caregivers actually do: the caregiving skills of partners of men with AIDS. *AIDS Care* **9**, 691–706. (doi:10.1080/713613223)
- 110 Hochschild, A. R. 1983 *The managed heart: the commercialization of human feelings*. Berkeley, CA: University of California Press.
- 111 Mendelsohn, O. & Vicziany, M. 1998 *The untouchables: subordination, poverty, and the state in modern India*. Cambridge, UK: Cambridge University Press.
- 112 Livingstone-Smith, D. 2011 *Less than human: why we demean, enslave and exterminate others*. New York, NY: St Martin's Press.
- 113 Brandt, A. M. 1988 AIDS in historical perspective: four lessons from the history of sexually transmitted diseases. *Am. J. Public Health* **78**, 367. (doi:10.2105/AJPH.78.4.367)
- 114 Pastore, J. L. 1993 *Confronting AIDS through literature: the responsibilities of representation*. Champaign, IL: University of Illinois Press.
- 115 Brown, L., Macintyre, K. & Trujillo, L. 2003 Interventions to reduce HIV/AIDS stigma: what have we learned? *AIDS Educ. Prev.* **15**, 49–69. (doi:10.1521/aeap.15.1.49.23844)
- 116 Schaich Borg, J., Lieberman, D. & Kiehl, K. A. 2008 Infection, incest, and iniquity: investigating the neural correlates of disgust and morality. *J. Cogn. Neurosci.* **20**, 1529–1546. (doi:10.1162/jocn.2008.20109)
- 117 Zhong, C. B. & Liljenquist, K. 2006 Washing away your sins: threatened morality and physical cleansing. *Science* **313**, 1451–1452. (doi:10.1126/science.1130726)
- 118 Schnall, S., Benton, J. & Harvey, S. 2008 With a clean conscience. *Psychol. Sci.* **19**, 1219–1222. (doi:10.1111/j.1467-9280.2008.02227.x)
- 119 Zhong, C. B., Strejcek, B. & Sivanathan, N. 2010 A clean self can render harsh moral judgment. *J. Exp. Soc. Psychol.* **46**, 859–862. (doi:10.1016/j.jesp.2010.04.003)
- 120 Fayard, J. V., Bassi, A. K., Bernstein, D. M. & Roberts, B. W. 2009 Is cleanliness next to godliness? Dispelling old wives' tales: failure to replicate Zhong and Liljenquist (2006). *J. Articles Support Null Hypothesis* **6**, 22.
- 121 Danovitch, J. & Bloom, P. 2009 Children's extension of disgust to physical and moral events. *Emotion* **9**, 107–112. (doi:10.1037/a0014113)
- 122 Nussbaum. 2004 *Hiding from humanity: disgust, shame and the law*. Princeton, NJ: Princeton University Press.
- 123 Kass, L. 1997 The wisdom of repugnance. *New Republic* **216**, 17–26.
- 124 Aunger, R. & Curtis, V. 2008 Kinds of behaviour. *Biol. Phil.* **23**, 317–345. (doi:10.1007/s10539-007-9108-4)
- 125 Barrett, L. F. 2006 Are emotions natural kinds? *Perspect. Psychol. Sci.* **1**, 28–58. (doi:10.1111/j.1745-6916.2006.00003.x)
- 126 Griffiths, P. E. 1997 *What emotions really are: the problem of psychological categories*. Chicago, IL: University of Chicago Press.
- 127 Henrich, J. 2004 Cultural group selection, coevolutionary processes and large-scale cooperation. *J. Econ. Behav. Organ.* **53**, 3–35. (doi:10.1016/S0167-2681(03)00094-5)
- 128 Fehr, E. & Fischbacher, U. 2003 The nature of human altruism. *Nature* **425**, 785–791. (doi:10.1038/nature02043)
- 129 West, S. A., Griffin, A. S. & Gardner, A. 2007 Evolutionary explanations for cooperation. *Curr. Biol.* **17**, R661–R672. (doi:10.1016/j.cub.2007.06.004)
- 130 Unicef, WHO. 2009 *Diarrhoea: why children are still dying and what can be done*. New York, NY: Unicef.