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ARTICLE

Health and the avoidance of macroparasites: a preliminary cross-cultural study

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Abstract Some evolutionary explanations of cross-cultural differences propose that human personality is caused by pathogen stress. Both xenophobia and ethnocentrism evolved under conditions with high parasite prevalence. Further, inter-individual variation in disgust or fear of parasites is expected to be influenced by human health, where healthy people should express lower disgust sensitivity to parasites. We examined inter-individual variation of children's fear, disgust and self-perceived danger between two distinct cultures differing in overall pathogen prevalence. We found that children were able to distinguish between disease-relevant and disease-irrelevant groups of invertebrates and that children in regions with high pathogen prevalence expressed greater fear, disgust and self-perceived danger of all animals, irrespective of disease threat. After controlling for confounding factors, better health of children was associated with lower perceived danger of disease-relevant animals. Gender differences were found only in conditions with low pathogen stress. Our results support the idea that cross-cultural differences in human perception of animals are mediated by pathogen threat. Further research is necessary to investigate causal relationship between human health and avoidance of potentially hazardous animals.

Keywords Cross-cultural research · Disgust · Fear · Health · Human · Parasites

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Introduction

Parasites pose threats to the health of humans and cause serious disease problems or even deaths of millions of people a year (Macpherson 2005). In extant hunter–gatherer groups, about 30–50% of the population dies before reaching reproductive age, most from disease (Hill and Hurtado 1996). Parasite threat is therefore expected to influence not only human survival but also evolution of effective immunological and behavioural responses that lower costs of parasitism in the arms races between parasites and their hosts (Behnke 1990).

Besides the immune system, which works after a parasite enters the human body, selection pressures posed by parasites led to the evolution of an antiparasite defence system that inhibits contact with potentially infectious objects. This behavioural immune system is defined as a set of mechanisms that allow individuals to detect the potential presence of parasites in objects (or individuals) and/or to prevent contact with those objects (or individuals) (Schaller 2006; Schaller and Duncan 2007).

Several researchers propose that disgust may be an adaptive strategy to decrease the likelihood of being infected by pathogens (Curtis et al. 2004; Rubio-Godoy et al. 2007). Empirical evidence reveals that both humans and nonhuman animals show a disgust reaction and behavioural rejection toward objects (or individuals) that are potentially contaminated by parasites (Goodall 1986;

Kiesecker et al. 1999; Curtis et al. 2004). Disgust is apparently distinguishable from fear (Phillips et al. 1997); while disgust involves withdraw of activity, fear heightens activity in preparation for fight or flight (Lerner 2005).

According to predictions based on evolutionary psychology, inter-individual variation of disgust sensitivity should vary according to risk of being infected by (parasitic) disease. The cost of being infected is higher in people with compromised immune system, but lower in healthy people (Stevenson et al. 2009). The former group is therefore expected to express greater levels of disgust than the latter group. Some data reveal that human health may be responsible for these differences; for example, Park et al. (2003) found that individuals who score highly on a measure of perceived vulnerability to disease (PVD) were less likely to report having friends or acquaintances with disabilities. Complementarily, Faulkner et al. (2004) found that higher levels of PVD predicted stronger anti-immigrant attitudes, but only toward immigrants from subjectively foreign locations; there was no similar effect on attitudes toward culturally familiar immigrant populations. These findings support the evolutionary logic of how the behavioural immune system works: both people with physical disabilities and immigrants may pose greater risk of disease transmission, thus the behavioural immune system is activated, especially in people who perceive themselves as more vulnerable to disease threat. It is therefore predicted that negative attitudes toward others (xenophobia) and positive attitudes toward one's own cultural ingroup (ethnocentrism) are posed by risk of disease in a given geographic area (Navarrete and Fessler 2006; Fincher et al. 2008; Schaller and Muray 2008). Furthermore, xenophobia and ethnocentrism are greater in humans with compromised normal immunological defence (Navarrete et al. 2007).

The present study examined the role of the behavioural immune system of school children under conditions with high and low parasite prevalence. We chose two distinct countries from Europe and Asia (Slovakia and Turkey). Historical and current records reveal that Turkey poses more parasitic diseases than Slovakia (Guernier et al. 2004; Fincher et al. 2008; Schaller and Muray 2009). We predicted that (1) parasitic invertebrates that are associated with potential disease risk will be perceived differently (in terms of participants' self-perceived fear, disgust and danger elicited by colour pictures) as compared with disease-irrelevant invertebrates; (2) the behavioural immune system (self-perceived fear, disgust and danger) will be more activated in participants from countries with higher pathogen prevalence (or, alternatively, disease exposure would result in lower disgust sensitivity as a result of habituation) and (3) the behavioural immune system will be more activated in participants with lower self-perceived health score. We also controlled for gender differences (4), expecting that the behavioural immune system will be more activated in females, as repeatedly suggested by previous works (e.g. Curtis et al. 2004).

Methods

The sample

The participants of the study consisted of 314 primary and secondary school students (85 females and 65 males from Slovakia and 72 females and 92 males from Turkey) aged between 8 and 15 years old in Turkey and Slovakia. The mean age of participants was 11.79 years (SE $= 0.09$ years) and was not significantly different between the two countries (Mann–Whitney U test, $U = 10{,}968.50$, $P = 0.10$). The participants responded to questions related to (1) age/grade, (2) gender, (3) whether they have any animals as pets or farm animals, and, if yes, (4) what animal species they have as pets or farm animals, (5) whether they live in a home with or without garden and (6) whether they live in a city or in a village.

The mean scores of the general health questionnaire were not significantly different for urban/rural participants and for participants with or without garden. Also, mean scores of disgust, fear or perceived danger were not significantly different between these subgroups of participants. Therefore these factors were excluded from later analyses.

Measuring of disgust, fear and perceived danger

We presented 25 colour pictures (5 disease-relevant adult insects, 5 ectoparasites, 5 endoparasites, 5 disease-irrelevant adult insects and 5 insect larvae/earthworm) in lecture halls (see the Appendix for a complete list of species). 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 controls. 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, disgust and how dangerous they thought the animal was in nature, each on a 5-point scale (e.g., 1 = not at all, 5 = extremely dangerous).

General health

To measure the current health of participants, a general health questionnaire (GHQ) was used. It consisted of 45 statements adopted from literature (Goldberg and Hillier 1979; Kind et al. 1998). Each question was answered on a 5-point scale (1 = strongly disagree, 5 = strongly agree). Negative items were reverse scored. Sample items include, for example, "I am sick all the time", "I feel stress in my head", "I regulary take medicine", and "I have hypersensitiveness". Higher values on the GHQ indicated better general health.

Pathogen prevalence

We acquired human pathogen prevalence scores for Slovakian and Turkish students from the Global Infectious Disease and Epidemiology Network (GIDEON; http://www.gideononline.com) in July 2009. GIDEON is a continually updated database available to the medical community and researchers. The same method was used by Fincher and Thornhill (2008). We used a set of parasites similar to those used in prior research (Gangestad et al. 2006; Fincher and Thornhill 2008; Schaller and Muray 2009). We classified the country-wide disease level of major groups of parasites: leishmanias (two types), trypanosomes, malaria, schistosomes, the filariae, spirochetes (seven types), leprosy, typhus and dengue. We used GIDEON's three-point scale of parasite prevalence (3 = endemic, 2 = sporadic, 1 = not endemic) based on distribution maps provided in GIDEON following Fincher and Thornhill (2008). Lyme disease and leprosy were treated differently because GIDEON does not map the precise distribution. Thus, we coded infection rates per capita of 0–0.01/100000 as 1, 0.01–1/100000 as 2 and >1/100000 as 3 (Fincher and Thornhill 2008).

Statistical analyses

To examine possible differences in fear, disgust and danger ratings between the five animal groups, we used multivariate analysis of covariance (MANCOVA) including the five animal groups (disease-relevant groups: disease-transmitting insects, endoparasites, ectoparasites; disease-irrelevant groups: adult insects and insect larvae) as independent variables and the scores on the ratings (fear, disgust and danger) as dependent variables. The number of owned animals reported by participants was used as a covariate, because this might influence participants' attitudes toward animals (e.g. Prokop et al. 2009; Prokop and Tunnicliffe 2010). Separate for each rating scale and pairwise post hoc Tukey tests were performed to compare animal groups, country and gender differences. Multiple regression (forward stepwise method) was used to examine effects of ratings on GHQ score. Because data were not normally distributed, pathogen prevalence score was compared by Wilcoxon signed ranks test.

Results

Pathogen prevalence

The prevalence of major parasitic diseases was significantly higher for Turkish students as compared with Slovakian students (Wilcoxon signed ranks test, $Z = 2.20$, $P = 0.03$, $n_1 = n_2 = 16$). Especially, serious parasitic diseases such as filiariasis, leishmaniasis, malaria and schistosomiasis were not reported for Slovakia (GIDEON).

Rating scores

Effect of country

The reliability of respondents' ratings was highly consistent (Cronbach's $\alpha = 0.97$). Mean ratings of fear, disgust and danger for all five animal groups are shown in Fig. 1. Disgust scores were consistently higher than ratings of fear and dangerousness in Slovakia, but dangerousness was rated highest in Turkey.

Three-factor multivariate analysis of covariance (MANCOVA) revealed that participants' rating scores were significantly influenced by country ($F_{3,1547.0} = 713.62$, $P < 0.001$, $\eta^2 = 0.58$, Fig. 1). The total number of animals that were kept as pets by the participants (defined as a covariate) did not have a significant effect on rating scores ($F_{3,1547.0} = 0.86$, $P = 0.46$).

Turkish participants rated all animals higher, which means that animals were perceived as more fearful, disgusting and dangerous, compared with Slovakian participants. Subsequent Tukey post hoc pairwise comparison revealed that these differences were significant for all groups of animals between the two countries (all $P < 0.001$).

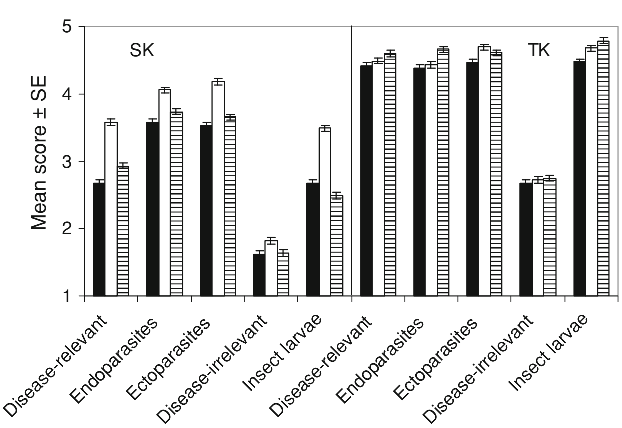

Fig. 1 Ratings of fear (*black bars*), disgust (*open bars*) and danger (*line bars*) of five groups of animals in Slovakia (*SK*) and Turkey (*TK*)

Effect of animal group

Multivariate ANOVA revealed that there was a significant effect of animal group on each rating scale ($F_{12,4093.72} = 220.6$, $P < 0.001$, $\eta^2 = 0.39$). These ratings were highly dependent on country because country-animal group interaction was significant ($F_{12,4093.27} = 35.2$, $P < 0.001$, $\eta^2 = 0.09$). As shown in Fig. 1, ectoparasites and endoparasites were rated as most fearful, dangerous and disgusting, followed by disease-relevant insects, insect larvae and disease-irrelevant insects in Slovakia. In contrast, Turkish participants rated all animal groups, with the exception of disease-irrelevant insects, very similarly.

Significance of gender

Both effect of gender ($F_{3,1547.0} = 37.44$, $P < 0.001$, $\eta^2 = 0.07$) and interaction between country and gender ($F_{3,1547.0} = 35.80$, $P < 0.001$, $\eta^2 = 0.06$) were statistically significant. Slovakian females scored significantly higher in ratings of disgust, fear and dangerousness than Slovakian males (all P based on Tukey's post hoc pairwise comparisons were less than 0.001). Interestingly, however, Turkish males and females scored almost identically (all Tukey's $P > 0.99$) (Fig. 2).

Does health influence emotions toward animals?

The general health questionnaire (GHQ) was highly reliable ($\alpha = 0.89$). We therefore used the mean score of all 45 items for subsequent analyses. Slovakian participants showed higher mean score on the GHQ than did Turkish participants (mean ± SE, 3.93 ± 0.04 and 3.78 ± 0.03, respectively) (ANOVA, $F_{1,310} = 10.26$, $P = 0.002$). However, the effect size for this difference was very small

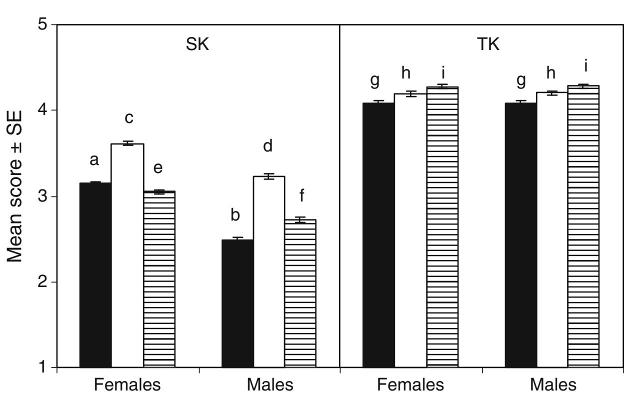

Fig. 2 Gender differences in overall ratings of fear (*black bars*), disgust (*open bars*) and danger (*line bars*) of animals in Slovakia (*SK*) and Turkey (*TK*). *Letters above bars* denote differences based on Tukey post hoc test. *a* versus *b*, *c* versus *d*, *e* versus *f* $P < 0.001$; *g* versus *g*, *h* versus *h*, *i* versus *i* $P > 0.99$

($\eta^2 = 0.032$). The effect of gender on GHQ score was not significant ($F_{1,310} = 0.001$, $P = 0.98$, $\eta^2 < 0.001$).

The mean score of the category of insect larvae/earthworm was similar to the score for disease-relevant insects and parasites (Fig. 1). We therefore pooled all these categories (i.e. except for disease-irrelevant adult insects) and used mean scores of fear, disgust and dangerousness (independent variables) to examine whether GHQ score (dependent variable) was associated with animal avoidance. Removing the insect larvae/earthworm category did not influence the results of this analysis. Forward stepwise multiple regression, in which age of participants, gender and effect of country were controlled, revealed that only disease-relevant insects and parasites (pooled with insect larvae/earthworm) were associated with GHQ score ($F_{3,310} = 6.95$, $R^2 = 0.063$, $P < 0.001$). Disease-irrelevant adult insects were removed from the multiple regression model (Table 1). Perceived danger showed significant negative association with GHQ score, which means that, the higher the level of perceived danger, the lower the GHQ scores.

Discussion

This study examined the relationship between human self-perceived health and the behavioural immune system under conditions with low and high parasite prevalence. Although our study found associations between human health and perceived danger, fear and disgust of potentially hazardous animals, further research is needed to examine the causal relationship between these factors. In agreement with current evidence showing that pathogens are more prevalent in tropical zones compared with more temperate zones (e.g. Guernier et al. 2004), pathogen prevalence was higher in Turkey (Mediterranean region) compared with Slovakia (temperate region). Four hypotheses discussed below were explicitly tested:

(1) Parasitic invertebrates that are associated with potential disease risk will be perceived differently as compared with disease-irrelevant invertebrates.

Table 1 Forward stepwise multiple regression model with perceived danger, disgust and fear of disease-relevant invertebrates (pooled with insect larvae/earthworm) as predictors, and GHQ defined as dependent variable

	β	SE of β	B	SE of B	t(310)	P
Intercept			0.00	0.02	0.00	1.00
Danger	−0.24	0.08	−0.24	0.08	−3.06	<0.001
Disgust	0.14	0.08	0.12	0.07	1.80	0.07
Fear	−0.10	0.09	−0.07	0.07	−1.05	0.29

This hypothesis was at least partly supported. In general, participants were able to distinguish between disease-relevant and disease-irrelevant invertebrates, because the former group of animals elicited higher level of danger, fear and disgust than the former group of animals. These differences were more pronounced under conditions with lower parasite risk (Slovakia) whereas ecto- and endoparasites received higher mean score of fear, disgust and danger than potential vectors of diseases (adult insects) or insect larvae. Our findings extend previous findings of Davey et al. (1998), Curtis et al. (2004) and Gerdes et al. (2009), who also found that disease-relevant objects (or individuals) were perceived as more disgusting or dangerous than others. However, the category of insect larvae/earthworm (i.e. also disease-irrelevant invertebrates) evoked similar responses to that of disease-relevant insects, which supports the idea that worm-like invertebrates may be avoided because they are long, wriggly and/or slimy and resemble intestinal helminths (Curtis and Biran 2001). In addition, worms are often associated with corpses, which are also considered disgusting (Rozin et al. 2000), so avoiding such animals may be viewed as an adaptive strategy. Finally, the behavioural immune system does not react to specific cues triggered by parasites, because these may greatly vary; instead it responds in a hypersensitive and overgeneral way to the perceived presence of parasites in the sensory environment (Schaller and Duncan 2007). Thus, low differences in mean scores of insect larvae/earthworm and similarly looking parasites are expectable. Lower differences between animal subgroups found among Turkish participants would be explained by generally higher risk of being infected by parasites (see below, hypothesis 2). In summary, our results support the biological preparedness hypothesis which proposes that fear learning associated with animals that were potentially hazardous for our pretechnical ancestors is specific to selective cues (i.e. disease-relevat animals) (Seligman 1971).

(2) The behavioural immune system (self-perceived fear, disgust and danger) will be more activated in participants from countries with higher pathogen prevalence. In strong agreement with this hypothesis, Turkish children who are more vulnerable to pathogen stress showed significantly higher fear, perceived danger and disgust in ratings of all animal species (both disease relevant and irrelevant). This means that the alternative hypothesis which proposed that participants exposed to higher pathogen threat would be less sensitive to parasites by habituation was not supported. Slovakian children generally rated animals highest on disgust, but Turkish children rather rated animals as dangerous. It is probable that costs of incautious behaviour are relatively higher in Turkey, where the risk of disease transmission is higher. Thus, Turkish peoples may adopt a more cautious and conservative attitudes toward animals (Nettle 2006; Schaller and Muray 2008). In Slovakia, where the costs of incautious behaviour are relatively lower, the pressures toward cautious behaviour are much lower than in Turkey.

(3) The behavioural immune system will be more activated in participants with lower self-perceived health score. Ratings of danger and fear by Slovakian children partially support this hypothesis, because children with higher GHQ score tended to rate disease-relevant animals (and insect larvae/earthworm) as less dangerous and showed lower fear of these animals. The observation that mean scores of disease-irrelevant adult insects were not associated with GHQ score also supports the idea that greater vulnerability to disease activates the behavioural immune system (Park et al. 2003; Faulkner et al. 2004; Navarrete and Fessler 2006; Navarrete et al. 2007; Schaller and Duncan 2007). However, one important question arises: Why is there no stronger association between GHQ score and ratings of animals?

We suggest that stronger association could not be reached because GHQ includes a very broad range of potential health problems, rather than items focusing on parasitic diseases in particular. Future research using, for example, the perceived vulnerability to disease scale (PVD) (see Duncan et al. 2009), is required to examine the association between avoidance of animals and perceived disease risk in humans. However, the use of GHQ still has merit because GHQ positively correlates with PVD (Duncan et al. 2009). Further research, for example on immunologically compromised individuals (which warrants greater inter-individual variability), would provide fruitful information on the importance of health in anti-parasite avoidance behaviour.

(4) The behavioural immune system will be more activated in females. Slovakian females scored significantly higher than males in danger, disgust and fear dimensions. This is consistent with women's enhanced evolutionary role in protecting the next generation (e.g. Fessler and Navarrete 2003). The absence of gender differences in disgust sensitivity or danger in Turkey disagrees with previous research (Curtis et al. 2004; Gerdes et al. 2009), but this result may be influenced by the relatively higher prevalence

of pathogens in that country. It is possible that benefits of incautious behaviours are too low to enhance any gender differences in this region. Another possibility is that all of the scores in Turkey were so high that there was insufficient variation to detect gender differences. Further research is, however, necessary to examine why risky behaviour of males is more pronounced in regions with low pathogen stress.

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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 pinworm (*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 swallowtail (*Papilio machaon*).

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

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