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Perceived vulnerability to disease predicts environmental attitudes

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Investigating predictors of environmental attitudes may bring valuable benefits in terms of improving public awareness about biodiversity degradation and increased pro-environmental behaviour. Here we used an evolutionary approach to study environmental attitudes based on disease-threat model. We hypothesized that people vulnerable to diseases may ultimately protect themselves by increasing pro-environmental efforts. Indeed, school children who perceived themselves to be vulnerable to diseases had better pro-environmental attitudes than their less disease vulnerable counterparts. Disease sensitive children showed greater beliefs to myths about owls and cuckoos, but myths did not correlate with environmental attitudes. Children from rural areas and girls showed greater environmental concerns than males and children from cities. Only scientistic attitudes toward owls showed correlations with environmental attitudes which suggests that attitudes toward animals show no strong associations with environmental concerns as was implicitly suggested in previous studies. Overall, our study showed that an evolutionary approach can be applied to investigate the nature of inter-personal differences in environmental attitudes in humans.

Keywords: animals, behavioural immune system, environmental attitudes, perceived vulnerability to diseases

INTRODUCTION

Rapid loss of biodiversity and increased health risks associated with environmental pollution are alarming and environmental issues have gained importance in international relations (Clapp 1998). Unfortunately, increased efforts of world leaders (Butchart et al. 2010) to improve critical situation in environmental protection were still not translated to significant changes to promote biodiversity of the general public: knowledge about biodiversity loss is low (Balmford et al. 2002, Lindemann-Matthies & Bose 2008, Robelia & Murphy 2012) and the real pro-environmental behavior of citizens is insufficient (Kuhlemeier et al. 1999). Environmental education is recently believed to be an effective tool that may help to reverse negative trends in biodiversity loss and increasing environmental pollution (e.g., Wilson 1996, Brewer 2002).

Attitudes involves behavioural, cognitive and emotional component (Eagly & Chaiken 1993) thus studying them is expected to help with designing effective pro-environmental programs and actions and, finally, improve pro-environmental behaviour. In the field of environmental education, environmental attitudes are influenced particularly by gender differences and residence. Women usually report greater environmental concern and greater pro-environmental behaviour (McMillan et al. 1999, Zelezny, Chua & Aldrich 2000, Shobeiri, Omidvar & Prahallada 2006). They are more environmentally responsible and make a significant contribution to environmental protection

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State of the literature

- Situation in environmental protection were still not translated to significant changes to promote biodiversity of the general public: knowledge about biodiversity loss is low and the pro-environmental behavior of citizens is insufficient.
- Women usually report greater environmental concern and greater pro-environmental behaviour and they are more environmentally responsible and make a significant contribution to environmental protection.
- People more susceptible to diseases are expected to react more sensitively to pathogen threat

Contribution of this paper to the literature

- This study investigated novel, previously unstudied, associations between individual's vulnerability to diseases, environmental concerns and myths about controversial animals.
- Positive attitudes toward animals were associated with greater environmental concerns
- People with greater worries about pathogen transmission express also greater concerns about environmental threat.
- People more vulnerable to diseases would show stronger beliefs to myths, because these beliefs can protect them against potential threat.

(Jenkins & Pell 2006, Kose et al. 2011, Müderrisoğlu & Altanlar 2011). Residence of people showed mixed effects on environmental attitudes. For example, Arcury & Christianson (1993), McMillan et al. (1999) and Müderrisoğlu & Altanlar (2011) showed that urban residents hold similar environmental attitudes than rural residents. However, some authors showed that greater environmental concern (Van Liere & Dunlap 1981) a larger number of environmental responsibility values (Berenguer, Corraliza & Martin 2005) are found in cities.

Environmental pollution increases individual's risk disease threat and/or pathogen contamination (Harada 1995, Mawdsley et al. 1995, Tyrrell & Quinton 2003, Fawell & Nieuwenhuijsen 2003, Millenium Ecosystem Assessment 2005, Hassing et al. 2009). Unsafe water, air pollution, poor sanitation and poor hygiene are seen to be the major sources of exposure (Briggs 2003). Humans show inter-individual differences in perceived risk of being contaminated by pathogens (Park et al. 2003). These differences are attributed to the behavioural immune system defined as a set of mechanisms that allows individuals to detect the potential presence of parasites in objects (or individuals) and act to prevent contact with those objects (or individuals). The behavioural immune system offers a first line of defence against health threatening parasites (Schaller 2006, Schaller & Duncan 2007). People more susceptible to diseases are expected to react more sensitively to pathogen threat (Miller & Maner 2012). Research showed that these people show a relatively greater level of aversive response to physically disabled individuals (Park et al. 2003), towards older adults (Duncan & Schaller 2009), immigrants (Faulkner et al. 2004), toward obese people (Park et al. 2007) or toward disease transmitting animals (Prokop et al. 2010a,b,c, Prokop & Fančovičová 2013). These people also engage more frequently in various anti-parasite behaviours like avoiding physical contact with pets (Prokop & Fančovičová 2010, Prokop et al. 2010c) or disease-transmitting animals (Prokop & Fančovičová 2011). Stevenson et al. (2009) showed that participants who had heightened contamination sensitivity had significantly fewer recent infections, supporting an idea that the behavioural immune system has a protective effect against infectious diseases.

In this study, we primarily examined possible links between perceived vulnerability to diseases and environmental attitudes at the level of inter-personal differences. We suggest that if the behavioural immune system reacts sensitive when disease threat increases, then people more vulnerable to diseases should also express stronger environmental concerns, because environmental pollution influences human health. As far as we are aware, no study investigated these associations yet. Our second aim was investigation of possible associations between perceived vulnerability to diseases and belief to myths about controversial animals. The rationale of this aim is that beliefs to myths about animals often result in direct persecution and, as a consequence, negative impact of humans on the environment (Brito et al. 2001, Fita et al. 2010, Ceriaco et al. 2011, Ceriaco 2012, Prokop & Fančovičová 2012). It is possible that disease-sensitive people are more prone to believe that some animals pose danger to humans, because over-perception of a danger is more beneficial from evolutionary perspective than the risk of being endangered (Miller & Maner 2012). Third, the higher environmental concern on one side, and beliefs to untrue myths by disease-sensitive people on the other side is contradictory, so the question is whether beliefs to myths itself influence environmental attitudes. By examining attitudes toward owls and cuckoos, examples of controversial birds emblazoned by myths that were never systematically investigated, we examined which animal attitude domain (if any) influences environmental attitudes. We also included keeping animals at home as additional potential predictor of environmental attitudes, because it influences attitudes to animals (Prokop & Tunnicliffe 2010) and the behavioural immune system (Prokop & Fančovičová 2011, Prokop et al. 2010a,c).

METHODS

The participants (n = 240) 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)?") and (4) for having any animals at home. All participants were from Czech secondary grammar schol with the average age 14.27. The number of boys and girls was equal. The respondents from town was in the majority (n = 167). The majority of respondents are pet owners (n = 182).

Attitudes to animals' questionnaire

Attitudes to animals questionnaire consisted from 36 items focused on attitudes toward owls (18 items) and cuckoos (18 items). The items were constructed according to our prior studies in this field (e.g., Prokop et al., 2008, Prokop and Tunnicliffe, 2008, Prokop et al., 2009). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. Large values for the KMO measure indicate that a factor analysis is appropriate. In our research, the Kaiser-Meyer-Olkin measure of sampling adequacy was greater than 0.78. Another indicator of the strength of the relationship among variables is Bartlett's Test of Sphericity. This is used to test the null hypothesis that the variables in the population correlation matrix are uncorrelated. The observed significance level was high ($\chi2 = 3430.50$, $p < 0.001$). It was therefore concluded that the strength of the relationship among the variables was strong. This meant we could use factor analysis to analyze the data.

All the animal attitudes data were submitted to factor analysis (PCA) with Varimax rotation. Eleven factors with eigenvalues > 1.00 were derived, but only first three factors were interpretable due to low number of items that loaded to remaining factors. The first factor termed scientistic domain explained 17% of the variability of results. Example of items include I would like to read any book about owls, I would like to know more about the research on cuckoos. This domain was represented by a total of 10 items with Cronbach alpha 0.89. The second factor was termed negativistic domain and explained 14% of the total variance of results. This domain was represented by items like Even the thought of touching a cuckoo scares me and I am feared of owls. Total number of items in this domain was six and Cronbach alpha was 0.79. The third factor termed myths was represented by various items about common myths of owls and cuckoos and explained 8 % of the total variance of results. Example items were Hooting of an owl is a harbinger of death, Cuckoo peek means how many years you will be alive. Total number of items in this domain was 8 and Cronbach alpha was 0.82. All items received a minimum required factor loading score of 0.30 (e.g., Anastasi & Urbina 1997) and, except for the myth domain, all were identical between owls and cuckoos (only the word owl and cuckoo was different) following Prokop & Tunnicliffe (2008). Myths domain could not be designed to be identical, because myths about cuckoos and owls differ. However, almost identical mean scores (see Fig. 1) and correlations between these domains and loadings of these items to the same domain strongly suggest that there were no conceptual differences between myths about owls and cuckoos and that these items were perceived similarly by respondents. The number of items with the minimum critical value of 0.3 was the same both for owls and for cuckoos. The order of items in questionnaires was random.

Perceived vulnerability to disease. The perceived vulnerability to disease scale (PVD) (Duncan, Schaller & Park 2009) was used to assess the respondents' self-perceived vulnerability to disease. This scale consists of 15 items (actual Cronbach's alpha = 0.75); one subscale assesses beliefs about one's own susceptibility to infectious diseases (Perceived Infectability [PVD-PI] with 7 items); the second subscale assesses emotional discomfort in contexts that suggest an especially high potential for pathogen transmission (Germ Aversion [PVD-GA] with 8 items). Items were rated on a five point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Negatively worded items were scored in reverse order.

We used the PVD-PI subscale to assess inter-personal differences in perceived vulnerability to infectious diseases (item example: In general, I am very susceptible to colds, flu and other infectious diseases). The PVD-GA subscale assesses some behaviours and emotional avoidance of some pathogen-relevant stimuli (item example: I prefer to wash my hands pretty soon after shaking someone's hand). Thus, the PVD-GA subscale reports pathogen avoidance behaviours rather than perceived vulnerability to diseases. To support the reliability of the two subscales, total number of illnesses significantly correlated only with the PVD-PI subscale, but not with the PVD-GA subscale ($r = 0.16$ and 0.03, $p < 0.05$ and 0.68, respectively) similarly as in Prokop et al. (2010c) and Prokop and Fančovičová (2013).

Environmental attitude questionnaire

The environmental attitudes, where measured through self-constructed questionnaire consisted of 24 5-point Likert type items. The part of items was focused on the protection of nature in genereal view (example item: I am out of stress, when I am in the nature) and part was focused on the behaviour aimed to protection of nature (example item: I do not care about the problems of environment). The items were in positive and negative meaning. Negatively worded items were scored in reverse order. The reliability of the Environmental attitude questionnaire was high (Cronbach's alpha = 0.85).

Statistical analyses

Correlations between several idenpendent predictors and a dependent variable were calculated with multiple regression analysis. Forward stepwise method was used to select the most parsimonious model. Data were first tested for normality with Kolmogorov-Smirnov test. Only the PVD-PI subcale was initially not normally distributed, so we used Box-Cox transformation to normalize these data. Variance inflation factor (VIF) was calculated to examine whether there is no risk of multicillinearity between independent variables, but all values were ≤ 2.17 suggesting that there was no collinearity between variables in our sample (Allison, 1999).

One problem of this study is relatively large sample size for pairwise statistics which can produce significant results that can be applied only to a small fraction of population. To make our statistical analyses more conservative, the power of statistical difference between attitudes toward owls and cuckoos was analysed by calculating the effect size measure (Cohen's d) for groups (Cohen 1988), because it is independent of sample size. The measure is calculated as the difference between two means, divided by the standard deviation of either group. Cohen (1988) offered the following guidelines for interpreting effect sizes: d = 0.20 (small effect), d = 0.50 (medium effect), and d = 0.80 (large effect). In commonsense terms, a d of 0.20 may be statistically significant but the difference is not apparent to the casual observer; a d of 0.50 is noticeable to the average person; and a d of 0.80 or higher is quite obvious (Lippa 2002).

RESULTS

Factors influencing environmental attitudes

Multiple regression (forward stepwise method) with environmental attitudes as a dependent variable and with independent predictors listed in Table 1 resulted in significant model that explained 33% of the variance of the results ($R^2 = 0.33$, $F(6,231) = 18.58$, $p < 0.00001$). All the variables entered the model except for attitudes toward cuckoos score. The more positive attitudes toward owls the respondent had, the more positive environmental attitudes were reported. Respondents

Table 1. Multiple regression (forward stepwise method) on environmental attitudes. Attitudes toward cuckoos (total score) were excluded from the model.

	β	β ± SE	B	B ± SE	t(231)	P
Intercept			-3.49	9.24	-0.38	0.71
Attitudes toward owls (total score)	0.47	0.05	0.48	0.06	8.58	< 0.001
Residence	0.16	0.05	0.19	0.07	2.90	< 0.001
PVD-GA	0.20	0.06	0.17	0.05	3.57	< 0.001
gender	-0.13	0.06	-0.14	0.06	-2.33	0.02
PVD-PI	-0.10	0.06	-0.13	0.07	-1.75	0.08
N of animals at home	0.08	0.05	0.04	0.03	1.50	0.14

Table 2. Partial correlations (controlled for gender, residence and number of animals at home) between PVD and attitude domains. Asterisks denote statistically significant relationships (*p<0.05, **p<0.01, ***p<0.001). Unmarked correlations are not statistically significant.

		Owls			Cuckoos		
	PVD-PI	Scientistic	Negativistic	Myths	Scientistic	Negativistic	Myths
PVD-GA	0.25 ***	0.26 ***	-0.05	-0.23***	0.24***	-0.11	-0.14*
PVD-PI		0.06	-0.21 **	-0.02	0.06	-0.17**	-0.11
Scientistic (O)[1]			0.07	-0.09	0.72 ***	0.04	-0.09
Negativistic (O)[1]				0.25 ***	-0.37	0.58 ***	0.18**
Myths (O)[1]					-0.12	0.24 ***	0.59 ***
Scientistic (C)[2]						-0.08	-0.13 *
Negativistic (C)[2]							0.23 ***

[1] Owls
[2] Cuckoos

living in villages scored higher (M = 3.63, SE = 0.06, N = 72) than those living in cities (M = 3.42, SE = 0.04, N = 166). Higher PVD in the PVD-GA domain significantly correlated with positive environmental attitudes. Girls (M = 3.55, SE = 0.05, N = 120) had more positive environmental attitudes than boys (M = 3.41, SE = 0.05, N = 119). The PVD-PI score and total number of animals that respondents reported to have at home did not contribute significantly to the multiple regression model.

Which of animal attitude domains influence environmental attitudes?

Multiple regression (forward stepwise method) was used to test which attitude domains (scientistic, negativistic and myth about owls and cuckoos) uniquely influence environmental attitudes. The multiple regression model was significant and explained 32 % of the total variance of results ($R^2 = 0.32$, $F(3,236) = 37.07$, $p < 0.00001$). Three of the six variables entered the model: scientistic and negativistic attitudes toward owls and negativistic attitudes toward cuckoos (β = 0.52, 0.11 and 0.11, p < 0.0001, 0.10 and 0.11, respectively). This suggests that scientistic attitudes toward owls almost exclusively positively correlate with environmental attitudes whereas effects of other domains on the dependent variable is weak. Respondents who disagreed with negative statements about owls and cuckoos tended to have more positive (albeit not significantly) environmental attitudes.

Relationships between PVD and attitude domains

Partial correlations were performed to examine additional correlations between the PVD domains and attitudes toward owls and cuckoos. Results are shown in Table 2. We acknowledge that most of these correlations are moderate, but the show consistent patterns. First, attitude domains for owls and cuckoos showed strong correlations with each other meaning that scientistic attitudes toward owls predict scientistic attitudes toward cuckoos and the same can be applied to negativistic attitudes. Importantly, myths toward owls and cuckoos also strongly correlated despite the items to measure myths were different. Second, negativistic attitudes consistently correlated with myths which suggests that respondents with higher perceived fear of animals also hold stronger beliefs to myths about these animals. Third, the PVD-GA subscale consistently and positively correlated with scientistic attitudes and negatively with myths. This suggests that respondents with higher emotional discomfort and worries about disease transmission likes e.g. information about owls and cuckoo more, but these respondents are more prone to believe to myths about these animals than participants with lower PVD-GA score. Finally, the PVD-PI subscale correlated negatively with negativistic attitudes suggesting that respondents more vulnerable to infectious diseases show greater fear of animals than others.

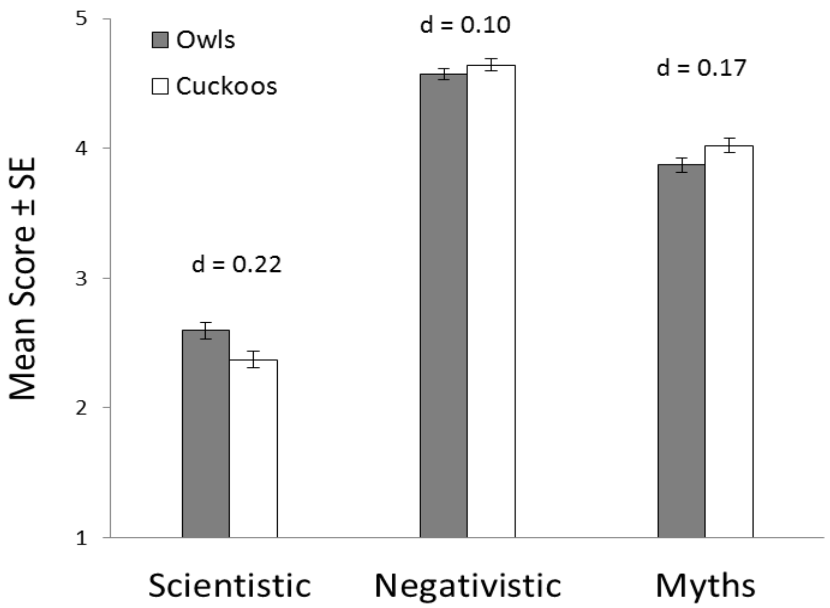

Figure 1. Differences in attitudes toward owls and cuckoos in three domains. Numbers over the bars show effect sizes (Cohen *d*).

Differences in attitudes toward owls and cuckoos

Despite the differences in mean scores in attitudes toward owls and cuckoos were significant or marginally significant for all domains (paired t-tests, scientistic, negativistic and myths domains, $t = 4.73$, 1.75 and 2.94, $p < 0.0001$, $p = 0.08$ and $p < 0.01$, respectively), both owls and cuckoos were perceived very similarly among participants, because effect sizes were low (Figure 1). In general, respondents showed low interest about owls and cuckoos (low mean score in scientistic domains), low fear of these animals (high mean score in negativistic domains) and beliefs to myths were also less frequent (high mean score in myths domains).

DISCUSSION

This study investigated novel, previously unstudied, associations between individual's vulnerability to diseases, environmental concerns and myths about controversial animals. Our main prediction that perceived vulnerability to diseases should be associated with environmental concerns was supported, because the PVD-GA subscale positively correlated with environmental attitudes. This suggests that people with greater worries about pathogen transmission have also greater concerns about environmental threat. The logic of this associaiton lies in sensitivity of the behavioural immune system that protect humans against disease threat (Schaller 2006, Schaller & Duncan 2007). These people are therefore expected to protect/invest to protection of the environment more than less disease vulnerable people whose behavioural immune system is supressed due to relatively low risk of being contaminated. Increased effort to save biodiversity ultimately enhances chance of survival of an individual, thus pro-environmental attitudes are stroger in people more vulnerable to diseases. This finding further contributes to literature about environmental attitudes on one side, and to literature about disease-avoidance mechanisms one the other side.

Our second aim was further to investigate possible associations between perceived vulnerability to diseases and belief to myths about controversial animals. Previous research showed links between myths and negativistic attitudes toward various animals (Prokop & Tunnicliffe 2008, Prokop et al. 2009) and persecution of animals (Brito et al. 2001, Fita et al. 2010, Ceriaco 2012). We suggested that people more vulnerable to diseases would show stronger beliefs to myths, because these beliefs can protect them against potential threat. For example, killing bats can decrease risk of being infected by rabies. We found small, but significant and very consistent (the same direction for both owls and cuckoos) correlations between myths and the PVD-PI subscale. Our second prediction was therefore supported. Note that these myths were investigated on examples of harmless animals such as cuckoos and owls that do not pose real disease threat to humans and our research was conducted on school children. Further research on animals that are potentially risky in terms of disease transmission (e.g., bats) that can be conducted on adults would provide stronger conclusion whether this association is only statistical artefact, or part of evolved psychological mechanism designed to protect humans against disease threat.

Positive attitudes toward animals were associated with greater environmental concerns which supports our further prediction. Multiple regression showed that attitudes toward owls almost exclusively positively correlate with environmental attitudes, but other domains or attitudes toward cuckoos showed no associations with environmental attitudes. This finding is particuly interesting from various reasons. First, previous research on attitudes toward animals (e.g., Kellert 1985, Prokop et al. 2008, Prokop et al. 2009) did not investigate associations between animal attitudes and environmental concerns, although it was implicitly believed that these domains are associated with each other. Here we showed that this is not fully true, because only scientistic attitudes showed strong correlation with environmental attitudes. Perhaps surprisingly, Prokop & Fančovičová (2010) showed that fear of a large carnivore predator correlate with individual's willingness to eliminate their population. This would suggests that negativistic attitudes toward animals would correlate with environmental protection. However, no correlation between these variables were found. This can be explained by differences in human willingness to protect various animals groups (Prokop & Fančovičová, 2013).

Gender differences in environmental attitudes reflect results of previous studies, where women was found to be more pro-environmentally oriented than men (McMillan et al. 1999, Zelezny, Chua & Aldrich 2000, Shobeiri, Omidvar & Prahallada 2006, Jenkins & Pell 2006, Kose et al. 2011, Müderrisoğlu & Altanlar 2011) and provide additional support reliability of our research tool. From an evolutionary perspective, disease-threat model can be applied to explain gender differences in environmental concerns. Females invest more to reproduction than males, thus avoidance of disease-connoting cues (Curtis et al. 2004, Prokop et al. 2010c), such as environmental pollution, can be expected. This idea can be further tested for example by comparing environmental concerns between women that take care over children and their childless counterparts.

Residence showed significant effect on environmental attitudes. In particular, respondents living in rural areas scored higher that those living in cities. This contradicts with some previous research

(Arcury & Christianson 1993, McMillan et al. 1999, Müderrisoğlu & Altanlar 2011) that showed that urban residents hold similar environmental attitudes than rural residents. We argue that these findings can reflect current changes in the use of resources in rural areas. While common humans in previous years used domestic animals agricultural plants for personal use, gardens are currently used mainly for relax and planting ornamental plants due to aesthetic reasons. Thus, rural people can invest more to gardening and keeping pets than urban people which can be at least partly associated with better environmental attitudes. These issues require deeper investigation.

Keeping pets was not associated with environmental attitudes suggesting that having a pet may influence attitudes toward animals (Prokop & Tunnicliffe 2010), but needs not necessarily be translated to pro-environmental attitudes. The present study showed that most of animal attitude domains did not correlate with environmental attitudes which indirectly support an idea that having a pet needs not increase environmental concerns. However, we did not investigate individual differences in preferences and taking care over pets, which can be considered as a confounding factor of this investigation. Additional research in this field is required before definite conclusion can be made.

CONCLUSION

Evolved disease avoidance mechanisms seem to be activated not only when risk of disease threat increases, but also more globally, when perceived risk of environmental pollution is high. People vulnerable to diseases show grerater environmental concerns and believe to untrue myths about some animals more than less disease-vulnerable people and females have better pro-environmental attitudes than males. Attitudes to animals need not to be strongly associated with environmental attitudes, but this idea needs further empirical support. Our study presented in the example of vulnerability to diseases and environmental attitudes suggests that evolutionary theory is a viable scientific approach that can help to understand inter-personal differences in environmental attitudes.

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