PSIHOLOGIJA, 2011, Vol. 44 (4), 281–293

UDC: 613(437.6)
DOI: 10.2298/PSI1104281P

Preferences for spicy foods and disgust of ectoparasites are associated with reported health in humans

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Infectious diseases that influence human survival are responsible for the evolved emotional, cognitive and behavioural strategies that reduce the risk of disease transmission. The preference for spices in foods of contemporary humans was thought to be an anti-pathogen strategy that could reduce disease transmission. We investigated the possible associations between reported health and anti-pathogen strategies in a sample of Slovak high school students. We found that the reported consumption of spices and ectoparasite avoidance was positively associated with the total number of reported illnesses in the last year and hand washing was negatively associated with this. This means that immunologically compromised people prefer spices more and avoid contact with disease-relevant insect vectors more than their healthier counterparts. Females engaged in anti-pathogen behaviours more than males, but consumed spicy foods less frequently, suggesting their evolutionary role in the maternal investment to their offspring or different susceptibility to certain diseases. Our results suggest that people vulnerable to diseases are more disgust sensitive and prefer foods with antimicrobial properties more than healthy people, supporting an idea that human emotions and behaviour are influenced by the threat of parasites.

Key words: *anti-pathogen behaviour, disgust, parasites, spices*

In the process of natural selection, certain alleles, rather than others, are favoured for survival and the reproduction of their bearers. This results in a non-random distribution of certain alleles/phenotypes in the human population. Human emotions, cognitive functions and behavioural strategies evolved in response to the pressures of selection in ancestral environments (reviewed by Michalski & Shackelford 2010; Schaller, Conway, & Peavy, 2010).

Pathogens are believed to be one of the most powerful weapons of natural selection. The current report of the World Health Organisation (WHO, 2010) shows that in 2008, there were an estimated 243 million cases of malaria, causing 863,000 deaths. In the same year, about 2 million people died from diseases

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associated with AIDS, and 496 million people were treated for lymphatic filiariasis (WHO, 2010). All this data, of course, does not realistically reflect the pathogen threat that influenced the survival of our ancestors. For example, leprosy dropped from 5.2 million cases in 1985 to 213,036 cases in 2009 (WHO, 2010). In the 1300s, plague is estimated to have killed between 25% and 50% of the populations of Europe, Asia and Africa (Gottfried, 1983), but recently there have been no known cases of plague in Europe, and only few cases were reported worldwide in 2009 (WHO, 2010).

The effects of pathogens on human survival can be demonstrated at a population and individual level. With respect to the former, research has shown that human populations living under severe parasitic constraints have increased reproductive investment, represented by increases in both the weight (Thomas et al., 2004) and the number of offspring (Guégan, Thomas, de Meeüs, Hochberg, & Renaud, 2001). This suggests that natural selection favours heavier newborns (who are less susceptible to parasitic diseases) and a larger number of offspring in areas where parasite-driven mortality is high. Fincher (2008) found a positive association between pathogen prevalence and the cultural value of collectivism, arguing that collectivism evolved as effective anti-pathogen psychology. Collectivism is associated with higher ethnocentrism (attraction and support of internal members) and xenophobia (i.e. avoidance of and dislike towards external members) than individualism (Fincher, Thornhill, Murray, & Schaller, 2008; Thornhill, Fincher, & Devaraj, 2009). In regions that have historically suffered from high levels of infectious diseases, people report lower mean levels of extraversion and openness (Schaller & Murray, 2008). Living in smaller groups separated from others possesses a smaller risk of pathogen transmission, and one of the results of grouping could be an increased number of religions. It has been suggested that collectivism and xenophobia could be evolutionary mechanisms that cause increased religious diversity in geographic areas with high pathogen stress (Fincher & Thornhill, 2008). With respect to the latter, several researchers propose that disgust may be an adaptive strategy to decrease the likelihood of being infected by pathogens (Curtis & Biran, 2001; Curtis, Aunger, & Rabie, 2004; Rubio-Godoy, Aunger, & Curtis, 2007). Schaller (2006) and Schaller and Duncan (2007) introduced *behavioural immune systems*, which are defined as a set of mechanisms that allow individuals to detect the potential presence of parasites in objects (or individuals) and act to prevent contact with those objects (or individuals).

Recent research indicates that the behavioural immune system in general and the emotion of disgust in particular are important parts of any pathogen avoidance system (reviewed by Oaten, Stevenson, & Case, 2009; Schaller & Duncan, 2007; see also Tybur, Lieberman, & Griskevicius, 2009). It has been shown that the behavioural immune system is particularly activated amongst immunologically compromised individuals (Fessler, Eng, & Navarrete, 2005;

Navarrete, Fessler, & Eng, 2007). This is thought to be because there would be a higher cost from invasion of parasites for them compared to healthy individuals. For example, humans who think themselves more vulnerable to disease transmission have greater aversive responses to physically disabled individuals (Park, Faulkner, & Schaller, 2003), towards elderly individuals (Duncan & Schaller, 2009), immigrants (Faulkner, Schaller, Park, & Duncan, 2004), or toward disease transmitting animals (Prokop & Fančovičová, 2011; Prokop, Fančovičová, & Fedor, 2010; Prokop, Usak, & Fančovičová, 2010a; Prokop, Usak, & Fančovičová, 2010b). With respect to active pathogen avoidance behaviours in humans, it has been found that sensitivity to disgust correlates with reported anti-parasite behaviours such as hand washing or avoiding physical contact with pets (Porzig-Drummond, Stevenson, Case, & Oaten, 2009; Prokop & Fančovičová, 2010; Prokop et al., 2010). Females are expected to perform more anti-parasite behaviours, because their parental investments are higher (Curtis et al., 2004; Oaten et al., 2009), but this was not always supported. In a number of studies, females scored higher in anti-parasite behaviours than males (Porzig-Drummond et al., 2009; Prokop & Fančovičová, 2011), but certain studies showed reverse patterns (Prokop et al., 2010) or no gender differences in anti-parasite behaviour (Prokop & Fančovičová, 2010).

Besides anti-parasite behaviour related to the avoidance of animals known to transmit serious zoonotic diseases to humans (Wolfe, Dunavan, & Diamond, 2007), some researchers propose that eating spicy foods might also be an effective anti-pathogen strategy (Billing & Sherman, 1998; Ohtsubo, 2009). The importance of spices as a sign of wealth is underlined by that fact that Alaric the Goth, who laid siege to Rome in 408 AD, demanded as ransom various precious metals and 3,000 pounds of pepper (Sherman & Billing, 1999). Most spices contain secondary compounds that kill bacteria and fungi or inhibit their growth (Billing & Sherman, 1998); thus, the use of spices, especially in meat-based recipes (Ohtsubo, 2009; Sherman & Hash, 2001) would be adaptive. Spices could have nutritional and health benefits: for example, they tend to be antioxidants, which are thought to reduce oxidative damage to cells (Sengur et al., 2011). It has even been suggested that consumption of turmeric (cucurmin) might contribute to the low prevalence of Alzheimer's disease in India (Gomez Pinilla, 2008). The use of spices might reduce foodborne diseases and food poisoning (Billing & Sherman 1998; Yossa, Patel, Miller, & Lo, 2010). To support this antimicrobial hypothesis, Billing and Sherman (1998) found that recipes from hotter climates, where bacteria and fungi grow more rapidly, called for more spices. Similarly, Ohtsubo (2009) found that unheated Japanese recipes called for more spices and vinegar than heated recipes, supporting the antimicrobial hypothesis. Interestingly, however, interpersonal differences in preferences of spices have never been studied from an evolutionary perspective.

In this study, we examined the associations between perceived health and certain anti-pathogen behaviours in a sample of young Slovak people. We hypothesised that people who perceive themselves more vulnerable to disease transmission would engage in various anti-pathogen behaviours (including consumption of spices) more than their healthier counterparts (Schaller & Duncan, 2007; Stevenson, Case, & Oaten, 2009). Anti-pathogen behaviours are expected to be more pronounced in females, who invest themselves in reproduction more than males and should therefore protect their children against potentially harmful events (Curtis et al., 2004). We predict that people who are more frequently ill 1) would perform more anti-pathogen behaviours and 2) would consume spicy foods more often to avoid further illness. Alternatively, frequently ill people would avoid spicy food, because it can cause additional suffering (e.g. problems with the gastrointestinal tract), or healthy people are healthy because they use more anti-pathogen strategies and prefer spicy food more often than frequently ill people. Lastly, we predict that 3) females would have a higher score as regards anti-pathogen behaviour than males, because their parental investment is higher than those of males.

Method

Participants. A total of 189 volunteers attending two high schools (116 females and 73 males) with a mean age of 17.88 (SE = .09) years (range = 16 – 18 years) participated in the study. Both these schools are typical of state schools. A classroom teacher administered questionnaires once. Participants were asked for personal information in the questionnaire: (1) their age and (2) gender.

Instruments. **Avoidance of parasitic diseases.** We self-constructed a new five-point Likert style Pathogen Avoidance Scale (PAS; 28 items with actual Cronbach's α = 0.81). The items on the PAS followed Macpherson's (2005) review on the role of human behaviour and transmission of parasitic diseases. Negatively worded items were scored in reverse order. The Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy (0.76) and Barlett's test of sphericity (χ^2 = 1302.5, df = 351, p <.001) yielded significant results (the minimal recommended value of the KMO test is 0.6, see Kaiser, 1974), which allowed us to submit data to the Principal Components Analysis (PCA with Oblimin rotation and Kaiser normalisation). The PCA resulted in eight independent components (PC1 – PC8) with eighteen values> 1.0. Researchers have disagreed on the minimum load that warrants item retention (Sharma, 1996; Tabachnick & Fidell, 2001), so we used a liberal assignment criterion of at least .40 following similar research works (e.g. McKibbin et al., 2008; Thompson & Mintzes, 2002). Exclusion of components that were represented by ≤ 2 items and exclusion of items that loaded to more than one component (Tybur et al., 2009) resulted in four independent components with 18 items, which explains 50% of the variance of results. The data from these 18 items were run with the PCA again, which resulted in six independent components (PC1 – PC6). A subsequent Parallel Analysis (Fabrigar, Wegener, MacCallum, & Strahan, 1999; Norris & Lecavalier, 2010) showed that the eigenvalues of data were higher from the 95-percentile of the simulated data with 1,000 iterations for only the first three components, meaning that PC1 – PC3 were most suitable for creating independent dimensions.

Description of PAS dimensions. Descriptive statistics for PAS components are shown in Table 1. One dimension showed only modest reliability (the critical value is .7, see Nunnaly, 1978), which was probably caused by the low number of items in this dimension. Other researchers, however, also reported alpha coefficients in the rage .43 – .95 (e.g. Goetz & Shackelford, 2009).

The Hand-washing dimension measures the washing of hands and the washing of foods (vegetables and fruits) (items: I wash my hands after I go home, I wash my hands before eating, I wash fruits before eating, I wash my hands after defecation, I carefully wash vegetables before eating them). The Swimming dimension measures aversion of or preference to swimming in public pools (items: I enjoy swimming in swimming pools (reverse scored), I like swimming in various swimming pools during summer, I do not like swimming in public pools). The Ectoparasite avoidance dimension measures avoidance of ectoparasites and behaviours associated with parasite transmission (example items: I do not like social settings due to risk of lice transmission, Removing lice from hair is disgusting to me, I avoid wearing the clothes of unknown people).

Table 1
Descriptive statistics of Pathogen Avoidance Scale (PAS)

	Items (n)	Mean	*SE*	Alpha	Average Inter-Item Correlation	Skewness	Kurtosis
Hand washing	5	4.32	.05	.81	.47	–1.33	1.89
Swimming	3	2.9	.07	.82	.6	0.36	0.35
Ectoparasite avoidance	3	3.52	.06	.48	.24	0.01	–0.58

Incidence of illnesses and preference for spices. The incidence of illnesses was measured by asking “How many times were you ill during the last year (365 days)?”. The preference for spices was asked through two questions: “Do you like spice foods?” [preference of spices] and “How frequently do you consume spicy foods?” [consumption of spices]. The former question was rated on a ten-point Likert style scale (1 = absolutely not, 10 = absolutely yes), and the latter question was rated on a four-point Likert style scale (1 = never, 4 = very frequently). Both items measuring the preference and consumption of spicy foods moderately correlated. About 43% (81 out of 189) of participants reported that they like spicy foods; 29% of participants (55 out of 189) responded that they eat spicy foods frequently or very frequently. The incidence of illnesses reliably assesses perceived health, because it correlates with Duncan, Schaller and Park’s (2009) Perceived Infectability subscale (Prokop, Usak, & Fančovičová, 2010b) and with General Health Questionnaire (Prokop et al., 2010).

Procedure. The original questionnaire (PAS) with 45 items was first pre-tested on a sample of 53 high school students. We calculated the mean correlations between items and deleted all items with low inter-item correlations (r <.10), resulting in a final questionnaire with 28 items. Data from the pilot study was not included in further analyses. This questionnaire was administered to the sample of 189 students described above.

Statistical analysis. The total number of illnesses (dependent variable) showed the Poisson distribution; thus, the Generalised Linear Model (GLM) with Poisson distribution was used to test whether independent variables (gender, consumption and preference of spicy foods and mean scores of three PAS dimensions [Hand washing, Swimming and Ectoparasite avoidance dimension]) show a significant effect on the dependent variable. Including or excluding the preference or the consumption of spicy foods did not change the results of the GLM, and there were almost no changes in the goodness of fit statistics when the consumption of spicy food was removed or included. Thus, both these variables were included in the model. The effect sizes were calculated with Cohen's d, where $d = 0.20$ were interpreted as a small effect, $d = 0.50$ as a medium effect and $d = 0.80$ as a large effect (Cohen, 1988). Statistical tests were performed with SPSS 19.0.

Results

Effects of pathogen avoidance and preference for spicy foods on reported health

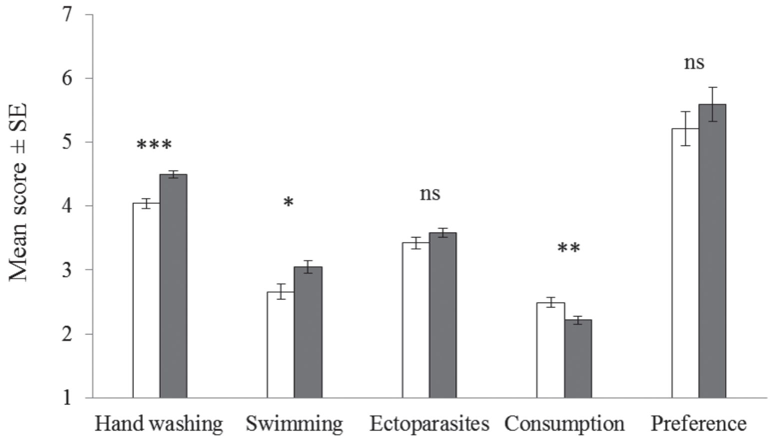
The GLM showed that almost all predictors, except for the Swimming dimension, were associated with the total number of reported illnesses (Table 2). This suggests that participants who reported more diseases in the last year avoided ectoparasites more but tended to wash their hands less than their healthier counterparts. The frequency of consumption of spicy foods increased with the number of reported illnesses. The preference of spicy foods tended to show a reverse correlation with the number of reported illnesses. Females reported significantly more illnesses in the last year than males.

Table 2. Results of Generalized Linear Model on total number of reported illnesses in the last year

	B	SE	95% Confidence interval		Wald's χ2	p
			Lower	Upper		
Intercept	0.41	.45	–0.48	1.12	0.8	.37
Gender	–0.36	.11	–0.56	–0.15	11.19	<.001
Hand washing	–0.15	.07	–0.29	–0.01	4.24	.04
Swimming	–0.03	.05	–0.12	0.06	0.34	.56
Ectoparasite avoidance	0.22	.06	0.09	0.34	11.77	.001
Consumption of spices	1.70	.58	0.56	2.85	8.49	.004
Preference of spices	–0.05	.02	–0.08	–0.01	5.53	.019

Gender differences in pathogen avoidance

As predicted, females always scored higher than males (Fig. 1), meaning that their avoidance of pathogens is more pronounced than in males. In contrast, males reported to consume spicy foods more often than females, although there was no difference in the preference for spices between sexes (Fig 1).



Note: ***p <.001, d = 0.69, ** p <.01, d = 0.41, *p <.05, d = 0.38, ns = not statistically significant, d ≤ 0.20).

Figure 1. Gender differences in pathogen avoidance.
Asterisks denote differences between males (open bars) and females (grey bars) based on t-tests for unequal samples.

DISCUSSION

This study has shown that there is a possible link between the immune system and the behavioural immune system, because the associations between reported illnesses and certain anti-pathogen behaviours were statistically significant. In other words, we have provided further evidence that the emotion of disgust is adaptive, because it is linked with perceived health and protects individuals against disease transmission (Curtis & Biran, 2001; Duncan & Schaller, 2007; Oaten et al., 2009). Furthermore, we found that interpersonal variability in preference for spicy foods can be explained as an adaptive anti-pathogen strategy and that females perform more anti-pathogen behaviours than males.

We found that the total number of reported illnesses (an indirect measurement of the immune system) positively correlated with the disgust of ectoparasites. This is in agreement with recent work showing that immunologically compromised people i) are more disgust sensitive (Fessler et al., 2005), ii) are more fearful of disease-relevant animals (Prokop & Fančovičová, 2011; Prokop et al., 2010; Prokop, Usak, & Fančovičová, 2010a; Prokop, Usak, & Fančovičová, 2010b), and iii) show greater aversion towards immigrants and elderly, obese or physically disabled individuals (Duncan & Schaller, 2009; Faulkner et al., 2004; Park et al., 2003). Previous research has also shown that people who perceive themselves less vulnerable to diseases wash their hands and/or vegetables more frequently, indicating that washing hands has health benefits (Prokop & Fančovičová, 2011) while other researchers found a positive association between hand washing and perceived vulnerability to diseases (Porzig-Drummond et al., 2009; Prokop et al., 2010a). Here, we have shown that people who had less health problems washed their hands more frequently (Prokop & Fančovičová, 2011) suggesting that a low frequency of hand washing is associated with a cost to health.

Participants vulnerable to diseases consumed spicy foods more. This suggests that people who perceive themselves more vulnerable to diseases eat foods with anti-microbial properties more often than their healthier counterparts. Although the preference for spicy foods indicated an opposite direction with reported health, this association was much smaller than the association between consumption of spices and health (Table 2). Moreover, *consumption* of spices is biologically a more relevant variable when examining the possible links between anti-pathogen behaviour and health compared with the *preference* of spices, because preference itself does not guarantee *consumption* of spices. These results support evolutionary explanations for preferences for spices, suggesting that anti-microbial properties defend people against potentially harmful diseases in contaminated foods (Billing & Sherman, 1998; Ohtsubo, 2009; Sherman & Hash, 2001). All research in this field was, however, focused on environmental effects on traditional recipes, but as far as we are aware, this is the first study showing that inter-personal preferences for spices fit with evolutionary explanations of human food preference. Taken together, preferences for spicy foods can be viewed as an adaptive strategy that positively influences the health status of participants.

However, if eating spicy foods is beneficial, why is this preference not widespread among all people? Although a number of health benefits associated with consumption of spices were reported (e.g., Gomez Pinilla, 2008; Kaefer & Milner, 2008; Tapsell et al., 2006; Sengur et al., 2011), there are also several costs with the consumption of spices. For example, in high concentrations, phytochemicals can be allergens, carcinogens or teratogens (e.g., Ames, Profet, & Gold, 1990; Surh & Lee, 1996). These potential dangers help explain why spices are not preferred by the majority of people and are especially avoided by pregnant women (Flaxman & Sherman, 2000). Further research might, for example, examine whether preferences of spices are more pronounced in individuals who were originally immunologically compromised or whether healthy people, who are therefore able to suffer some of the costs associated with consumption of spicy foods, prefer to consume spices.

Females scored higher in two of the three anti-pathogen dimensions compared with males. This result corroborates recent work showing that females are more disgust sensitive (e.g., Curtis et al., 2004; Oaten et al., 2009; Porzig-Drummond et al., 2009; Prokop, Usak, & Fančovičová, 2010b; Tybur et al., 2009) and engage more in anti-pathogen behaviours like hand washing (Porzig-

Drummond et al., 2009; this study) and avoiding public pools or toilettes (Prokop & Fančovičová, 2011). From the evolutionary perspective, these gender differences are adaptive, because females invest themselves in reproduction more than males (Curtis et al., 2004; Oaten et al., 2009). Future research should be focused on anti-pathogen behaviours, including samples of women carrying children.

Interestingly, females showed a lower preference for spicy foods than males, even though spices have antimicrobial effects (Billing & Sherman, 1998). However, as we noted above, consumption of spices may also be costly in terms of increasing the risk of allergies (e.g., Ames et al., 1990; Surh & Lee, 1996). Our present research has shown that females suffer from disease more than males, and the recent research of Needham and Hill (2010) also found that females have a higher chance of reporting allergies, headaches and other diseases. Thus, it may be that males who generally engage in greater risk-taking activities (Byrnes, Miller, & Schaffer, 1999) and who suffer less from at least certain diseases would consume more spicy foods than females. Further research, in which risky behaviours and preferences for spicy foods will be examined, is necessary.

Limitations of the study

This study has several limitations regarding reliability and validity of the obtained data. Specifically, the data reported here was calculated from own reports that do not necessarily provide an accurate measurement of the examined variables. Perhaps the use of supplementary data from ambulances or hospitals would provide more precise measures of the state of health of participants. Secondly, perceived health was measured by the number of reported illnesses, but the types of illnesses were not listed in greater detail. Our predictions are based on the expectation that emotional, cognitive and behavioural strategies are influenced by *infectious* diseases. We cannot, however, reject the idea that at least certain diseases are chronic somatic diseases and/or accidents (e.g., injuries, poisoning). Further research should carefully distinguish between infectious and non-infectious diseases and their effects on anti-pathogen behaviours in humans. Optimally, research should be carried out in various countries that differ in both pathogen prevalence and cultural practises. In such a case, we could predict whether people inhabiting areas with high pathogen prevalence would be more disease-sensitive and would prefer spicy foods more than others. Preference for spices was measured by two questions that do not allow for more precise distinguishing between various kinds of spices. It is known that not all spices are equally strong antimicrobial agents (e.g. garlic being much stronger than pepper, see Billing & Sherman, 1998), and as such, further in-depth research in this field is required before a definite conclusion could be made. Certain personality traits could also account for some variability of results. For example, the perceived vulnerability to diseases positively correlates with neuroticism and negatively correlates with socio-sexual orientation (Duncan, Schaller, & Park, 2009). This means that future studies should take into account the effect of personality traits. Finally, it needs to be noted that our research was carried out on a sample of high school students. Food preferences obtained from older participants, independent of their parents, could provide more stable and stronger results (Birch, 1999).

CONCLUSION

To conclude, our study revealed that health is associated with certain anti-pathogen behaviours, including disgust of ectoparasites and preferences for spicy foods. We suggest that the emotion of disgust evolved as a strategy to protect humans against objects or subjects carrying infectious diseases, and preferences towards spicy foods protect humans against pathogens. Females engage in anti-pathogen behaviours more than males, suggesting their evolutionary role in protecting the new generation or their different susceptibility to certain diseases. The relatively lower preference for spices by females calls for further research to examine the possible differences in physiological costs from the consumption of spices between genders.

Acknowledgement

We thank Ibrahim Senay for help with parallel analysis. David Livingstone improved the English. This study was partly supported by grant VEGA no. 1/0124/11 and KEGA no. 175–006TVU–4/2010.

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