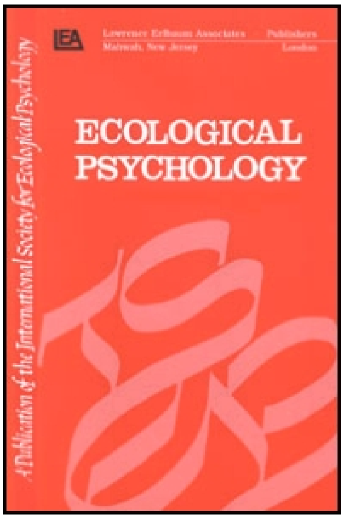

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Health Is Associated With Antiparasite Behavior and Fear of Disease-Relevant Animals in Humans

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Health Is Associated With Antiparasite Behavior and Fear of Disease-Relevant Animals in Humans

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Evolutionary arms races between humans and parasites resulted in a set of behavioral adaptations that serve as parasite-avoidance mechanisms. We investigated associations among reported health of the respondent, antiparasite behavior, and sensitivity to disgust and fear of disease-relevant and irrelevant animals. Ninety-seven participants (15–19 years old) rated their fear and disgust at 25 colorful pictures of disease-relevant and disease-irrelevant invertebrates. Consistent with previous work, we found that participants reported greater fear and disgust of disease-relevant invertebrates relative to disease-irrelevant invertebrates. Better perceived health correlated with lower fear of disease-relevant invertebrates. Sensitivity to disgust correlated with reported antiparasite behaviors. Contrary to expectations, we found a positive correlation between antiparasite behavior and reported health, which suggests that antiparasite behavior influences perceived health (but not vice versa), and we found that males perform more antiparasite behaviors than females. These results support the idea that disgust and fear of disease-relevant objects are adaptive emotions that prevent contact with contagious objects, especially in individuals with low perceived health.

Parasites are powerful tools of natural selection because they are major causes of human morbidity and mortality (Damond et al., 2004; Wolfe, Dunavan, &

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Diamond, 2007). Humans face continuous selection pressure from pathogens, both now and in our ancestral past (Dobson & Carper, 1996; Gonçalves, Araújo, & Ferreira, 2003). For example, it is estimated that between 576 and 740 million individuals are infected with hookworm today (Bethony et al., 2007). One to 2 million people die from malaria that is transmitted through mosquitoes annually (Crompton, 1999; Sachs & Malaney, 2002). According to Fontaine et al. (2009), nearly 2 million children die from diarrhea every year. Each year, about 85,000 people in Europe are infected with Lyme borreliosis that is transmitted by ticks (Lindgren & Jaenson, 2006).

Natural selection arguments for specific behaviors have been presented in ecological psychology by Coss and his associates. Coss & Charles (2004) and Coss & Schowengerdt, (1998) are examples. Coss and Moore (2002) found that preschool girls preferred tree climbing when escaping from a fictive predator, whereas males preferred terrestrial refuges. They argued that these differences between males and females are results of evolutionary pressures because natural selection favored tree climbing by females who are historically lighter bodied than males.

Although the research on how predators influence human behavior has a relatively long history (Edmunds, 1974; Seligman, 1971), adaptive mechanisms that help us avoid parasites have been only recently investigated (Curtis, Aunger, & Rabie, 2004; Curtis & Biran, 2001; Fessler & Navarrete, 2003; Rozin, Haidt, & McCauley, 2000; Schaller, 2006; Schaller & Murray, 2010). Natural selection is responsible for a range of behaviors that reduce the risk of infection with pathogens, such as viruses, bacteria, multicellular parasites, and their carriers (Curtis, 2007; B. L. Hart, 1990; Loehle, 1995). Lobsters avoid other lobsters with viral infections (Behringer, Butler, & Shields, 2006). Some birds actively avoid parasitized nests (Tomas, Merino, Moreno, & Morales, 2007) and/or include plants with insecticidal effects in their nests to repel parasites (Lafuma, Lambrechts, & Raymond, 2001). Male rats perform postcopulatory genital grooming, which reduces the risk of being infected by sexually transmitted diseases (B. J. Hart, Korinek, & Brennan, 1987). Chimpanzees, our close relatives, groom to remove ectoparasites (Goodall, 1986).

Although there is mostly anecdotal evidence about how human ancestors avoided infections by pathogens (Curtis, 2007), several behavioral adaptations that evolved as disease-avoidance mechanisms in contemporary humans do exist (Park & Schaller, 2009; Schaller & Duncan, 2007). Behavioral avoidance of disease transmission (the behavioral immune system; Schaller, 2006) is activated especially in immunologically compromised individuals (Navarrete, Fessler, & Eng, 2007) because there is higher cost of parasite threat compared with healthy individuals. Women in the first term of pregnancy, whose bodies are naturally immunosuppressed, show especially high levels of xenophobia (negative attitudes toward others) and ethnocentrism (positive attitudes toward one's own cultural in-group; Faulkner, Schaller, Park, & Duncan, 2004; Navarrete & Fessler, 2006; Navarrete et al. 2007). People who feel especially vulnerable to parasite transmission have greater aversive responses against physically disabled individuals (Park, Faulkner, & Schaller, 2003), toward older adults (Duncan & Schaller, 2009), immigrants (Faulkner et al., 2004), or disease-relevant animals or microorganisms (Prokop, Uşak, & Fančovičová, 2010; Stevenson, Case, & Oaten, 2009; Tybur, Lieberman, & Griskevicius, 2009). Physical contact with all these groups of people increases the probability of transmission of a novel, infectious disease. Although post hoc evolutionary explanations are criticized (Burton, 2002) and it can be argued that these findings are based on correlative data (it is impossible to confirm causation or to exclude the possibility of spurious results), experimental research by Mortensen, Vaughn Becker, Ackerman, Neuberg, and Kenrick (2010) revealed that exposure to a disease prime led university students to rate themselves as less extraverted. Furthermore, students with high perceived vulnerability to disease rated themselves as less agreeable and less open to experience than the control students did. These results are compatible with the cross-cultural study of Schaller and Murray (2008) that showed that personality traits varied by geographic region in conjunction with regional levels of disease prevalence. High disease prevalence was associated with lower levels of extraversion, openness to experience, and agreeableness (Schaller & Murray, 2008).

The most powerful emotion associated with our behavioral immune system in the context of disease avoidance is disgust (Curtis et al., 2004; Oaten, Stevenson, & Case, 2009). Disgust is an emotion that can be related to avoidance of certain animals, ill humans, feces, vomit, sexual substances, and other harmful substances or events (Rozin et al., 2000). Disgust may produce specific autonomic responses, such as reduced blood pressure, heart rate deceleration, and decreased skin conductance (Stark, Walter, Schienle, & Vaitl, 2005) along with changes in respiratory behavior (Ritz, Thons, Fahrenkrug, & Dahme, 2005). Most recently, Schaller, Miller, Gervais, Yager, & Chen (in press) found that visual perception of disease-connoting cues elicited aggressive immunological responses in humans. Along with disgust, fear seems to also be a powerful emotion influencing disease avoidance. These two emotions are compatible but distinguishable (Curtis & Biran, 2001). Whereas disgust involves a suspension of activity, fear heightens activity in preparation for fight or flight (Phillips, Senior, Fahy, & David, 1998). This is probably an explanation why disgust correlates with fear of animals (Gerdes, Uhl, & Alpers, 2009; Prokop et al., 2010).

There is increasing evidence that higher disgust sensitivity is evolutionary adaptive because it decreases the likelihood of being infected by pathogens (Curtis et al., 2004; Faulkner et al., 2004; Oaten et al., 2009; Schaller, 2006; Stevenson et al., 2009; Tybur et al., 2009). According to the biological preparedness theory, primates have learning predispositions that were selected in our evolutionary history by natural selection (Seligman, 1971). That is, natural selection favored survival of individuals who effectively avoided or escaped these dangerous animals. This resulted in the evolution of phylogenetically based predispositions that allow associations between dangerous stimuli with aversive outcomes. In humans, females are more fear/disgust sensitive than males (Curtis et al., 2004; Davey et al., 1998; Gerdes et al., 2009; Oaten et al., 2009; Porzig-Drummond et al., 2009; Røskaft, Bjerke, Kaltenborn, Linnell, & Andersen, 2003) and these emotions are expected to correlate with some antiparasite behaviors. For example, females more likely than males engage in posttoileting hand washing (Guinan, McGuckin-Guinan, & Sevareid, 1997) that significantly reduces transmission of several parasitic diseases (for a review, see Curtis & Cairncross, 2003).

To date, little is known about whether disgust, or fear, is associated with the specific behaviors humans may perform to avoid being infected by pathogens. In this study we investigated associations between perceived health, sensitivity to disgust and fear, and specific antiparasite behaviors in humans. We predicted that (a) participants would show greater fear and disgust of disease-relevant animals compared with disease-irrelevant animals, perhaps because fears and phobias of animals associated with survival of our pretechnological ancestors are much easier to induce than other kinds of fear; (b) participants with lower health would show greater fear or disgust of disease-relevant (but not disease-irrelevant) animals because these emotions protect them against disease-relevant objects; (c) participants with Košer health would show stronger antiparasite behaviors because these strategies helped immunologically compromised people to minimize contact with costly pathogens; alternatively, higher fear of disease-relevant invertebrates would be associated with better perceived health correlated as a consequence of the advantages of avoiding disease-relevant invertebrates (Stevenson et al., 2009); (d) antiparasite behaviors would correlate with fear and disgust because these emotions and behaviors were complementary as both of them were directed to pathogen avoidance; and finally, (e) females would perform more antiparasite behaviors and would be more disgust/fear-sensitive because of their evolutionary role in protecting the next generation (e.g., Curtis et al., 2004).

METHODS

The Sample

The sample of participants (40 females and 57 males) consisted of 15–19-year-olds attending two randomly selected high schools in Western Slovakia. The mean age of the participants was 16.52 years ($SE = .08$). The participants were asked (a) for their age/grade; (b) for their sex; (c) if they kept any animals as pets or farm animals, and, if yes, (d) what animal species they kept as pets or farm animals; and (e) whether they live in a city or in a village. The latter variable failed to show any significant effect on the General Health Questionnaire score or on mean score of disgust, fear, or perceived danger of disease-relevant and irrelevant invertebrates. Thus, data of participants living in both urban and rural environments were pooled. Having animals at home was measured because the more animals are reported by the participant, the more positive attitudes toward animals he or she has (Prokop & Tunnicliffe, 2010; Prokop, Özel, & Uşak, 2009).

Measuring of Disgust and Fear

We presented 25 color pictures (5 disease-relevant adult insects, 5 ectoparasites, 5 endoparasites, 5 disease-irrelevant adult insects, and 5 insect larvae/earthworm) in lecture halls (see Appendix). The first three groups of animals were risky to humans in terms of decreased immunity and/or health problems and the latter two groups served as a control. Disease-irrelevant adult insects were controls for disease-relevant adult insects and ectoparasites, and insect larvae/earthworm were controls for endoparasites. We adjusted picture sizes to a standard body length. Pictures had similar contrast and brightness. The pictures were presented in random order. Each picture was presented for 1 min. During this time, participants rated fear and disgust, each on a 5-point scale (e.g., 1 = *not at all,* 5 = *extremely disgusting*).

Measuring of Health State

The General Health Questionnaire (GHQ) was used for measuring current health of each participant; it consisted of 46 statements adopted from available works (Goldberg & Hillier, 1979; Kind, Dolan, Gudex, & Williams, 1998). Each question was answered on a 5-point scale (1 = *strongly disagree,* 5 = *strongly agree*). Negative items were reverse-scored. The items included, for example, "I am sick all the time," "I feel stress in my head," "I regularly take medicine," "I have hypersensitiveness," or "My health state is perfect." The GHQ was highly reliable (Cronbach's alpha = .89). We therefore used the mean score of all 46 items for subsequent analyses. Higher scores reflected better perceived health. The score of participants ranged from 102 to 216 (possible range was 46–230). To support the reliability of GHQ, we included three questions regarding current perceived health of participants and found that all of them significantly correlated with mean GHQ score: "Please rate how healthy you felt last month" (1 = *perfectly,* 4 = *absolutely bad,* $r = -.47$, $p < .001$), "Please imagine how good or bad your heath state currently is: the best state is 100 and the worst state is 0" ($r = .68$, $p < .001$), and "How many times were you ill during last year?" (1 = *never,* 2 = *1 time per year,* 3 = *2–3 times per year,* 4 = *more than 3 times per year,* $r = -.42$, $p < .001$). We therefore conclude that the GHQ reliably reflects the current perceived health of participants.

Measuring of Antiparasite Behavior

Antiparasite behavior was measured by eight items (Cronbach's alpha = .70) rated on a 4-point scale (1 = *never/very dirty,* 4 = *very frequently/absolutely clean*). The items include personal hygiene (three items including "Do you wash your hands before eating/after defecation?" and "Try to rate the current cleanliness of your hair"), contact with companion animals (four items, all reverse-scored, such as "Do you pet wandering/home cats/dogs?"), and personal contact with a person who may suffer from various diseases (one reverse-scored item: "Would you be willing to give first aid to a homeless person?"). High scores reflect more intense parasite avoidance. Development of these items was based on the fact that poor hygiene and contact with companion animals or infected humans increases risk of parasite transmission (Hwang, Kiss, Ho, Leung, & Gundlapalli, 2008; Macpherson, 2005; Ramirez, Ward, & Sreevatsan, 2004).

RESULTS

Effect of Animal Group

As predicted, both fear and disgust scores were higher for disease-relevant invertebrates (pooled data of disease-relevant groups of animals were compared against pooled data of disease-irrelevant groups of animals; see Figure 1). Unexpectedly, males and females rated fear and disgust disease-relevant invertebrates ($t_{(95)} = .08$ and .59, both $p > .55$, respectively) and fear and disgust of disease-irrelevant invertebrates similarly ($t_{(95)} = 1.53$ and 1.79, both $p > .07$, respectively). Descriptive data for gender differences are shown in Figures 2 and 3. These results remained unchanged even after controlling for the effect of health state.

Association Between Health, Fear, and Disgust of Invertebrates

Fear and disgust of disease-relevant and disease-irrelevant invertebrates were significantly correlated ($r = .34$ and .54, $n_1 = n_2 = 97$, both $p \leq .001$, respectively). Multiple regression (forward stepwise method) with health as the

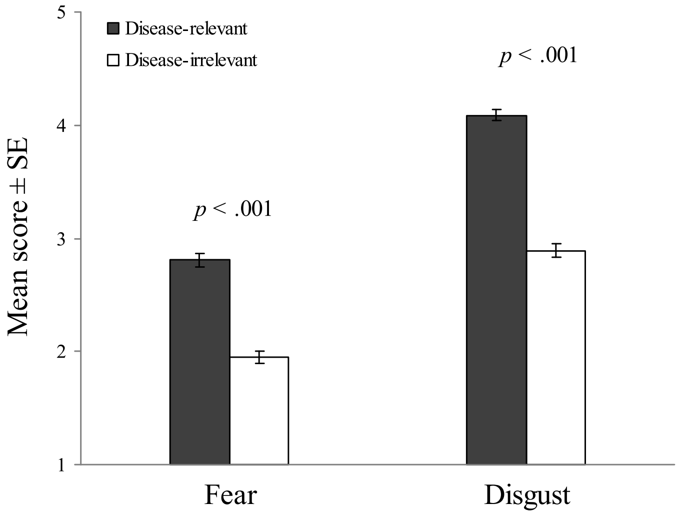

FIGURE 1 Differences in mean scores of fear and disgust between disease-relevant and disease-irrelevant groups of invertebrates. *P* values are based on paired *t* tests.

dependent variable and mean scores of fear and disgust of disease-relevant and disease-irrelevant groups of invertebrates and gender as independent variables was performed. The mean score of antiparasite scale significantly correlated with total number of participants' animals at home ($r = -.36$, $p < .001, n = 97$). We therefore performed a residual analysis in which the mean score of antiparasite behavior was controlled for the total number of participants' animals at home. Residuals of regression were then included as further independent variable into multiple regression model. The model was significant ($R^2 = 0.22$, $F(4, 92) = 6.32$, $p < .001$), but only two predictors showed significant effects on health: fear of disease-relevant invertebrates and antiparasite behaviors ($\beta = -.39$ and .33, $t_{(92)} = -3.98$ and 2.86, both $p \leq .005$, respectively). Disgust of disease-relevant invertebrates and gender also entered the model, but their effect was not significant ($\beta = .15$ and $-.14$, $t_{(92)} = 1.46$ and -1.17, both $p > .14$). Fear and disgust of disease-irrelevant invertebrates were removed from the model. These results suggest that participants with poorer health had greater fear of disease-relevant invertebrates and that better health positively correlated with more antiparasite behaviors (if having animals at home was controlled for). Gender differences did not influence these results.

We further asked whether antiparasite behaviors (dependent variable controlled for total number of animals at home) correlate with disgust and fear of disease-relevant and irrelevant invertebrates and whether there are some

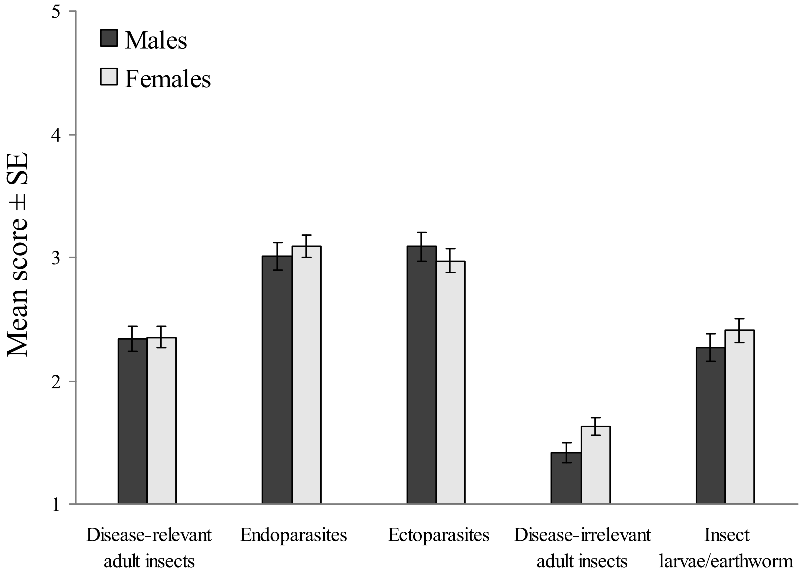

FIGURE 2 Mean rating scores in perceived fear of disease-relevant and disease-irrelevant invertebrates.

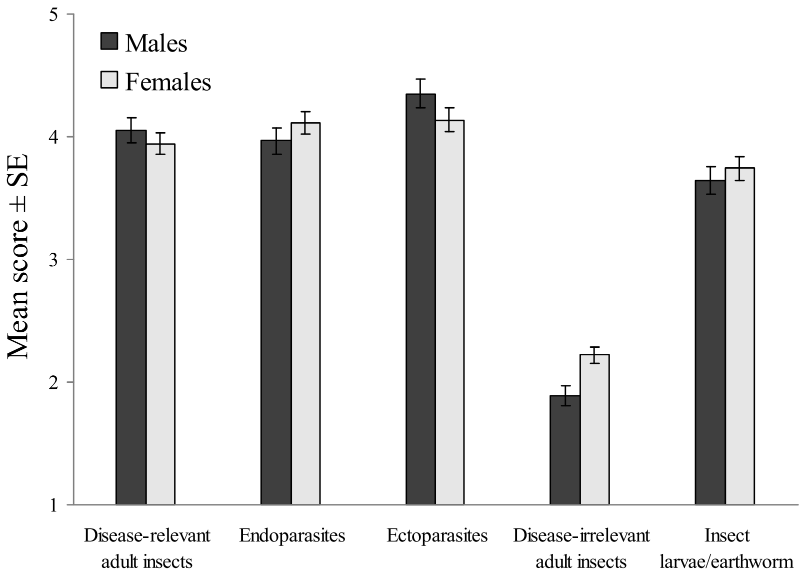

FIGURE 3 Mean rating scores in perceived disgust of disease-relevant and disease-irrelevant invertebrates.

gender differences (independent variables). Multiple regression (forward stepwise method) resulted in significant model ($R^2 = .41$, $F(5, 91) = 12.70$, $p < .001$) in which gender showed a significant effect on antiparasite behaviors ($\beta = .55$, $t_{(91)} = 6.61$, $p < .001$). Males performed more antiparasite behaviors compared with females ($M \pm SE$, $3.65 \pm .05$, $n = 57$ and $3.01 \pm .06$, $n = 40$, respectively; an additional t test fully corroborated this finding, $t_{(95)} = 7.86$, $p < .001$). All other variables entered the multiple regression model and showed significant or marginally significant effect on antiparasite behaviors. Participants with stronger disgust of disease-relevant invertebrates and fear of disease-irrelevant invertebrates performed more antiparasite behaviors ($\beta = .18$ and .27, $t_{(91)} = 1.81$ and 2.15, $p = .07$ and .03, respectively). Disgust of disease-irrelevant insects and fear of disease-relevant invertebrates was not associated with antiparasite behaviors ($\beta = .01$ and $-.19$, $t_{(91)} = 1.11$ and -1.72, both $p > .09$, respectively).

DISCUSSION

Consistent with previous research, this study provided further support for existence of links between health and behavioral avoidance of harmful animals in humans. However, as far as we know, this is the first study that examined links between perceived health and specific behaviors associated with parasite avoidance. Five hypotheses were explicitly tested: (H1) Participants will show greater fear and disgust of disease-relevant animals compared with disease-irrelevant animals. This hypothesis was fully supported because mean scores of fear and disgust of disease-relevant invertebrates were substantially higher than scores of disease-irrelevant invertebrates. These data corroborate previous research (Davey et al., 1998; Gerdes et al., 2009; Prokop & Tunnicliffe, 2010; Prokop et al., 2010). From an evolutionary perspective, fear primarily occurs to sources that are survival relevant (Öhman & Mineka, 2001). This result therefore partially supports the biological preparedness hypothesis (Seligman, 1971). This hypothesis assumes that evolutionary pressures have predisposed primates (including humans) to condition fear more readily to stimuli related to recurrent survival threats than to stimuli that never have threatened survival. However, according to this hypothesis, individuals must still experience a conditioning episode to acquire fear or phobia (Davey et al., 1998); thus individuals acquire negative associations when experiencing disease-relevant animals easier than disease-irrelevant animals. Because we did not ask participants for their experiences with disease-relevant and disease-irrelevant animals, further research in this area is required.

(H2) Participants with lower health will show greater fear and disgust of disease-relevant (but not disease-irrelevant) animals and (H3) stronger antiparasite behaviors because these strategies help immunologically compromised people to minimize contact with costly pathogens. In agreement with Hypothesis 2, participants with lower perceived health showed higher fear of disease-relevant animals. That is, immunologically compromised people must avoid potentially contagious objects more than healthy people because their compromised immune system is not able to protect them against parasites effectively (e.g., Prokop et al., 2010; Schaller & Duncan, 2007; Stevenson et al., 2009; Tybur et al., 2009). However, Hypothesis 3 was not supported because healthy people reported more antiparasite behaviors compared with people who perceived themselves less healthy. This result seems incompatible with previous research which showed that, for example, people who felt themselves less vulnerable to disease (i.e., more healthy) show less negative attitudes toward unfamiliar immigrants who may pose disease treat (Faulkner et al., 2004). However, this finding indirectly supports the results of Stevenson et al. (2009), who found that participants who were more disgust sensitive had significantly fewer recent infections. Better health can therefore be viewed at least partly as a result of more effective strategy protecting our bodies against parasites.

At present, it is difficult to understand why our results are contradictory to previous research. Whereas previous research suggested that the effect of pathogens on the immune system altered behavioral strategies of humans by favoring avoidance of things that posed risk of parasite transmission (i.e., the immune system alters behavior; e.g., Duncan & Schaller, 2009; Navarrete et al., 2007; Park et al., 2003; Schaller & Duncan, 2007), our data suggest that the behavioral immune system is influenced by natural selection pressures and activation of behavioral antiparasite strategies positively influences health (i.e., antiparasite behavior alters functioning of the immune system). We propose that these differences with previous work would be at least partly explained by conceptually different variables that were measured. Whereas Faulkner et al. (2004) measured *attitudes* toward familiar and nonfamiliar immigrants or *attitudes* toward older people (Duncan & Schaller, 2009), our measures were based on specific *behaviors* associated with avoidance of parasite transmission. Although we acknowledge that attitudes and behavior generally correlate (Glasman & Albarracın, 2006; Kraus, 1995), we argue that attitudes should have different costs compared with some behaviors. Our data should be, however, also interpreted with caution because we used self-reports rather than direct observations of these behaviors. For example, *Daphnia magna* and damselfly larvae (*Ischnura verticalis*) experience elevated predation risk when exhibiting antiparasite responses (Baker & Smith, 1997; Decaestecker, De Meester, & Ebert, 2002), suggesting that there might be trade-offs between antiparasite behaviors and other vital activities (Rohr, Swan, Ravel, & Hudson, 2009). Potential costs of antiparasite behaviors in humans thus deserve further research before making any conclusions.

(H4) Antiparasite behaviors will correlate with fear and disgust because these emotions and behaviors are complementary as both of them are directed to pathogen avoidance. In agreement with this hypothesis, heightened disgust sensitivity toward disease-relevant invertebrates and fear of disease-irrelevant invertebrates positively correlated with antiparasite behaviors. This suggests that people who find pathogen-connoting cues more disgusting perform antiparasite behaviors, like posttoilet washing hands (Porzig-Drummond et al., 2009) or avoiding contact with companion animals, more frequently than others. Although previous research supported the idea that disgust is the most important emotion in the context of disease avoidance (e.g., Curtis et al., 2004; Oaten et al., 2009; Park & Schaller, 2009; Tybur et al., 2009), only limited number of analyses showed that disgust sensitivity was associated with various antiparasite *behaviors* in real life (Porzig-Drummond et al., 2009; this study). Further research focused on more diverse behaviors associated with parasite resistance is required.

(H5) Females will perform more antiparasite behaviors and will be more disgust/fear-sensitive because of their evolutionary role in protecting the next generation. We found no support for this hypothesis because all groups of invertebrates were perceived similarly by males and females. Although we did not repeat our findings from previous research in which females scored higher in ratings of disgust, fear, and dangerousness of invertebrates than males (Prokop et al., 2010), we suggest that low variability in mean scores of disease-relevant insects in both sexes would be responsible for this failure. Furthermore, contrary to Hypothesis 5, females did not perform more antiparasite behaviors than males. This finding is quite surprising because at least some antiparasite behaviors, like posttoileting hand washing, were found to be more frequent in females (Guinan et al., 1997). Because four antiparasite items were related to caressing dogs and cats, these results would be partly explained by greater affiliation of females to domestic pets (e.g., Miura, Bradshaw, & Tanida, 2000), but this still does not explain why closer contact with companion animals that pose risk of parasite transmission (Macpherson, 2005) is more profound in females who are generally more disgust sensitive (e.g., Curtis et al., 2004; Prokop et al., 2010). Further research involving more diverse samples of participants (especially women having children) is necessary to test whether higher maternal investment is associated with antiparasite behavior in females.

Limitations of the Study

Although this study shows statistically significant support for most predictions, there are some notable limitations. First, the sample of disease-relevant and disease-irrelevant animals was restricted to a few invertebrates. Although we maintain that these examples arouse disgust/fear, further research should involve a more diverse range of animals including vertebrates, which will make any generalization more convincing. Second, the role of parents' education (Okyay, Ertug, Gultekin, Onen, & Beser, 2004; Scott, Lawson, & Curtis, 2007) and actual knowledge about infection transmission was not controlled for. However, our research was primarily focused on emotions. Emotional response comes first but cognitive processes later, when the defense response is under way (Öhman, Flykt, & Lundqvist, 2000), which implies that our data were not confounded by these factors. Although none of the participating schools was actually involved in hygiene campaigns (e.g., du Pré, 2005) and failures of health education approaches in promoting hygiene (Curtis & Biran, 2001) suggest that interventions are not responsible for all antiparasite behaviors in humans, we acknowledge that further research controlling these predictors is required. One might, for example, test whether individuals with poorer health adopt antiparasite behaviors more easily and quickly than others.

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APPENDIX

List of Species Used in PowerPoint Presentation

Disease-relevant adult insects: dengue mosquito (*Aedes aegpti*), blue bottle fly (*Calliphora vomitoria*), tse-tse fly (*Glossina palpalis*), German cockroach (*Blatella germanica*), red-tailed flesh fly (*Sarcophaga haemorrhoidalis*).

Endoparasites: common roundworm (*Ascaris lumbricoides*), Medina worm (*Dracunculus medinensis*), beef tapeworm (*Taenia saginata*), human pin-worm (*Enterobius vermicularis*), common liver fluke (*Fasciola hepatica*).

Ectoparasites: bedbug (*Cimex lecturarius*), common tick (*Ixodes ricinus*), human louse (*Pediculus humanus*), medicinal leech (*Hirudo medicinalis*), human flea (*Pulex irritans*).

Disease-irrelevant adult insects: rhinoceros beetle (*Oryctes nasicornis*), azure damselfly (*Coenagrion puella*), ladybird beetle (*Coccinella septempunctata*), duetting grasshopper (*Chorthippus biguttulus*), Old World swallow-tail (*Papilio machaon*).

Insect larvae/earthworm: mosquito (*Culex* sp.), green pug (*Chloroclystis rectangulata*), common earthworm (*Lumbricus terrestris*), yellow mealworm (*Tenebrio molitor*), ladybird beetle (*Coccinella septempunctata*).