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Contents

Original Article

Self-Protection Versus Disease Avoidance

The Perceived Physical Condition is Associated with Fear of Predators in Humans

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Abstract. Predators and pathogens are powerful natural selection tools that influence the evolution of two domain-specific management systems: self-protection and disease avoidance. Both systems are activated by specific ecological conditions and protect humans against physical harm or disease transmission. The perception of predators is associated with fear, and the perception of disease-relevant animals is associated with disgust. Fear of predators negatively correlated with the perceived physical condition of participants, suggesting that the self-protection system is activated particularly in people who are more vulnerable to predation threat. People vulnerable to infectious diseases rated predators as more dangerous, suggesting that the disease-avoidance system activates behavior-reducing contact with harmful animals. Females had a higher score in terms of fear, disgust, and perceived danger in particular when considering animals that pose physical harm and/or a disease threat. Our results support the adaptation view, suggesting that the self-protection and disease-avoidance systems are domain specific, and that both have been shaped by natural selection in order to protect humans against harmful animals or events.

Keywords: disgust, fear, predation, self-protection, disease avoidance

Introduction

The existence of *Homo sapiens sapiens* on Earth was influenced by natural selection. Our ancestors shared habitats with diverse species of large predatory carnivores and were hunted by some paleopredators (Treves & Palmqvist, 2007). Recent records suggest that at least 421,000 poisonings and 20,000 deaths occur each year due to snakebite (Kasturiratne et al., 2008) and 471 attacks on humans by sharks between 1580 and 2011 were fatal (ISAF, 2012). Large terrestrial carnivores such as wolves and big cats (lions and leopards) killed at least 683 people in France up until the 1920s (Linnell et al., 2002), and 247 people were killed in Uganda between 1923 and 1994, respectively (Treves & Naughton-Treves, 1999). Although human mortality due to predation is in all probability much lower than at any other time in our evolutionary history, these examples suggest that attacks on humans by predators still occur. Interestingly, fewer females than males (Linnell et al., 2002; Treves & Naughton-Treves, 1999) have traditionally survived attacks by large carnivores, suggesting that physically stronger males are better equipped to counterattack such predators (Røskaft, Bjerke, Kaltenborn, Linnell, & Andersen, 2003). Sexual dimorphism in the skeletal and muscular development supports this idea. Indeed, males have on average 61% more muscle mass than females, which is developmentally related to their much higher levels of testosterone (Lassek & Gaulin, 2009).

Besides predators, ubiquitous pathogens seriously threaten human lives. The historically most dreaded disease (Morelli et al., 2010), the plague, killed between 25% and 50% of the populations of Europe, Asia and Africa during the 1300s alone (Gottfried, 1983). Current reports of the World Health Organization (WHO, 2010) reveal that, in 2008, there were an estimated 243 million cases of malaria causing 863,000 deaths. In that same year approximately 2 million people died from diseases associated with AIDS, and 496 million people were treated for lymphatic filiariasis (WHO, 2010). Mortality from infectious disease is substantially higher in males than in females (Owens, 2002). Females, however, suffer from higher levels (i.e., both prevalence and severity) of morbidity (e.g., Waldron, 1983) and have worse self-rated health and more hospitalization episodes than males (Case & Paxson, 2005). Guided by an evolutionary perspective, we investigated whether predator and disease-connoting cues activate emotions hy-

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pothesized to protect humans against potential threats caused by predators and pathogens.

Self-Protection and Disease Avoidance Mechanisms

Ancestral humans evolved sensory, affective, cognitive, and behavioral mechanisms that work together in order to reduce the fitness costs of potential threats (reviewed by Michalski & Shackelford, 2010; Schaller & Murray, 2011; Schaller, Conway, & Peavy, 2010). In their current review Neuberg, Kenrick, and Schaller (2011) propose that there are two functionally distinct threat management systems, one devoted to self-protection and the other to disease avoidance. Self-protection and disease-avoidance systems are defined by a set of functionally distinct domain-specific systems, each of which was designed to respond to a different affective and consequently with a different behavioral response to particular forms of threat (Neuberg et al., 2011). While self-protection is associated with the emotion of fear, the disease-avoidance system is characterized predominantly by the emotion of disgust. Both of these emotions are functionally specific and respond to functionally different events (e.g., Keltner, Haidt, & Shiota, 2006; Nesse, 1990; Roseman, Wiest, & Swartz, 1994). While fear has been linked with escape or fighting (Bennett-Levy & Marteau, 1984), disgust has been thought to reinforce avoidance (Oaten, Stevenson, & Case, 2009; Phillips, Senior, Fahy, & David, 1998; Rozin, Haidt, & McCauley, 2000). In addition, the neurobiological core of the two systems differ (LeDoux, 2000; Neuberg et al., 2011; Oaten et al., 2009; Phillips et al., 1997).

Both self-protection and disease-avoidance systems are highly sensitive to varying socioecological conditions and are more likely to be engaged when environmental cues signal that individuals are temporarily more susceptible to the specific threat (Neuberg et al., 2011). Thus, the self-protection and disease-avoidance system should be activated particularly under conditions in which individuals perceive themselves as vulnerable to physical harm and infectious diseases, respectively. Current research supports this idea. With respect to the self-protection system, non-Black individuals in the United States are especially slow to unlearn fearful responses to the faces of Black strangers (Olsson, Ebert, Banaji, & Phelps, 2005), and this effect appears to be specific to male faces (Navarrete et al., 2009) probably because they pose a higher risk of physical threat than females (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007). Prokop and Fančovičová (2010a) revealed that humans with a lower perceived physical condition, and thus less able to defend themselves against a predator, had a stronger fear of brown bears (*Ursus arctos*) than individuals with a higher perceived physical condition. However, they did not examine the participants' fear of other animals, so that it is unclear whether the perceived physical condition mediates the fear of animals in general, or whether the physical condition is associated specifically with predators as might be expected from an evolutionary perspective (Røskaft et al., 2003). With respect to the disease-avoidance system, humans who think of themselves as more vulnerable to disease transmission have greater aversive responses to physically disabled individuals (Park, Faulkner, & Schaller, 2003), toward older adults (Duncan & Schaller, 2009), immigrants (Faulkner, Schaller, Park, & Duncan, 2004), obese people (Park, Schaller, & Crandall, 2007), or toward disease-transmitting animals (Prokop, Fančovičová, & Fedor, 2010; Prokop, Usak, & Fančovičová, 2010a, 2010b). They also exhibit more antipathogen behavior (Porzig-Drummond, Stevenson, Case, & Oaten, 2009; Prokop & Fančovičová, 2010b, 2011b; Prokop, Fančovičová et al., 2010). In addition, disgust responses are more exaggerated during the first trimester of pregnancy when females are immunologically compromised (Fessler, Eng, & Navarrete, 2005). Taken together, these examples suggest that the risk of physical harm is associated with fear and perceived vulnerability to diseases is associated with elevated disgust sensitivity and related behavior, also known as the behavioral immune system (Schaller, 2006). Females show a greater fear of predators (e.g., Bjerke, Reitan, & Kellert, 1998; Davey et al., 1998; Ericsson & Heberlein, 2003; Kaltenborn, Bjerke, & Nyahongo, 2006; Kellert, 1985; Kleiven, Bjerke, & Kaltenborn, 2004; Prokop, Özel, & Usak, 2009; Prokop & Tunnicliffe, 2010; Røskaft et al., 2003) perhaps due to a lower physical condition that does not allow for effective defense against predators compared to males (Røskaft et al., 2003). Females are also more disgust sensitive (for a review, see Oaten et al., 2009) because the choice of a mate with a low resistance to parasites can result in low parental investment. In addition, females care for infants who need to be protected from infectious diseases. On the other hand, it is speculated that both fear and disgust sensitivity could be influenced by sexual selection (Oaten et al., 2009), and/or that these differences are the result of conformance to traditional gender roles in which females are allowed to be fearful while males are not (Pierce & Kirkpatrick, 1992).

The Current Study

Most reported works examined only one part of the two proposed management systems, self-protection and disease avoidance. Moreover, even when both were examined simultaneously (e.g., Cottrell & Neuberg, 2005), these works were predominantly carried out in the field of social psychology, leaving predation as a powerful weapon of natural selection (Darwin, 1859/1958) unexamined. We examined whether predators and pathogens activate specific emotions that have evolved primarily to protect individuals against various environmental threats. We hypothesize that the emotions are activated by visual perception of two distinct groups of animals that influence human survival: predators and disease-relevant animals. We hypothesized the following:

- *Hypothesis 1:* Females would show an increased perceived vulnerability to diseases, a lower perceived physical condition, a greater fear, disgust, and a perceived danger of potentially dangerous animals than males.
- *Hypothesis 2:* Perception of predators would be associated with fear, and perception of disease-relevant animals would be associated with disgust.
- *Hypothesis 3:* Fear of predators would be negatively associated with perceived physical condition because better physical condition allows for successful counterattacks on a predator.
- *Hypothesis 4:* Disgust of disease-relevant animals would be associated with perceived vulnerability to disease.

Methods

Participants

The sample of participants (112 males and 85 females, 3 participants were excluded) consisted of 10–20-year-olds attending four randomly selected elementary and high schools in Western Slovakia. The mean age of the participants was 15.11 years (*SD* = 2.51). Our previous research (Prokop & Fančovičová, 2010b; Prokop et al., 2010a) had revealed that children of at least 8 years of age are sensitive to animals which pose a disease threat to humans. Thus, 10-year-old children seemed to be appropriate for testing our hypotheses. Participant parents were asked for permission to perform the research with their children 1 month prior to beginning this study. The participants were asked (1) for their age/grade; (2) for their sex; and (3) for incidence of illness last year ("How many times were you ill during the last year (365 days)?"). Participants were unaware of our hypotheses. After the research was completed, the participants were debriefed regarding the research goals.

Measuring of Disgust, Fear and Perceived Danger

We presented 15 color pictures in lecture halls to groups of students. Each picture contained one animal and was presented individually. Five pictures were predators (blue shark, *Prionace glauca*; common boa, *Constrictor constrictor*; brown bear, *Ursus arctos*; Bengal tiger, *Panthera tigris*; and gray wolf, *Canis lupus*); six pictures were disease-relevant animals (brown rat, *Rattus norvegicus*; head lice, *Pediculus capitis*; hard tick, *Ixodes ricinus*; Geoffroy's bat, *Myotis emarginatus*; house mouse, *Mus musculus*; and mosquito, *Anopheles gambiae*); and four pictures were control animals, i.e., neither predatory nor disease-relevant animals (horse, *Equus ferus caballus*; Eurasian red squirrel, *Sciurus vulgaris*; European rabbit, *Oryctolagus cuniculus*; and Old World swallowtail, *Papilio machaon*). The first two groups of animals were risky to humans in terms of a predation threat, decreased immunity, and/or health problems, and the latter group served as a control. We adjusted the picture sizes to a standard body length. The pictures had a similar contrast and brightness. The pictures were presented in random order. Each picture was presented for 1 min. During this time, participants rated their fear ("How afraid would you be of this animal if you encountered it in the field?"), disgust ("How disgusting would you consider this animal?"), and perceived danger ("How dangerous would you consider this animal?"), each on a 5-point scale (e.g., 1 = *not at all*, 5 = *extremely disgusting*). The ratings of fear, disgust, and perceived danger of animals were generally reliable for all three animal groups (predators: Cronbach's α = 0.70–0.83, disease-relevant animals: Cronbach's α = 0.59–0.81, control animals: Cronbach's αs = 0.54–0.58). Although the α values for the control animals were lower, other researchers reported α coefficients in a range between 0.43–0.95 (e.g., Goetz & Shackelford, 2009). We calculated individual scores for each subscale by averaging the responses to the constituent items. Age partly affected the mean scores of the perceived danger and disgust of the control animals (both $r = .17$, both $p < .05$), while other dimensions were unaffected by age (all $r < .01$, all $p > .1$). Age was thus defined as a covariate in further statistical analyses.

Measuring of Vulnerability to Diseases

The Perceived Infectability (PI) subscale derived from the Perceived Vulnerability to Disease scale (PVD; Duncan, Schaller, & Park, 2009) was used to assess the self-perceived vulnerability to disease of the participants. The questionnaire was administered in the Slovak language and was adapted from the translated version used in previous research (Prokop et al., 2010b). This subscale consists of 7 items and assesses beliefs about one's own susceptibility to infectious diseases (Cronbach's α = 0.75). The items were rated on the 5-point Likert scale from 1 (= *strongly disagree*) to 5 (= *strongly agree*). Example questions:

- "In general, I am very susceptible to colds, flu, and other infectious diseases"
- "If an illness is 'going around,' I will get it"

Negatively worded items were scored in reverse order. In the present study, the correlation between the PI subscale and the total number of illnesses over the last year (*M* = 2.38, *SD* = 2.05, range = 0–15) was moderate ($r = .39$, $p = .001$, $N = 197$). This provides additional support for the reliability of the PI subscale.

Measuring of the Perceived Physical Condition

To assess the perceived physical condition (PPC), seven items modified from the Physical Strength subscale (Hagger, Hulyaa Sci, & Indwall, 2004; Klomsten, Skaalvik, & Espnes, 2004) were used (actual Cronbach's $\alpha = .78$). The questionnaire was administered in the Slovak language and was adapted from the translated version used in previous research (Prokop & Fančovičová, 2010a). The items were rated on the 5-point Likert scale from 1 (= *strongly disagree*) to 5 (= *strongly agree*). Example items:

- "I am physically stronger than other people of the same age and sex."
- "I am able to be physically active for a longer time without a break."

We calculated individual scores for each subscale by averaging the responses to the constituent items. The mean score of the PI subscale correlated with the PPC subscale and ($r = -.23$, $p < .001$, $N = 197$). The PI subscale was consequently controlled for the effect of PPC with their residuals used in further statistical analyses. We controlled the mean score of the PPC subscale with the PI score with the same procedure. Age did not affect the PI or PPC score ($r = .09$ and $.03$, *ns*).

Design

The dependent variables in this research were the mean scores of fear, disgust, and perceived danger of the three types of animal groups (predators, disease-relevant animals, and control animals). The categorical predictor was gender, the mean score of the PPC subscale, the PI score, and age were treated as continuous predictors. The effect of age was not statistically significant in all the analyses (all $p > .28$, *ns*), so that effect is not further mentioned, though it is always included as a continuous predictor. Partial η^2 was used in order to measure the effect size (0.01 was considered small, 0.04 moderate, and 0.1 large; Huberty, 2002).

Results

Hypothesis 1

Gender Differences in PI and PPC

An analysis of covariance (ANCOVA) showed that there were significant differences between males and females in the PI score, meaning that females perceived themselves as more vulnerable to diseases than males ($F(1, 194) = 4.99$, $p = .03$, $\eta^2 = .03$, see Figure 1). Conversely, males scored higher in the PPC scale, suggesting that they perceived themselves as physically stronger than females ($F(1, 194) = 10.97$, $p = .001$, $\eta^2 = .05$, see Figure 1). These results support Hypothesis 1.

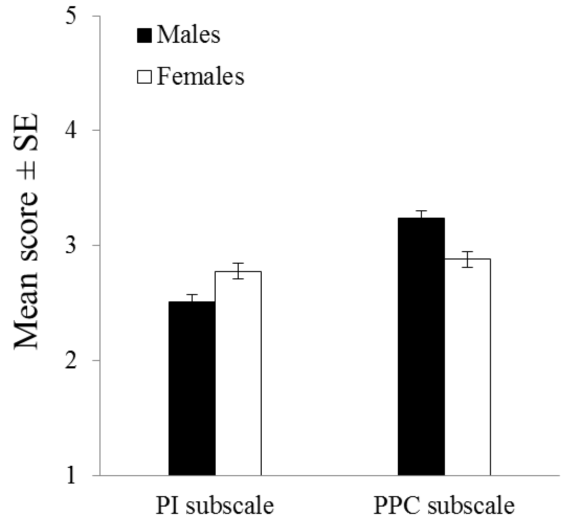

Figure 1. Differences in the mean scores of Perceived Infectability (PI) and Perceived Physical Condition (PPC) subscale between males and females based on raw data.

Gender Differences in Perceived Fear, Disgust, and Danger of Animals

A 3 (Type of animal group: within subjects) × 2 (Gender: between subjects) analysis of covariance (ANCOVA) was used to examine whether there are gender differences in fear of predators, disease-relevant animals, and control animals. There were significant gender differences in fear of animals ($F(1, 192) = 39.19$, $p < .0001$, $\eta^2 = .17$). The interaction term Gender × Type of animal group ($F(2, 384) = 12.55$, $p < .0001$, $\eta^2 = .06$) revealed that females showed a greater fear of predators and disease-relevant animals (Tukey posthoc test, both $p < .0001$), but not of control animals (Tukey posthoc test, $p = .65$) than males. These results support Hypothesis 1.

3 (Type of animal group: within subjects) × 2 (Gender: between subjects) ANCOVA with disgust of predators, disease-relevant animals, and control animals showed that there were significant gender differences in disgust of animals ($F(1, 192) = 14.68$, $p < .001$, $\eta^2 = .07$). The interaction term Gender × Type of animal group ($F(2, 384) = 8.94$, $p < .001$, $\eta^2 = .04$) revealed that females showed a greater disgust of predators and disease-relevant animals (Tukey posthoc test, both $p = .001$), but not of control animals (Tukey posthoc test, $p = .99$) than males. These results support Hypothesis 1.

Similarly, as previously found, a 3 (Type of animal group: within subjects) × 2 (Gender: between subjects) ANCOVA with perceived danger of predators, disease-relevant animals, and control animals showed that there were significant gender differences in the perception of animals ($F(1, 192) = 9.91$, $p = .002$, $\eta^2 = .05$). Females always scored higher than males, but the interaction term Gender × Type of animal group was not significant ($F(2, 384) =$

0.34, $p = .71$, $\eta^2 = .002$). The Tukey posthoc test, however, revealed that females showed a greater fear than males of predators and disease-relevant animals (Tukey posthoc test, $p = .03$ and .05, respectively), but not of control animals (Tukey posthoc test, $p = .19$). These results, again, support Hypothesis 1.

Hypothesis 2

Perception of Predators Associated with Fear, and Perception of Disease-Relevant Animals Associated with Disgust

Within-subjects ANCOVA revealed that predators were associated with the greatest fear, followed by disease-relevant animals and control animals ($F(2, 384) = 36.77$, $p < .0001$, $\eta^2 = .16$). Disease-relevant animals were associated with the greatest disgust, followed by predators and control animals ($F(2, 384) = 47.59$, $p < .0001$, $\eta^2 = .20$). Predators were perceived as most dangerous followed by disease-relevant animals and control animals ($F(2, 384) = 76.70$, $p < .0001$, $\eta^2 = .29$, see Figure 2). These results support Hypothesis 2.

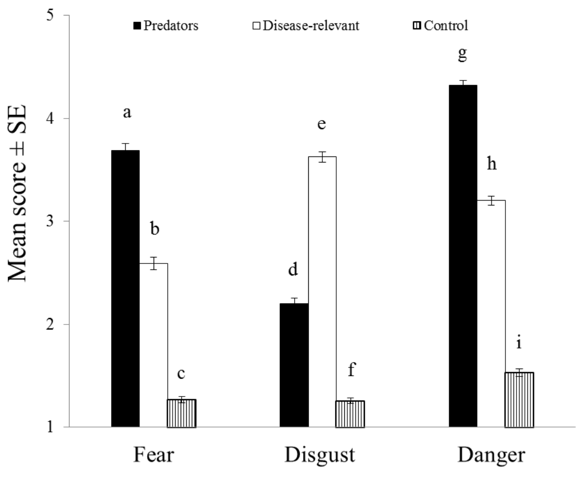

Figure 2. Perceived fear, disgust and danger of the three groups of animals. The letters above the bars denote differences between groups based on the Tukey posthoc tests.
a vs. b, b vs. c, a vs. c: all $p < .001$
d vs. e, e vs. f, d vs. f: all $p < .001$
g vs. h, h vs. i, g vs. i: all $p < .001$

Hypothesis 3

Perceived Danger and Fear of Predators Negatively Associated with Perceived Physical Condition

The extended results were derived from a 3 × 2 ANCOVA on fear of animals described above, which showed that there was an interaction term Type of animal group × PPC ($F(2, 384) = 12.97$, $p < .0001$, $\eta^2 = .06$). As hypothesized, PPC was significantly negatively associated with fear of predators ($\beta = -.30$, $t = -4.32$, $p < .0001$), but not with disease-relevant or control animals ($\beta = -.11$ and .09, $t = -1.58$ and 1.24, $p = .11$ and .22, respectively). Additional interaction terms were not significant (all $p > .13$). A 3 × 2 ANCOVA on the perceived danger of animals showed similar patterns. There was an interaction term Type of animal group × PPC ($F(2, 384) = 5.22$, $p = .006$, $\eta^2 = .03$). The mean PPC score correlated with the perceived danger of predators ($\beta = -.21$, $t = -2.92$, $p = .004$), but not with disease-relevant or control animals ($\beta = .05$ and .004, $t = 0.68$ and 0.05, $p = .50$ and .96, respectively). Additional interactions were not significant (all $p > .17$). Hypothesis 3 was therefore fully supported.

Hypothesis 4

Disgust of Disease-Relevant Animals Associated with Perceived Vulnerability to Disease

We failed to find a correlation, derived from the original ANCOVA model, between the PI subscale and disgust for disease-relevant animals ($\beta = .07$, $t = 0.93$, $p = .35$). Additional associations with the PI subscale were also not significant. Hypothesis 4 was therefore not supported. The PI subscale correlated, however, with the perceived danger of predators ($\beta = .18$, $t = 2.51$, $p = .013$), but not with the perceived danger of disease-relevant or control animals ($\beta = .02$ and .11, $t = 0.29$ and 1.50, $p = .78$ and .14, respectively). This suggests that participants who perceived themselves as vulnerable to infection transmission perceived predators as more dangerous.

Discussion

This study examined how two functionally distinct threat management systems, the self-protection and the disease-avoidance system, work within two ecologically distinct conditions: the predation and pathogen threat. We found certain evidence to support the idea that these two management systems are domain specific with each activating different emotions and behavioral responses (Cottrell & Neuberg, 2005; Neuberg et al., 2011). We argue, however, that these two systems are not *absolutely* domain specific, because the same emotions are being activated, though the level of activation varies. This is in accordance with Stark et al. (2003), who discovered that disgust and fear are processed in similar brain structures. Four hypotheses were tested:

Hypothesis 1: Females would show an increased perceived vulnerability to diseases, a lower perceived physical condition, a greater fear, disgust, and a perceived danger of animals than males.

In agreement with this hypothesis, we determined that females did perceive themselves as more vulnerable to diseases than males. Other researchers found mixed support for gender differences in perceived vulnerability to disease. Duncan and Schaller (2009) and Prokop and Fančovičová (2011a), for example, did not find gender differences in their samples, although Duncan et al. (2009) and Prokop et al. (2010b) discovered that females perceived themselves to be more vulnerable to diseases than males. It is possible that gender differences in the perceived vulnerability to disease and physical condition emerge only after puberty, in all probability as a result of the increased level of sex-specific hormones and physiological changes associated with muscle mass and strength. In agreement with this hypothesis, participants in Duncan's et al. (2009) and Prokop et al.'s (2010b) research were university students, which indirectly supports this idea. Further research with more details regarding the onset of puberty in participants is required to test this idea.

In line with a great deal of research demonstrating among females a greater fear of predators (e.g., Bjerke et al., 1998; Davey et al., 1998; Ericsson & Heberlein, 2003; Kaltenborn et al., 2006; Kellert, 1985; Kleiven et al., 2004; Prokop et al., 2009; Prokop & Tunnicliffe, 2010; Røskaft et al., 2003) and a greater disgust sensitivity (e.g., Curtis, Aunger, & Rabie, 2004; Oaten et al., 2009; Prokop & Fančovičová, 2010b, 2011a, 2011b; Prokop et al., 2010, 2010a, 2010b; Tybur, Lieberman, & Griskevicius, 2009), we found that females scored higher in fear, disgust, and perceived danger of predators and disease-relevant animals than males. Greater fear of predators could be explained by the weaker physical condition of females, which precludes effective combat with a predator (Røskaft et al., 2003). Our data partly support this hypothesis, because (1) females had a lower perceived physical condition than males and (2) the perceived physical condition correlated negatively with fear of predators. With respect to the disease-avoidance system, certain authors hypothesize that females have a greater investment in offspring than males, so that the costs of being contaminated are higher and sensitivity to disgust is consequently higher in females than in males (e.g., Curtis et al., 2004; Oaten et al., 2009). Perhaps correspondingly, reported mortality from infectious disease is substantially lower in females than in males (Owens, 2002). Perhaps further study not involving children but only women could shed more light in the evaluation of this hypothesis. Further research controlling varying levels of certain sex-specific hormones (e.g., estrogen in females) is necessary to determine whether participants reached sexual maturity. However, the significant interaction term Gender × Type of the animal group in fear and disgust of predators and disease-relevant animals (but not with control animals) suggests that female self-protection and disease-avoidance systems respond specifically, but not superficially, to environmental cues to reduce the fitness costs of potential threats. Interestingly, Stark et al. (2003) did not find gender differences in brain activity when their participants were exposed to various fear- and disgust-relevant pictures. However, the stimuli used in their research were not focused solely on animals, suggesting that methodological differences could account for the significant gender differences found in the present research.

Hypothesis 2: Perception of predators would be associated with fear and the perception of disease-relevant animals could be associated with disgust.

Our results support this hypothesis since the mean score of fear and perceived danger of predators was higher than the mean scores of disease-relevant and control animals. In contrast, disease-relevant animals were perceived as more disgusting than predators or control animals. This suggests that the self-protection system represented predominantly by fear is activated when humans encounter predators, and that the disease-avoidance system is activated in contact with disease-relevant animals. Previous research showed that disease-relevant vertebrates were associated with greater fear than disease-relevant invertebrates (Prokop et al., 2010b), which would suggest that large animals are generally perceived as more dangerous than small animals. This example clearly supports the idea that the two management systems do not react to *specific* cues triggered by predators/parasites, because these may greatly vary (Neuberg et al., 2011; Schaller & Duncan, 2007). The responses of these two systems may sometimes be incorrect, but this is explained by the fact that the costs of errors exceed the benefits from perfect discrimination of fear/disease-relevant and irrelevant cues (Haselton & Nettle, 2006). It is better, for example, to escape a wolf regardless of whether it is rabid or not, because any contact is *potentially* dangerous, particularly in terms of physical harm.

Hypothesis 3: Fear of predators would be negatively associated with the perceived physical condition.

In line with current hypotheses, activation of the self-protection system examined here in the context of fear of predators has been associated with the perceived physical condition supporting Hypothesis 3. The perceived physical condition did not correlate with the reported fear of disease-relevant or control animals supporting the idea that the two management systems are at least partly distinct and domain specific (Neuberg et al., 2011). We propose that the evolutionary significance of this association can be explained by the ability to escape predation in some animals as well as in our ancestors (Prokop & Fančovičová, 2010a; Røskaft et al., 2003). Early hominids who were under a high predation threat (reviewed by Treves & Palmqvist, 2007) could search for food in available sites more successfully when their physical condition was high and they were therefore more able to escape or counterattack predators. Our data are based on participants' *perceived*, not on their *real* physical condition. But perceived physical condition would reflect the real physical condition. More precise measurements of the physical condition of the participants would be required.

Hypothesis 4: The disgust of disease-relevant animals would be associated with the perceived vulnerability to disease.

Hypothesis 4 was not supported as there were no associations between the reported disgust of disease-relevant animals and the perceived infectability score. These results, however, should be taken with caution, because, for example, perceived vulnerability to disease was a subjective evaluation, not a validated report by a respondent's GP or parents. It could well be that people who are generally more anxious (e.g., neurotic) see themselves as more susceptible to infectious diseases as well as report more illnesses over the last year. At present, it is not clear why disgust did not correlate with perceived infectability. We would assume that the origin of infectious diseases would partly explain this problem. While research supporting an association between disgust and a perceived vulnerability to diseases has been carried out with special attention to the disgust of other people (Duncan & Schaller, 2009; Faulkner et al., 2004; Fessler et al., 2005; Park et al., 2003, 2007) and/or using the disgust scale (Haidt, McCauley, & Rozin, 1994) containing mixed items for measuring the various dimensions of disgust, the present research is based exclusively on human emotions toward animals. In light of the fact that infectious diseases have a zoonotic origin (Wolfe, Dunavan, & Diamond, 2007) and many animals were historically harmful to humans (Treves & Palmqvist, 2007), it may be that emotions elicited exclusively by animals might be associated more with fear when compared to emotions elicited with other subjects or objects. Clearly, further research focused on self-protection and disease avoidance within the social and biological sciences is necessary. However, the perceived infectability positively correlated with the perceived danger of predators. This result supports previous research indicating that people who felt themselves more vulnerable to diseases, perceive disease-relevant animals as more dangerous (Prokop et al., 2010a, 2010b), or have a greater fear of them (Prokop et al., 2010). Future research should further investigate activation of human emotions on older participants with and without their own children, with larger, more diverse samples. The perceived and actual threat should be taken into consideration, perhaps with comparing humans from countries where the density of important parasites/predators significantly differs.

Conclusions

Our research supports the idea that the self-protection system characterized by fear is associated with the perceived physical condition in modern humans. Disease-relevant animals are associated with elevated disgust. As expected, females showed higher fear, disgust, and perceived danger particularly when rating predators and disease-relevant animals. Taken together, our results suggest that emotions could be shaped by natural selection.

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