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Research Paper

Making your skin crawl: The role of tactile sensitivity in disease avoidance

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ABSTRACT

Mounting evidence indicates that animals, including humans, have evolved a behavioral disease-avoidance system designed to facilitate the detection and avoidance of sources of pathogens, and that this system interacts with physiological defenses. The skin acts as an important anatomical barrier, yet little research has investigated the role of tactile sensitivity in disease avoidance. Increased tactile sensitivity in the presence of potential sources of pathogens may facilitate prophylactic behaviors such as self-grooming. Across multiple studies, we tested the hypothesis that the induction of disgust—the key emotion underlying disease avoidance—may lead to greater tactile sensitivity compared to control conditions. A nonsignificant trend was found in a pilot study, which was replicated (and found to be significant) in Studies 1 and 2. To our knowledge, these results are the first to demonstrate disgust-induced changes in tactile sensitivity, and they contribute to the growing literature on the integrated evolved defenses against infectious disease.

1. Introduction

Parasites and pathogens pose one of the greatest threats to human survival and have played a central role in shaping the evolution of human physiology and behavior (Prokop & Fedor, 2013; Wolfe et al., 2007). While animals, including humans, have evolved a highly complex set of physiological mechanisms (i.e., the immune system) to manage infections (Hart, 1990; Parham, 2009; Schaller, 2011), diseases and immune responses can be highly costly. Consequently, it has been proposed that animals have also evolved a *behavioral immune system* (BIS) that is designed to detect and facilitate avoidance of sources of infectious disease (Curtis, de Barra, & Aunger, 2011; Oaten, Stevenson, & Case, 2009; Schaller & Park, 2011). The BIS consists of psychological mechanisms that are attuned to perceptual cues associated with pathogens and that deploy aversive emotions, cognitions, and behavioral responses. A burgeoning literature has documented the characteristics of the BIS and its wide-ranging implications (for a review, see Murray & Schaller, 2016). There are two noteworthy characteristics of the BIS. The first is that it is functionally flexible, deploying heightened responses when perceived threat of infection is greater (e.g., exposure to stimuli associated with disease). The second is that disgust is the central emotion driving disease avoidance in humans (e.g., stimuli associated with disease elicit disgust and activate the BIS; Curtis et al., 2011; Schaller & Park, 2011).

In some ways, the BIS can be seen as a component of a broader system for combating disease, as conceptualized by researchers in the field of psychoneuroimmunology (Clark & Fessler, 2014). Indeed, growing evidence demonstrates that the "behavioral" and the "physiological" components are closely intertwined. This is illustrated by the role of disgust, the key emotion associated with disease avoidance. Consistent with Oaten et al.'s (2009) suggestion that immunological functioning could be activated via the perception of disgust-evoking stimuli, exposure to disgust-evoking stimuli has been found to promote white blood cell responses (Schaller, Miller, Gervais, Yager, & Chen, 2010), produce greater oral inflammatory responses (Stevenson, Hodgson, Oaten, Barouei, & Case, 2011), and increase body temperature (Stevenson, Hodgson, Moussavi, Langberg, Case, & Barouei, 2012). Conversely, people who have recently been ill (and have had their physiological system activated) have been found to exhibit heightened disease-avoidance tendencies (Miller & Maner, 2011).

Many diseases are transmitted by microparasites and parasite vectors (e.g., flies, fleas, and ticks), often through skin lesions. Such disease threats have long posed a selection pressure on humans (Carter & Mendis, 2002; Gonçalves, Araújo, & Ferreira, 2003). Vector disease transmission can occur via processes such as mite infestations associated with scabies (Fuller, 2013) and mosquito bites associated with malaria (Autino, Noris, Russo, & Castelli, 2012). Mechanical transmission from parasites found on the bodies of insects include

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gastroenteritis and trachoma (Graczyk, Knight, Gilman, & Cranfield, 2001), and *Escherichia coli* (Echeverria et al., 1983).

Due to the prominence of skin-transmitted diseases, the skin is expected to play a central role in disease avoidance. Not only does the skin provide a physical barrier against the intrusion of pathogens (Madison, 2003), it also secretes antibodies against parasites (Hosoi, 2006). Far more than just a passive barrier, the skin has been implicated as part of the immune system, providing multiple epidermal and dermal cell populations that respond rapidly to any contact between the organism and its environment (Williams & Kupper, 1996).

As the skin is implicated with the immune system and has specific function to deal with parasite load, it is likely that there will be a behavioral component that is specifically designed to complement these functions of detecting and avoiding disease threat. Animal and insect studies support the role of skin sensitivity for detection of disease threat; resultant behaviors such as scratching and oral grooming serve behavioral avoidance of disease (Hart, 1990; de Roode & Lefèvre, 2012). Four different ant species have been found to upregulate grooming in response to detecting contamination on nest mates (Tranter, Lefèvre, Evison, & Hughes, 2014). For rats, the removal and minimization of ectoparasites is resource intensive: between 8 and 30 percent of their evaporative water loss is due to oral grooming (Bolles, 1960). And female antelopes have been observed to engage in self-grooming and scratching approximately 2000 times during a 12-h period (Hart & Hart, 1988). Moreover, experiments have found increased ectoparasite infestation among mice and cows who were unable to self-groom orally or scratch (Bell, Jellison, & Owen, 1962; Bennett, 1969).

Humans also possess hygiene behaviors that are associated with disease avoidance (Curtis et al., 2011). Specific behaviors such as washing and scrubbing with different products (i.e., soaps and shower gels) are a form of self-grooming, as are more basic behaviors, such as scratching[1] and hand wiping. Indeed, a recent study has shown that self-grooming increases following exposure to disgust-evoking stimuli (Prokop, Fančovičová, & Fedor, 2014). Increased skin sensitivity may be a key precursor to self-grooming and is particularly important for minimizing skin-transmitted disease threat. Both early and accurate detection of disease threat allows the host to either avoid the associated costs altogether (complete removal) or mitigate the associated costs (e.g., minimizing infestation). Therefore, in line with the notion of functional flexibility (Murray & Schaller, 2016), it can be hypothesized that tactile sensitivity may be heightened in the presence of cues that elicit disgust and suggest increased threat of disease, which may facilitate detection. Detection would subsequently promote avoidance behavior with the function of either removing or at least minimizing the costs associated with contamination.

1.1. The present studies

We conducted three studies to test the hypothesis that exposure to disgust-evoking stimuli may increase tactile sensitivity. The first was a pilot study, which served as a feasibility study. Study 1 aimed to provide a more robust test by using a double-blind procedure and a sufficiently large sample. Study 2 attempted to replicate Study 1, using different disgust-evoking stimuli, and with an additional disease-irrelevant threat condition.

[1] There is an intuitive and sensible argument that scratching the skin may breach this protective barrier and increase the disease threat, rather than decrease it. As with most behaviors, there is a cost–benefit trade-off. For scratching, the costs of potentially breaching the skin barrier could possibly be offset by the benefits of preventing infection. Furthermore, superficial scratching may cause removal of the uppermost layers of the skin, but will rarely lead to a complete breach.

2. Pilot study

2.1. Participants and design

Forty undergraduate students (24 women, 16 men; mean age = 19.90 years, $SD = 1.61$) from the University of Portsmouth participated in exchange for course credit. The study employed a pretest–posttest between–subjects design; participants were randomly assigned to the disgust ($n = 20$) or the threat control ($n = 20$) condition. This study was part of a student project. Therefore, the sample size was based on practicalities around time and the availability of participants.

2.2. Materials and apparatus

2.2.1. Tactile sensitivity (TS)

TS was measured using Semmes-Weinstein monofilaments, thin pieces of plastic which are used to measure skin sensitivity in clinical settings (e.g., diabetics who have reduced blood flow; Kumar et al., 1991). The monofilaments consist of plastic rods with nylon fibers that vary in force (grams) from 0.008 g to 300 g (see Fig. S1 in the Supplemental Material available online). The standardized procedure for measurement was followed (Schreuders, Slijper, & Selles, 2010). The nylon fibers were applied with pressure to a patch of the participant's skin until it reached a 'C' shape. This procedure started with the smallest force (0.008 g) and was repeated with the monofilaments that have higher forces until the participant reported that they could feel the nylon fiber.

2.2.2. Stimuli

All participants were shown 20 neutral images (e.g., household furniture and appliances). Participants in the disgust condition were shown 20 disgust-evoking images (e.g., cadavers, faces, and vomit). Participants in the threat control condition were shown 20 threat-evoking images (e.g., dangerous animals, dangerous humans, and dangerous scenarios). All images were presented via a self-timed Microsoft PowerPoint presentation, with each image being displayed for 6s.

2.2.3. Box

For the TS measurements, a cardboard box was placed on a table, and a square hole was cut out at the participant's end with enough space for participants to place their forearm through. The experimenter's end was hooded to ensure that participants could not see the monofilaments being applied (see Fig. S2).

2.3. Procedure

Participants were first asked to complete a short questionnaire that consisted of basic demographic questions, handedness, and information on nerve and skin conditions. A measurement was taken on the underside of the participant's non-dominant forearm in order to determine where the monofilaments should be applied. After this, participants were shown a Microsoft PowerPoint presentation of 20 affectively neutral images.

Participants were then seated at the table with the box and asked to place their non-dominant arm with their palm facing up into the hole in order to take the pre-manipulation TS measure. Monofilaments were applied to approximately one-third way up the participant's non-dominant forearm. Each monofilament, from smallest to largest force, was applied in serial order. With each monofilament, participants were asked to report whether they felt something. If they had not, the experimenter moved on to the next monofilament.

Next, participants were asked to complete two tasks. The first was a questionnaire for an unrelated study on the themes of rejection and loneliness. The second was for participants to watch the PowerPoint