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Scary and nasty beasts: Self-reported fear and disgust of common phobic animals

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Animal phobias are one of the most prevalent mental disorders. We analysed how fear and disgust, two emotions involved in their onset and maintenance, are elicited by common phobic animals. In an online survey, the subjects rated 25 animal images according to elicited fear and disgust. Additionally, they completed four psychometrics, the Fear Survey Schedule II (FSS), Disgust Scale – Revised (DS-R), Snake Questionnaire (SNAQ), and Spider Questionnaire (SPQ). Based on a redundancy analysis, fear and disgust image ratings could be described by two axes, one reflecting a general negative perception of animals associated with higher FSS and DS-R scores and the second one describing a specific aversion to snakes and spiders associated with higher SNAQ and SPQ scores. The animals can be separated into five distinct clusters: (1) non-slimy invertebrates; (2) snakes; (3) mice, rats, and bats; (4) human endo- and exoparasites (intestinal helminths and louse); and (5) farm/pet animals. However, only snakes, spiders, and parasites evoke intense fear and disgust in the non-clinical population. In conclusion, rating animal images according to fear and disgust can be an alternative and reliable method to standard scales. Moreover, tendencies to overgeneralize irrational fears onto other harmless species from the same category can be used for quick animal phobia detection.

Since the famous case of 'Little Albert' (Watson & Rayner, 1920), human fears and anxieties have fascinated our mind. Fright is appealing to the entertainment industry as the trend in horror movies production and generated profits is constantly increasing (Phillips, 2005). For example, 8,055 horror titles were released in 2017 with grosses worth billions of dollars (IMDb, 2018). Accordingly, fear has attracted much of scientific research with more than 37,000 papers published only in the last 5 years (WoS, 2018). Besides that, clinical fears have considerable public health and economic impact (Olesen et al., 2012).

There is general consensus that animals are one of the most common triggers of human fears (Agras, Sylvester, & Oliveau, 1969; Arrindell, 2000). Throughout the evolutionary history, many animal species have been an important source of imminent

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threat to our survival either as predators (Barrett, 2005) or parasites (Hoberg, 2006). Thus, humans and non-human primates have been shaped by the natural selection to 'beware the beast' (Öhman, 2007) and new abilities to quickly identify a hidden threat have evolved, including an improved visual system (Isbell, 2006) and category-specific attention enabling rapid detection of animals over other objects in the environment (New, Cosmides, & Tooby, 2007), especially snakes (Öhman, Flykt, & Esteves, 2001), spiders (Blanchette, 2006), or big cats (Yorzinski, Penkunas, Platt, & Coss, 2014). Öhman and Mineka (2001) hypothesized that these instinctive reactions have been embedded in specific neural structures and circuits of the mammalian brain, the so-called fear module.

Although these selection pressures have substantially weakened as humans have become an efficient super-predator dominating the ecosystem and inflicting fear in others (Clinchy *et al.*, 2016), the pattern of our reactions in the presence of threatening animals has remained unchanged (Mineka & Öhman, 2002). In general, two basic emotions with the associated physiological and behavioural correlates may be triggered by species considered as dangerous, fear and disgust (Ekman, 1999; Gerdes, Uhl, & Alpers, 2009). Functionally, both emotions serve to protect the biological integrity of an organism (Nesse, 1990), but are principally different as to the characteristics of impending danger (Keltner & Gross, 1999). While fear is an adaptive response in situations of imminent threat that could lead to injury or even death (Davis, 1997; LeDoux, 2012), disgust is a part of the behavioural immune system that protects the individual against disease or contamination (Curtis, De Barra, & Aunger, 2011).

Therefore, dangerous animals trigger either of the emotion (or both at the same time) depending on the kind of threat they pose. While larger predatory species capable of harming or killing humans (crocodiles, bears, lions, tigers, snakes, etc.) evoke fear, disgust is usually triggered by smaller (and often parasitic) animals associated with dirt, decay, or disease (rats, cockroaches, ticks, worms, etc.; Davey *et al.*, 1998; Merckelbach, van den Hout, & van der Molen, 1987; Ware, Jain, Burgess, & Davey, 1994). Although once developed as adaptive responses in threatening situations, fear and disgust of animals may have significant clinical implications when they get out of control. Specific animal phobias are globally the most frequent mental illness (Steel *et al.*, 2014) with a lifetime prevalence 3.3–5.7% (Eaton, Bienvenu, & Miloyan, 2018) and considerable psychological, social, and economic burdens (Greenberg *et al.*, 1999).

The distribution of animal fears is, however, non-random, and some species tend to be feared and avoided by humans much more often than others (Agras *et al.*, 1969; Davey *et al.*, 1998; McNally & Steketee, 1985), especially snakes and spiders often elicit strong negative emotions in people (Bennett-Levy & Marteau, 1984; Davey, 1992, 1994a; Merckelbach *et al.*, 1987; Ware *et al.*, 1994). Given the fact that only a few animals cause the majority of animal phobias, Seligman (1971) proposed an influential theoretical model of biological preparedness arguing that phobic reactions reflect our evolutionary past and are associated with stimuli posing a real threat to survival of human pre-technological ancestors, hence snakes and spiders being among the most feared animals today (see also Bracha, 2006).

Although there has been some supportive evidence (see McNally, 1987 for a review), the preparedness theory cannot satisfactorily explain why so many people suffer from irrational fears of small animals presenting a low risk, such as mice, insect, snails, or worms. Similarly, the potential threat posed by venomous spiders to our ancestors has been repeatedly questioned and has no empirical support (Davey, 1994b; Gerdes *et al.*, 2009). Therefore, Matchett and Davey (1991) proposed an alternative disease-avoidance model, suggesting that animal phobias are not mediated by fear of being attacked, but have primarily evolved as a mechanism protecting us from the transmission of infectious pathogens. It is thus disgust, rather than fear, that is the primordial negative emotion involved in aversion to animals, particularly the smaller ones (Arrindell, Mulkens, Kok, & Vollenbroek, 1999; Davey, 1992, 1994a, 1994b; de Jong & Merckelbach, 1998; Sawchuk, Lohr, Tolin, Lee, & Kleinknecht, 2000; Ware *et al.*, 1994).

According to Rozin and Fallon (1987), nearly all disgust elicitors are animals, their parts or products, or objects that have been in contact with those. So far, there has been an extensive line of evidence demonstrating the strong association between high disgust sensitivity and fears and phobias of certain animals. For example, Matchett and Davey (1991) or Davey (1994a) found a significant correlation between disgust/contamination sensitivity scores and self-reported fear of animals that are unlikely to attack and harm humans, but still evoke high fear (e.g., rat, spider, cockroach) or revulsion (e.g., maggot, snail, slug; see also Arrindell *et al.*, 1999). On the contrary, disgust sensitivity was not associated with fear of predatory animals (e.g., tiger, lion, shark; Matchett & Davey, 1991; Tucker & Bond, 1997). Especially the relationship between disgust sensitivity and spider phobia has been repeatedly demonstrated (de Jong & Merckelbach, 1998; de Jong & Muris, 2002; Sawchuk *et al.*, 2000; for a review, see Davey & Marzillier, 2009). Moreover, Webb and Davey (1992) showed that disgust is not merely an emotion accompanying experienced fear of animals, but a causal link exists between experimentally manipulated disgust sensitivity and reported fear of certain animals. In the similar vein, treatment for spider phobia attenuates the spider's disgust-evoking status in both adults (de Jong, Vorage, & van den Hout, 2000) and adolescents (de Jong, Andrea, & Muris, 1997). At last, recent evidence suggests that even typically highly fearful animals such as snakes also pose a significant disgust potential (Rádlová *et al.*, 2019).

To our knowledge, no study has ever aimed to categorize animals according to both fear and disgust. Nevertheless, as shown above, the latter too may play a significant role in the human perception of certain animals and subsequently lead to development of severe and prevalent phobias when dysregulated. Therefore, one of the main purposes of our study was to investigate the intensity of animal fears and revulsions as well as potential association between these two negative emotions people experience when confronted with species that are actually responsible for the most frequent animal phobias (see Materials and methods for selection criteria). This way we could elucidate whether certain animals have the potential to trigger phobic disorder in humans either through dysregulated fear or disgust by studying responses of the non-clinical population.

In fact, the elusive role of fear and disgust in animal phobias could mean that qualitatively distinctive types of anxieties caused by different animal species exist (Merckelbach *et al.*, 1996). So far, only a limited number of studies have tried to group common animals into separate coherent clusters using a factor analysis. According to Ware *et al.* (1994), 34 animals rated according to fear could be categorized into two distinct dimensions referred to as predatory animals (e.g., tiger, alligator, lion, bear, shark, or wolf) and fear-relevant animals (e.g., bat, eagle, lizard, rat, slug, leech, mouse, spider, or cockroach). While the former group includes dangerous animals capable of causing serious injuries to humans if confronted in the wild, the latter one is formed by animals that are highly feared by people without posing real threat. Interestingly, the snake is the only animal that falls into both categories.

The two-factor solution for reported fears was also confirmed in a study using animals living in the United Kingdom (Davey, 1994a). These were referred to as either invertebrates (slug, snail, worm, maggot, etc.) or fear-relevant animals (mouse, rat, snake, bat, lizard, etc.). However, both clusters corresponded to the 'fear-relevant animals' identified by Ware *et al.* (1994), which only caused some confusion in the terminology. Arrindell (2000) repeated Davey's study with Dutch subjects and found a four-factor solution: (1) fear-relevant animals (mouse, rat, bat, etc.); (2) dry or non-slimy invertebrates (wasp, maggot, beetle, cockroach, spider, etc.); (3) slimy or wet looking animals (snail, worm, slug, eel, fish, etc.); and (4) farm animals (cow, goat, horse, goose, and chicken). A three-factor model for categorizing a list of 15 animals was found in a study by Tucker and Bond (1997), who called them (1) predatory (lion, tiger, bear, etc.); (2) fear-relevant (spider, snake, and eel); and (3) repulsive (slug, maggot, cockroach, rat, and leech).

Finally, in a cross-cultural study of animal fears, Davey *et al.* (1998) reported that a list of 51 animals could be separated into three coherent groups: (1) fear-irrelevant animals that are harmless with a low-fear status (chicken, duck, hamster, rabbit, etc.); (2) fear-relevant animals that can be characterized as fierce, dangerous, and predatory (lion, bear, shark, etc.); and (3) disgust-relevant animals that are typically small, harmless species evoking negative emotions through revulsion (cockroach, spider, worm, leech, mouse, rat, etc.). Furthermore, this three-factor solution was closely comparable across seven Western and Asian countries. Cross-cultural agreement in perception of animals seems to be a general pattern, not only for fear (Landová *et al.*, 2018), but positive emotions too (Frynta, Marešová, Reháková-Petrú, Šklíba, Šumbera, & Krása, 2011; Marešová, Krása, & Frynta, 2009).

Despite several attempts, categorization of animal fears remains inconclusive. The conducted studies used different animal sets and labels for the identified clusters. Especially, the use of the 'fear-relevant animals' term has not been consistent and referred to a variety of species ranging from fear-evoking, big predatory mammals to small, harmless invertebrates triggering disgust. The research has been further flawed by the way the tested species were selected and presented to subjects. The animal stimuli were either devised by undergraduate students (Davey, 1994a) or adopted from previous studies where the selection had been done arbitrarily by the authors (Matchett & Davey, 1991). They were presented to participants as a list of items to be rated on a Likert-type scale according to elicited fear. However, visual rather than verbal stimuli work better in evoking emotions as they leave less space for interpretation and thus have higher ecological validity. For example, it has been previously demonstrated that photographs may reliably substitute live snakes (Landová, Marešová, Šimková, Cikánová, & Frynta, 2012).

Thus, the second main goal of our study was to separate the phobic animals into coherent meaningful clusters based on their fear and disgust ratings. For these reasons, pictures of animals presumed to be a target of the most frequent phobias were selected. Such data concentrated only on clinically relevant species might shed more light on the characteristics of irrational animal fears and their aetiological mechanisms. We argue that by having included animals that may be highly fearful but in fact only very rarely trigger phobias in human subjects (predatory animals such as the lion, bear, shark, etc.), the previous factor analyses do not provide a clear picture of animal phobic categories. We also added four widely used standardized assessments, two measuring general fear and disgust propensity and two specific fear scales focused on snakes and spiders. This would allow us to evaluate different psychometric tools (picture vs. verbal) for fear and disgust of animals as well as to make comparisons with previous findings.

Additionally, our specific aims were to: (1) investigate whether fear and disgust are distinct, mutually exclusive dimensions or rather interlinked mental experiences that might be evoked in the same subject by the same species; (2) show the association between fear and disgust ratings of animal pictures and standardized questionnaires; (3)

compare a factor analysis of fear and disgust based on animal pictures to dimensions based on verbal items (Davey, 1994a; Davey *et al.*, 1998; Ware *et al.*, 1994); and (4) analyse the effect of individual characteristics or negative experiences with animals on self-reported fear and disgust.

Materials and methods

Subjects

In total, 2,291 subjects were recruited from a Facebook community of Czech and Slovakian volunteers willing to participate in various psychology research that has more than 16,000 followers. Several posts published on the Facebook wall were inviting for an online study focused on human perception of animal beauty. The data collection was conducted between March and December 2017. Out of those who joined the study, 1,798 subjects completed the whole survey providing comprehensive data. There were considerably more women (N = 1,278) than men (N = 519), one respondent did not indicate the gender. The mean age was 33.2 ± 0.3 years. Most of the subjects have obtained a university degree (N = 889), 795 people have completed secondary education, and 108 participants have stopped after elementary school.

Assessment battery

The online assessment battery consisted of images of phobic animals that the respondents rated according to fear and disgust, two psychometrics of the most common animal fears of snakes (Snake Questionnaire, SNAQ: Klorman, Weerts, Hastings, Melamed, & Lang, 1974; Czech translation: Polák, Sedláčková, Nácar, Landová, & Frynta, 2016) and spiders (Spider Questionnaire, SPQ: Klorman *et al.*, 1974), one assessment of general fear of various objects or situations (Fear Survey Schedule II, FSS: Geer, 1965), and a measure of disgust propensity (Disgust Scale – Revised, DS-R: Haidt, McCauley, & Rozin, 1994, modified by Olatunji *et al.*, 2007 and van Overveld *et al.*, 2011; Czech translation: Polák, Landová, & Frynta, 2018). The FSS and SPQ not available in Czech were first translated by two independent native bilingual speakers, and the items were checked through a back-translation procedure.

Images of phobic animals

Unlike previous research, where the choice of tested animal stimuli was sometimes arbitrary, our goal was to study human perception of animals objectively triggering the most common specific phobias. The aim was to cover the variety of animal species feared by humans, yet keeping the number of visual stimuli reasonable not to overload the respondents. However, as the exact data on prevalence of various animal phobias are rare and mostly concern only the one of snakes and spiders, we devised our list of species based on two approaches. First, we searched through several literature sources that mention which animals become the most frequent phobic targets (Becker *et al.*, 2007; Curtis, Magee, Eaton, Wittchen, & Kessler, 1998; Davey, 1994a; Davey *et al.*, 1998; Doctor, Khan, & Adamec, 2008; McNally & Steketee, 1985). Subsequently, to complete the list, we consulted an encyclopaedia of phobias (Doctor *et al.*, 2008). In order to objectivize each animal phobia frequency without having real prevalence data, we used the amount of information available in the encyclopaedia (quantified as the word count) as a proxy. We expected that the longer the description, the more knowledge clinicians have about, and the more frequent the animal phobia is in the general population.

This way, the following list of 23 animals (animal categories) has been devised (in the alphabetic order): ant, bat, bull, cat, cockroach, dog, fish, frog, horse, lizard, louse, maggot, moth, mouse, pigeon, rat, rooster, roundworm, snail, snake, spider, tapeworm, and wasp. Furthermore, a recent paper suggests that the snake is rather a heterogeneous category as different snake species strikingly vary in elicited fear or disgust (Landová *et al.*, 2018). Based on this finding, two kinds of snakes were used in our study, a venomous viper and a non-venomous grass snake. Finally, a picture of the red panda has been included as a control stimulus, hence 25 pictures in total (for specific animal species used in the set as typical representatives of the category, see Table S1). The image set consisted of colour photographs representing typical individuals of wild species (except for the domestic forms) taken from the Internet. All the source files had a licence to be freely used for scientific purposes. We digitally cropped the photographs, placed them on a white background, and resized them to a comparable size (regardless of their real size) using GIMP 2.8.16 (Kimball & Mattis, 2016).

Snake Questionnaire

The SNAQ is a 30-item self-report scale to assess the verbal–cognitive component of snake fear. Each item is a fearful or non-fearful statement related to snakes. Participants rate each item as true or false. The instrument is scored by assigning a '1' to each true response and '0' to each false response, seven items are reversed-scored. A total score (ranging from 0 to 30) is calculated by summing all 'true' statements, and it serves as a measure of the degree of phobic fear (Wikström, Lundh, Westerlund, & Högman, 2004).

Spider Questionnaire

The SPQ is a scale very similar to the SNAQ, adapted to quantify fear of spiders. It contains 31 items (fearful or non-fearful statement) rated as true or false. It is scored the same way as the SNAQ, nine items are reverse-scored. Scores can range from 0 to 31.

Fear Survey Schedule II

The FSS is a self-report instrument to assess overall level of anxiety in a person's life, as well as particular areas of anxiety (such as social situations, injury, death, animals). It contains 51 items that are nouns relating to animals, social situations, injury and death, objects, noises, and other situations that are rated by the respondent on a 7-point Likert scale according to elicited fear from 1 ('no fear') through 4 ('some fear') until 7 ('terror'). A total score is calculated as a sum of item scores and can range from 51 to 357.

Disgust Scale – Revised

The DS-R is a self-report personality scale to assess individual differences in propensity to disgust. There are 25 disgust elicitor items loading on one of the three factors (core disgust, animal reminder disgust, and contamination-based disgust) and two catch questions (item 12 and 16) allowing to identify those respondents who do not pay attention to the task or do not take it seriously. Each of the 27 items is rated by the participant on a 5-point Likert scale from 0 ('strongly disagree/not disgusting at all') to 4 ('strongly agree/extremely disgusting'). A total score (ranging from 0 to 100) is calculated by summing scores on all the 25 disgust elicitor items but three (items 1, 6, and 10) that are reverse-scored. Similarly, subscale scores may be calculated.

At the end, the subjects were asked a series of questions regarding their socio-demographic characteristics including the gender, age, and size of town when one grew up for the greatest part of childhood (further referred to as size of town). It has been previously shown that these variables have a significant effect on prevalence of animal phobias (Fredrikson, Annas, Fischer, & Wik, 1996) and other anxiety disorders (George, Hughes, & Blazer, 1986) and thus might affect fear and disgust of animals as well. Moreover, it is reasonable to presume that different early experiences (frequency of encounter) with animals in rural versus urban areas (hence the size of town during childhood) might shape our perception of them. Finally, one would expect that fear and disgust associated with animals might stem from negative painful experiences; therefore, we asked our subjects whether they have ever been scratched by a cat, bitten by a dog, or attacked by another animal. We asked specifically for injuries caused by cats and dogs not only because they are the most common pets that everybody has already come across, but also based on the evidence that cat and dog phobias usually have a precedent traumatic conditioning experience (Doogan & Thomas, 1992). All the participants provided their informed consent by pressing the corresponding button on the electronic form. The study has been approved by the respective institutional ethics committee.

Procedure

Prior to completing the survey, the respondents were briefly instructed on the general purpose of the study and the way their data would be handled. Upon clicking a button to commence, the individual parts of the assessment battery were presented in the following order: (1) rating the image set according to fear, (2) SNAQ, (3) FSS, (4) rating the image set according to disgust, (5) SPQ, (6) DS-R, and (7) socio-demographic characteristic questionnaire. There were several reasons for this specific task sequence. First, our primal interest lied more within the image ratings rather than the questionnaires, so we wanted to present the animal images before the corresponding scales to avoid a potential bias in the image evaluations. We focused on the emotion of fear, that is why we started with the fear evaluation followed by the fear-related questionnaires (i.e. SNAQ and FSS). Evaluation of the same image set, this time according to disgust, came after, followed by the disgust-related questionnaires (i.e. SPQ and DS-R; note that although the SPQ is presented as a measure of fear of spiders, it is generally accepted that spider phobia is associated more with disgust rather than fear, see above).

When rating the image set, all the 25 pictures were shown at once on the screen, one beneath the other. The image size was automatically set by the system to 655×436 px. There was a question above each image asking how fearful/disgusting the respondent finds the pictured animal and below was a 7-point Likert scale ranging from 'not at all' through 'moderately' until 'extremely'. The order of image presentation on the screen was completely random.

Statistical analyses

First, mean scores for fear and disgust evaluation of each tested animal were calculated. To identify a potential discrepancy in the evaluation of fear and disgust, we also calculated a mean difference between the two ratings for each tested stimulus and compared them by a paired samples *t*-test. A Pearson correlation coefficient was calculated between the mean fear and disgust ratings as well.

We have used several approaches to test for the association between individual scores on the four psychometrics and fear and disgust ratings of the tested animals. First, given the non-normal score distribution on some of the questionnaires, a Spearman correlation coefficient between the fear and disgust ratings and four questionnaire scores was calculated. The contribution of the respondent's gender, age, and scores on the four assessments to the animal fear and disgust ratings was examined in a redundancy analysis (RDA) as implemented in the R package vegan (Oksanen *et al.*, 2017; R Development Core Team, 2010). The RDA is a multivariate direct gradient method (Ter Braak & Šmilauer, 2018). It extracts and summarizes the variation in a set of response variables (subjective evaluation of the animal pictures according to fear and disgust) that can be explained by a set of explanatory variables (age, gender, disgust propensity, general fear, and specific fear of snakes and spiders as measured by the DS-R, FSS, SNAQ, and SPQ, respectively). This analysis permits to plot both the response and explanatory variables to a space defined by the extracted gradients and enables to detect redundancy (i.e., shared variability) between sets of response (subjective evaluation of pictures) and explanatory variables (scores on questionnaires). Statistical significance of the gradients was confirmed by permutation tests. Moreover, for the two most phobic animals, the snake and spider, a generalized linear model (GLzM) for the negative binomial distribution with a log link function has been used to evaluate the association between the fear/disgust rating and the score on a standardized measure of specific fear (i.e., the SNAQ and SPQ).

Next, we performed a parallel analysis on the original animal fear and disgust ratings to determine the appropriate number of factors to extract (Horn, 1965). It has been demonstrated that the parallel analysis is one of the most accurate methods for such purpose (Zwick & Velicer, 1986). Here, we followed a procedure developed by O'Connor (2000) using his updated syntax (). We ran 5,000 random permutations of a raw data set (which is a recommended procedure for scale data that might not necessarily follow a normal distribution) with 1,901 cases and 25 variables (fear/disgust scores for each tested animal) for fear and disgust separately to which the real data eigenvalues were then compared. Subsequently, a factor structure in the image ratings was examined using a factor analysis with the maximum likelihood extraction method and direct oblimin rotation. We also calculated subscale scores for fear and disgust evaluation by summing ratings of individual images within each of the identified factors. We then calculated a correlation coefficient between those subscale scores and the four questionnaire scores (based on the data distribution, a Pearson correlation is used for FSS and DS-R and a Spearman correlation for SNAQ and SPQ).

Finally, we performed general linear models (GLMs) to verify how mean fear and disgust rating calculated across all the tested animals for each participant and the subscale scores are affected by the size of town (categorized by population as follows: [1] up to 1,000, [2] between 1,000 and 5,000, [3] between 5,000 and 50,000, [4] between 50,000 and 100,000, [5] between 100,000 and 500,000, and [6] more than 500,000) and a negative experience with pet animals (being scratched by a cat or bitten by a dog, categorized as: [1] never, [2] only as a part of a game, [3] only as a warning, [4] yes, but only a little, [5] yes, I was bleeding, and [6] yes, I had to seek medical treatment), or attacked by another animal (categorized only as: [1] no, [2] yes). These calculations were performed in SPSS, version 22 (IBM Corp., 2013).

Results

Association between fear and disgust ratings and questionnaire scores

The mean scores of perceived fear and disgust of the tested stimuli are provided in Table 1; moreover, these were highly correlated (r = .72, p < .0001; Figure 1). Frequency of the highest score (7) given to each animal on both scales is shown in Figure 2.

Next, we employed the RDA to examine the contribution of respondent's scores on four questionnaires, gender, and age to the fear and disgust ratings of particular animals. The RDA model has generated six constrained axes, which explained 29.66% of the full variability. We then performed a permutation test (number of permutations = 10,000) to confirm the significance of each of the independent variables (constraints) in a sequential ('type I') test: FSS, $F(1,\ 1{,}774) = 359.36$, $p < .0001$; SNAQ, $F(1,\ 1{,}774) = 195.68$, $p < .0001$; SPQ, $F(1,\ 1{,}774) = 129.25$, $p < .0001$; DSR, $F(1,\ 1{,}774) = 39.46$, $p < .0001$; age, $F(1,\ 1{,}774) = 15.57$, $p < .0001$; and gender, $F(1,\ 1{,}774) = 8.72$, $p < .0001$. The visualization of the RDA results (see Figure 3) showed that negative evaluation of the animal stimuli is generally associated with high scores on both the FSS and DSR. This relationship dominated the first multivariate axis (RDA1). Although the SNAQ and SPQ

Table 1. Mean raw and standardized scores for fear and disgust evaluation of the tested animals with a difference in the mean fear and disgust score

Animal	Mean fear	Mean disgust	Difference in mean fear and disgust scores
Ant	2.12	2.26	−0.14**
Bat	2.11	2.01	0.10**
Bull	3.84	1.62	2.22**
Cat	1.24	1.17	0.07**
Cockroach	3.10	4.16	−1.06**
Dog	2.25	1.20	1.05**
Fish	1.15	1.38	−0.23**
Frog	1.84	2.48	−0.66**
Grass snake	3.32	2.47	0.85**
Horse	1.82	1.11	0.72**
Lizard	1.46	1.46	0.00**
Louse	3.58	4.83	−1.25**
Maggot	2.90	4.49	−1.59**
Mouse	1.62	1.78	−0.16**
Panda	1.57	1.17	0.40**
Pigeon	1.48	2.01	−0.53**
Rat	2.11	2.25	−0.14**
Rooster	1.78	1.34	0.44**
Roundworm	3.49	4.79	−1.30**
Snail	1.15	1.69	−0.54**
Spider	4.39	4.47	−0.08*
Tapeworm	3.60	4.83	−1.23**
Viper	4.34	2.83	1.51**
Wasp	3.42	2.84	0.58**

The difference in means is significant at $^*p < .01$; $^{**}p < .001$.

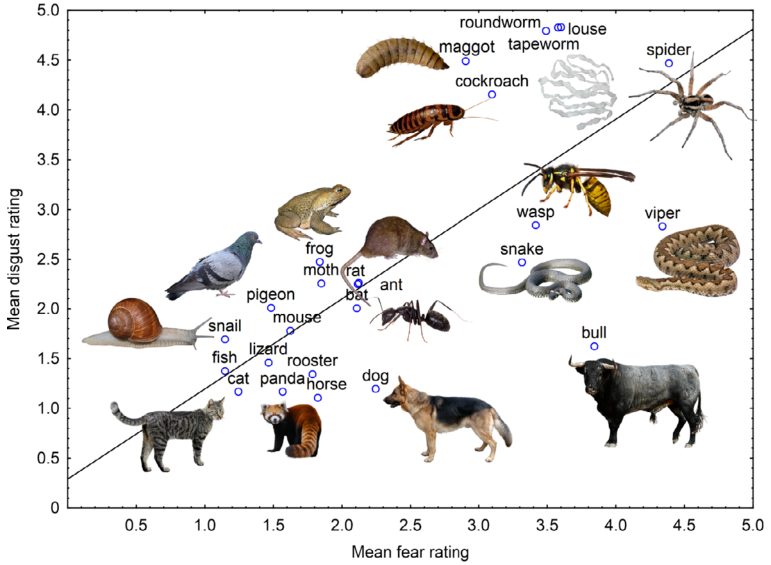

Figure 1. Correlation between the mean fear and disgust scores of the tested animals (*r* = .72). [Colour figure can be viewed at wileyonlinelibrary.com]

contribute to RDA1 as well, their opposition defines RDA2 axis. As expected, the SNAQ and SPQ scores are closely associated with negative evaluation of their target stimuli (according to both fear and disgust), i.e. snakes and spiders, respectively.

In order to standardize the questionnaires' weight and to examine the effects of high scoring respondents, we rescaled the scores on the DSR, FSS, SNAQ, and SPQ based on quartiles and recoded them as either (1) low (below the lower quartile), (2) medium (interquartile values), or (3) high (above the upper quartile). These were further included into the RDA as explanatory variables instead of the original ones. In this case, we utilized the automatic model-building feature based on both the Akaike criterion (but with permutation tests) and permutation *p*-values. Both methods agreed on inclusion of the following variables into the reduced model (constrained axes explained 26.83% of the full variability), which were then confirmed as significant by the sequential 'type I' test (number of permutations = 10,000): SNAQ3, $F(1, 1{,}770) = 259.08$, $p < .0001$; FSS1, $F(1, 1{,}770) = 129.93$, $p < .0001$; SPQ3, $F(1, 1{,}770) = 99.81$, $p < .0001$; FSS3, $F(1, 1{,}770) = 45.71$, $p < .0001$; SPQ2, $F(1, 1{,}770) = 41.95$, $p < .0001$; DSR1, $F(1, 1{,}770) = 21.79$, $p < .0001$; age, $F(1, 1{,}770) = 15.94$, $p < .0001$; SNAQ1, $F(1, 1{,}770) = 14.88$, $p < .0001$; DSR3, $F(1, 1{,}770) = 13.09$, $p < .0001$; and gender, $F(1, 1{,}770) = 6.74$, $p < .0001$). For correlation coefficients between the individual fear/disgust animal ratings and questionnaire scores, see Table S2.

This was further supported by a GLzM model that revealed a significant effect of both the fear and disgust rating of the grass snake on the SNAQ score (fear: Wald $\chi^2_{6,1848} = 49.53$, $p < .001$; disgust: Wald$\chi^2_{6,1848} = 20.45$, $p = .002$) and the effect of disgust elicited by the viper (Wald$\chi^2_{6,1848} = 43.37$, $p < .001$) but not fear of it (Wald$\chi^2_{6,1848} = 3.93$, $p = .686$) on the SNAQ score. Similarly, there was a strong significant association between the fear and disgust rating of the spider and the SPQ score (fear: Wald $\chi^2_{6,1816} = 50.59$, $p < .001$; disgust: Wald $\chi^2_{6,1816} = 179.99$, $p < .001$).

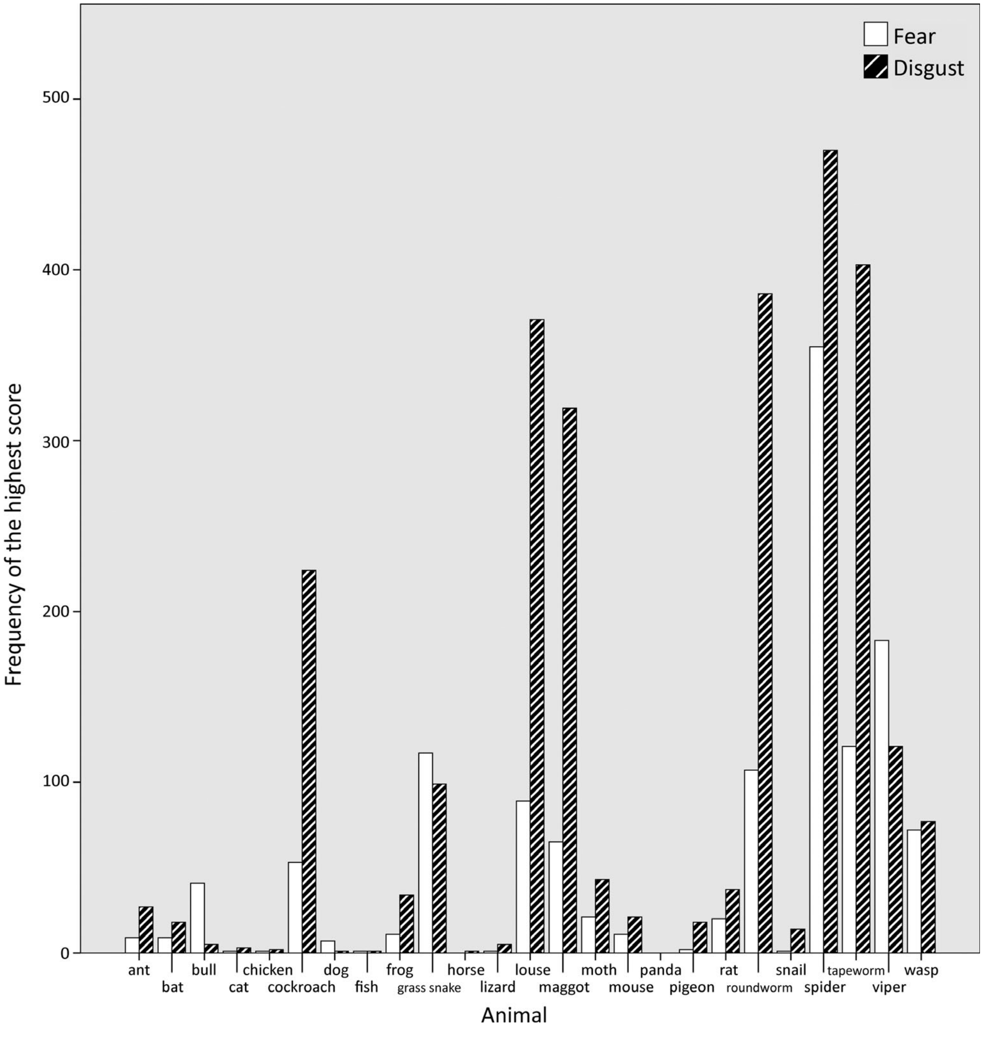

Figure 2. Frequency of the highest fear and disgust rating (7) given to each animal in the set

Factor analysis of fear and disgust of animals

The Kaiser–Meyer–Olkin measure of sampling adequacy (fear: 0.92; disgust: 0.90) and Bartlett's test of sphericity (fear: $\chi^2 = 19507.96$, $p < .001$; disgust: $\chi^2 = 23141.56$, $p < .001$) confirmed that the item structure of the data set warranted a factor analysis. The parallel analysis performed separately for fear and disgust ratings revealed that in both emotions only the first five eigenvalues extracted from the real data exceeded the 95th percentile of those based on the simulations of raw data sets. As for fear, the five factors together explained 47.99% of the total variance, most of which pertained to the first factor (29.01%) while the remaining four clusters were considerably weaker (7.54%, 3.68%, 3.76%, and 3.99% of variance, respectively). For disgust, the five-factor model explained 52.52% of the total variance with the following percentage of total variance explained for each factor: 28.47, 8.76, 5.67, 6.10, and 3.52, respectively (see Tables 2 and 3 with factor loadings for fear and disgust). There were significant correlations between the subscale scores calculated for each factor and the questionnaire scores (see Table 4).

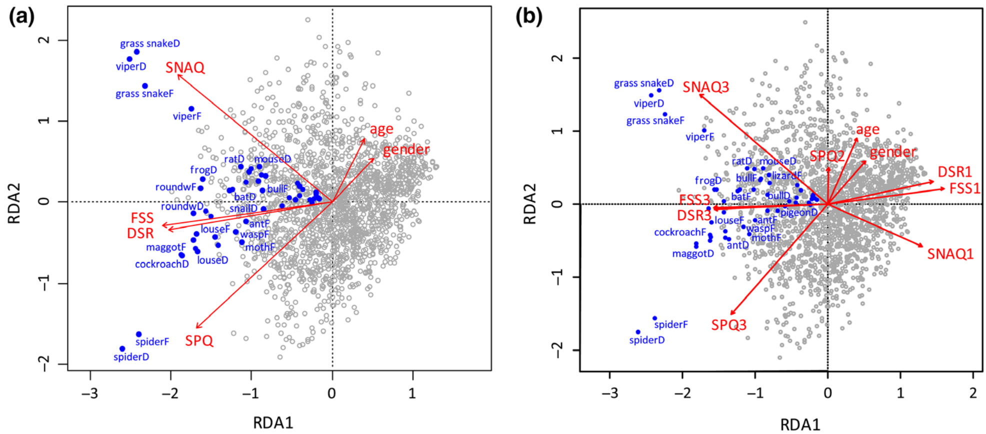

Figure 3. Redundancy analysis visualization of the effect of questionnaire scores (treated as either [a] a continuous variable or [b] when categorized based on quartiles as low [1], medium [2], or high [3]), gender, and age of the respondents on fear (F) and disgust (D) ratings of the tested animals. Eigenvalues of RDA1 and RDA2 axes are 20.45 and 4.71, respectively. Mean fear/disgust ratings of two snake pictures according to how the respondent scored on the Snake Questionnaire (SNAQ): fear of viper, low: 3.41, medium: 4.11, high: 5.86; $F(2, 1{,}848) = 396.81$, $p < .001$; disgust of viper, low: 1.49, medium: 2.38, high: 5.28; $F(2, 1{,}848) = 1000.45$, $p < .001$; fear of grass snake, low: 1.97, medium: 3.04; high: 5.37; $F(2, 1{,}848) = 685.50$, $p < .001$; disgust of grass snake, low: 1.24; medium: 1.98; high: 4.90; $F(2, 1{,}848) = 1172.25$, $p < .001$. Mean fear/disgust ratings of the spider picture according to how the respondent scored on the Spider Questionnaire (SPQ): fear of spider, low: 2.43, medium: 4.21, high: 6.40; $F(2, 1{,}816) = 966.50$, $p < .001$, disgust of spider, low: 2.16, medium: 4.33, high: 6.67; $F(2, 1{,}816) = 1141.50$, $p < .001$. [Colour figure can be viewed at wileyonlinelibrary.com]

Effect of individual characteristics on fear and disgust evaluation

We also computed a GLM with the respondent's gender, size of town, and negative experience with animals (scratched by a cat, bitten by a dog, and attacked by another animal) as fixed factors and age as a covariate on the overall mean fear and disgust rating. The mean fear score was significantly influenced by the gender, $F(1, 1{,}737) = 23.67$, $p < .001$; age, $F(1, 1{,}737) = 4.30$, $p = .038$; dog bite, $F(5, 1{,}732) = 5.38$, $p < .001$; and cat scratch, $F(5, 1{,}732) = 2.57$, $p = .025$; but not the size of town, $F(5, 1{,}732) = 0.96$, $p = .443$; nor another animal attack; $F(1, 1{,}737) = 2.73$, $p = .099$. Women reported significantly higher fear of the tested animals than men, and the mean fear rating only very slightly decreased with age ($r = -.064$). We also found a strong negative association between the mean fear rating and severity of a dog bite or cat scratch in the past; that is, people with no or little experience of being bitten by a dog or scratched by a cat gave higher fear ratings than people who had been seriously injured by these pet animals in the past.

The mean disgust score was affected by the gender, $F(1, 1{,}736) = 21.74$, $p < .001$; age, $F(1, 1{,}737) = 25.91$, $p < .001$; and dog bite, $F(5, 1{,}732) = 3.99$, $p = .001$; but not the size of town, $F(5, 1{,}733) = 1.60$, $p = .158$; cat scratch, $F(5, 1{,}732) = 1.93$, $p = .086$; nor another animal attack, $F(1, 1{,}736) = 1.55$, $p = .213$. As with fear, women reported significantly higher disgust than men and the mean disgust rating decreased with increasing age ($r = -.132$). Having been bitten by a dog also decreased the mean disgust rating and the more serious the injury, the lower the rating was. Finally, in a separate

Table 2. Factor loadings for fear evaluation of the tested animals

	Factor				
	1	2	3	4	5
Moth	**0.693**	0.040	0.005	0.043	−0.025
Cockroach	**0.655**	0.010	−0.033	−0.247	0.015
Ant	**0.553**	−0.048	0.032	−0.065	0.132
Maggot	**0.538**	−0.003	−0.011	−0.402	−0.105
Spider	**0.514**	−0.074	0.246	−0.066	−0.056
Wasp	**0.440**	−0.127	0.031	−0.076	0.268
Lizard	**0.326**	0.220	0.322	0.063	0.004
Frog	**0.317**	0.245	0.270	−0.061	−0.025
Snail	0.296	0.122	−0.002	−0.063	−0.050
Fish	0.258	0.136	0.041	0.034	0.062
Mouse	−0.039	**0.863**	0.039	−0.053	0.019
Rat	−0.062	**0.787**	0.040	−0.107	0.139
Bat	0.272	**0.331**	0.224	0.018	0.147
Grass snake	0.056	0.040	**0.820**	−0.023	−0.057
Viper	−0.109	−0.033	**0.749**	−0.110	0.186
Tapeworm	−0.043	0.046	0.037	**−0.832**	0.003
Roundworm	−0.023	0.054	0.074	**−0.820**	0.008
Louse	0.359	−0.017	−0.015	**−0.528**	0.079
Horse	−0.024	−0.049	−0.009	0.003	**0.708**
Dog	−0.088	0.006	0.035	−0.011	**0.685**
Bull	−0.055	−0.004	0.212	−0.086	**0.605**
Rooster	0.255	0.065	0.011	0.036	**0.416**
Panda	0.069	0.210	0.099	0.048	**0.401**
Cat	0.040	0.183	−0.023	−0.009	**0.322**
Pigeon	0.138	0.166	−0.050	−0.089	**0.314**

Factor loadings >0.30 are in boldface.

analysis we have also calculated the effect of those variables on the five fear and disgust subscale scores as derived from the factor analyses (see Table S3 for more details).

Discussion

We demonstrated in this study that in fact only a few animals associated with specific phobias elicit intense fear or disgust within the general population. Most of the tested species scored relatively low on both emotions, while two smaller groups of highly fearful (viper, wasp, snake, and bull) and repulsive animals (roundworm, tapeworm, maggot, louse, and cockroach) were formed on the other end of the axis with the spider in between. Interestingly, the fear and disgust ratings strongly correlated and were positively associated with scores on the administered scales. The mean fear and disgust score was also affected by the gender, age, and bad experience with dogs. Finally, a five-factor solution was found for categorizing the animals based on both fear and disgust ratings separating snakes, small non-slimy invertebrates (including the spider), mice with rats and bats, endo- and exoparasites, and big mammals into coherent clusters.

Table 3. Factor loadings for disgust evaluation of the tested animals

	Factor				
	1	2	3	4	5
Grass snake	**0.948**	0.035	−0.003	−0.030	0.012
Viper	**0.894**	0.070	0.000	−0.045	0.043
Lizard	**0.399**	−0.073	0.160	0.319	0.043
Tapeworm	0.055	**0.876**	0.038	−0.107	0.045
Roundworm	0.084	**0.870**	0.026	−0.050	0.065
Louse	−0.067	**0.680**	0.028	0.281	−0.003
Maggot	0.016	**0.567**	0.010	0.415	−0.114
Rat	0.041	0.068	**0.908**	−0.050	−0.036
Mouse	0.045	0.022	**0.882**	−0.078	0.023
Bat	0.162	−0.043	**0.365**	0.331	0.108
Pigeon	−0.112	0.066	0.277	0.210	0.216
Moth	−0.037	−0.002	0.095	**0.696**	−0.028
Ant	0.016	0.052	−0.088	**0.672**	0.058
Cockroach	−0.036	0.399	0.073	**0.538**	−0.068
Spider	0.151	0.156	−0.035	**0.519**	−0.100
Wasp	0.047	0.078	−0.079	**0.506**	0.158
Snail	0.048	0.060	0.050	**0.470**	0.040
Frog	0.299	0.050	0.192	**0.392**	−0.027
Fish	0.105	−0.031	0.079	**0.345**	0.157
Horse	−0.008	0.015	−0.090	−0.010	**0.709**
Dog	−0.014	0.038	−0.041	−0.045	**0.663**
Bull	0.184	0.020	−0.003	0.135	**0.531**
Panda	0.041	−0.038	0.093	0.025	**0.530**
Rooster	0.038	−0.090	0.080	0.282	**0.399**
Cat	0.004	0.034	0.130	−0.049	0.296

Factor loadings >0.30 are in boldface.

Table 4. Mean subscale scores and correlation coefficients between the subscale scores as identified in the factor analyses and the questionnaire scores

	Factor	Mean	SNAQ	FSS	SPQ	DSR
Fear	1	2.63	0.40	0.58	0.58	0.49
	2	1.95	0.41	0.44	0.22	0.40
	3	3.83	0.68	0.43	0.25	0.37
	4	3.56	0.31	0.51	0.28	0.46
	5	2.00	0.23	0.43	0.09	0.23
Disgust	1	2.25	0.74	0.39	0.29	0.40
	2	4.74	0.31	0.47	0.36	0.55
	3	2.01	0.38	0.37	0.22	0.40
	4	2.69	0.42	0.53	0.62	0.52
	5	1.29	0.31	0.34	0.19	0.26

Tested scales: DSR = Disgust Scale – Revised; FSS = Fear Survey Schedule II; SNAQ = Snake Questionnaire; SPQ = Spider Questionnaire.
All the coefficients are significant at $p < .001$.

Expectedly, the spider and venomous snake (viper), but not a harmless snake (grass snake), were the most feared animals by the majority of respondents in our study. Nearly 19% of subjects reported extreme fear or terror when exposed to the spider picture and 10% of subjects gave the highest fear score to the viper picture. This confirms the general agreement in the literature that snakes and spiders are the most intensively feared animals in humans with the highest prevalence in the general population (Davey, 1994a, 1994b; Davey *et al.*, 1998; Fredrikson, *et al.*, 1996; Merckelbach *et al.*, 1987). It also provides a circumstantial support to Seligman's theory of biological preparedness (1971), which considers snakes and spiders as exemplary species for evolutionary origins of specific phobias that can develop even without a preceding traumatic experience (Fredrikson, Annas, & Wik, 1997). Similarly, Öhman and Mineka (2001, 2003) believe snakes to be prototypical stimuli triggering the fear module hardwired in the mammalian brain. However, as can be demonstrated by our study, not all the snakes are alike and healthy adults, as opposed to phobic subjects, are able to adjust their fear response based on the real threat posed by the particular snake species. Compared to the viper, the picture of an innocuous grass snake was rated considerably lower on the fear scale and only 6% of subjects reported the highest fear, nearly half as frequent as fear of the viper. To our knowledge, this is the first study to show that snake fear much depends on the specific species presented to the subject which should be reflected in future research.

Unlike most of the previous studies of negative emotions towards animals (cf Prokop & Fančovičová, 2010), we have also included disgust evaluation. While the overall intensity of perceived fear and disgust (expressed as a sum of the mean fear/disgust ratings for each animal) was almost identical, the frequency of the highest scores attributed to the stimuli was much higher in the case of disgust (see Figure 2). We hypothesize that this might be attributed to the categorical difference between the two emotions. Disgust, as opposed to fear, can be easier elicited by still images, while fear relies more on the actual context. As Bennett-Levy and Marteau (1984) or Merckelbach *et al.* (1987) argued, fear of animals is associated with the characteristics such as speediness and suddenness of movement which cannot be interfered from the photographs. For example, there is a solid evidence that infants associate snakes with fear only when looking at videos but not still photographs indicating that the snakes' slithering movement is crucial (DeLoache & LoBue, 2009; LoBue & DeLoache, 2011).

As the most disgusting were found the animals that are exo- and endoparasites of humans, such as the louse, tapeworm, or roundworm, which may become vectors of serious life-threatening diseases including epidemic typhus, cysticercosis, or ascariasis, respectively (Macpherson, 2005). Especially intestinal worms represent a huge medical problem as estimated more than 1.5 billion people are infected by soil-transmitted helminths worldwide (WHO, 2018), almost a quarter of the population. This, on the other hand, provides substantial support to the disease-avoidance model of animal phobias (Matchett & Davey, 1991; Oaten, Stevenson, & Case, 2009; Ware *et al.*, 1994) stressing the role of disgust in the behavioural immune system to reflect the strong selective pressure of parasites in human evolution (Curtis, Aunger, & Rabie, 2004; Curtis *et al.*, 2011; Prokop & Fančovičová, 2010). Therefore, all that points to a conclusion that there are two major kinds of animal phobias, one represented by snakes as a prototypical stimulus that are associated with fear and match the presumptions of the biological preparedness concept. The other large group is mostly composed of small slimy or dry invertebrates known as dangerous parasites or vectors of diseases that are avoided through triggering a disgust response and for whom the disease-avoidance model has the highest explanatory power.

Spiders then, as discussed below, share their phobic characteristics with both of these groups.

Interestingly, the spider ranked on disgust right after these parasites and overcame generally highly repulsive animals such as the cockroach, snail, rat, or mouse. Thus, among the most feared and disgusting animals, the spider was the only species scoring equally high on both emotions. This confirms the finding of Gerdes *et al.* (2009) that spiders are special in eliciting significantly greater fear and disgust than any other arthropod. This might reflect emotional fear/disgust ambiguity of the spider stimulus (see also Davey, 1992, 1994b; Gerdes *et al.*, 2009).

It has been hypothesized within the context of disease-avoidance model that spider phobia develops from the convergence of the spiders' disgusting properties and the subjective probability of involuntary physical contact with humans. Indeed, spiders are regarded as highly disgusting by healthy subjects and even more by spider phobics (de Jong & Muris, 2002), potentially due to their quirky 'too-many-legs' body plan. At the same time, they are omnipresent in our homes, often lurking in hidden dark places and capable of fast unpredictable movement. According to de Jong and Muris (2002), spider phobic girls have higher tendency for irrational catastrophic beliefs regarding spiders' intentions and behaviour; specifically, they rather inflate the probability of spiders entering their room, approaching them, and making physical contact or even deliberately causing harm (Arntz, Lavy, van den Berg, & van Rijsoort, 1993). In short, spider phobia stems from fear of physical contact with a disgusting stimulus. A parallel can be found in the case of the cockroach that resembles the spider in its physical appearance and higher fear and disgust status. Interestingly, the cockroach is probably more dangerous to human health than the spider. Cockroaches both defecate and regurgitate on the food that they eat and cause food contamination by spreading highly infectious bacteria *Pseudomonas* and *Salmonella* that are transmissible to humans and cause serious diseases (Cornwell, 1968). Perhaps, the reason why there are not as many cockroach phobias is because these animals are not very frequent in our living space.

Our results suggest that the same mechanism might be at the core of other small animal phobias, especially of parasitic worms and lice. These animals pose a significant disgust status, even greater than the spider. Simultaneously, they are among the most feared animals ranking alongside the wasp or grass snake, prototypical fearful stimuli. This is also corroborated by a significant positive correlation between the respective factor scores and assessments of fear and disgust (FSS and DS-R; see Table 4). One might argue that as opposed to spiders, mainly intestinal helminths lack the ability of active locomotion, and thus fear of involuntary physical contact can be ruled out. However, we hypothesize that this is not the case and in fact several factors typical for human parasites may contribute to development of specific phobia through the same route as for spiders, thus being approached by something highly repulsive.

First, even though some intestinal parasites may grow into impressive body size at adulthood (the pork tapeworm infecting humans can reach up to 4 m in length), due to their life cycle hidden within the host body we nearly never have a chance to see the adult stage. In contrary, humans get typically infected by microscopic, hence invisible, ova or larvae (cysts) that are ingested with undercooked meat or dirtiness from unwashed hands. Second, they may be omnipresent and their distribution is unpredictable. For these reasons, despite being highly repulsive stimuli, we cannot rely on disgust in order to avoid them as neither themselves, the infected meat, nor another person infested with helminths can be recognized at first sight (likewise to lice infestation). Therefore, being as passive passengers not capable of active movement, parasites often use other vehicles to get into our bodies; hence, people fear them as disgusting entities that might get too close without us noticing or having much control over it. In this perspective, the maggot is an interesting animal stimulus that seems to stay half-way to be like a parasite. Even though it is as disgusting as the intestinal worms or lice, the maggot is easier to be spotted and avoided at distance. As a consequence, it does not elicit as much fear as intestinal worms (actually its fear ranking is below average), because the crucial probability of unwanted contact is very limited.

It is noteworthy that the dimension of fear and disgust in this study seemed closely associated (though less profoundly) in other species too as demonstrated by the high correlation coefficient $r = .72$. Therefore, it might also be possible that both emotions elicit similar negative feelings that for many individuals are hard to distinguish, especially in an online testing where no feedback or additional clarification is possible. Emotional intelligence, that is the ability of introspection and correct identification of experienced emotions, has significant interindividual variability and may even be improved through training as some other psychological skills (Mayer & Geher, 1996).

Perhaps, it is maybe more interesting not to ask which animals trigger high fear and disgust but rather which of them do not. Supposing that phobias derive from dysregulation of otherwise normative fears of objects or situations that provoke certain anxiety even in healthy individuals and bearing in mind our picture set should have represented the most common phobic animals, one might expect that the stimuli would all evoke a certain level of fear or disgust in our respondents. Interestingly, out of the 24 animals, only 10 received a mean score above point 3 (i.e. lower than moderate fear/disgust) on either of the scales, i.e. the cockroach, grass snake, louse, roundworm, spider, tapeworm, viper, wasp, and maggot. The remaining 14 animals, e.g., the rat, mouse, lizard, or snail, on average evoked only very little or no fear/disgust that was comparable to the control stimulus, the red panda. Thus, many of the animals that become objects of pathological anxiety do not have any normative fearful or avoidance potential.

We also focused on the association between fear and disgust ratings of animal pictures and scores on standardized questionnaire measuring general fear and disgust propensity (FSS and DS-R) and specific fear of the two most phobic animals, snakes and spiders (SNAQ and SPQ). As revealed in the RDA, high scores on the FSS and DS-R contributed the most to negative evaluation of all the animals according to either fear or disgust, which corroborates previous findings (Davey, 1994a; Matchett & Davey, 1991). Presumably, we have also found a significant association between fear/disgust evaluation of snakes and spiders and the respective fear questionnaire scores, the SNAQ and SPQ. However, it appears that the fear and disgust evaluation of the grass snake picture is a better predictor of the SNAQ score than the viper picture. As discussed above, the viper as a venomous snake representing a serious threat is highly feared among subjects no matter their actual level of snake fear, hence the lower effect of the SNAQ score. On the other hand, people close to phobia scoring high on the SNAQ generalize their fear onto any snake, even a totally harmless one. This has quiet significant implications for clinical practice as responses to innocuous representatives of the feared animal category might be used as a fast screening tool for specific phobias rather than pictures of fierce beasts.

So far, a few studies have focused specifically on non-clinical fears of various animals with the aim to group them into coherent clusters, while others used ad hoc or intuitive grouping instead (Gerdes *et al.*, 2009; Webb & Davey, 1992). There is no clear pattern in the existing literature as to animal fear categorization, because the outcomes are limited by the tested species selection procedure. We argue that the way the previous studies used to devise the stimuli set have been flawed as these often adopted a list by Matchett and Davey (1991) and Davey (1994a) that had been developed based on arbitrary judgement of the authors. Thus, we based our selection on a quantifiable criteria referring to the number of information available for each animal phobia in Doctor *et al.* (2008) which may be considered as a proxy to its prevalence. Second, we have used visual instead of verbal stimuli which are generally considered as more effective in provoking an emotional response. We have also extended the current evidence of a factor analysis of animal disgust evaluation, which allowed us to compare the identified clusters based on both emotions and see whether they overlap or are unrelated.

In this study, five clearly separated factors of fear and disgust evaluations were recognized. The first group comprised mostly small-size animals such as the moth, cockroach, ant, spider, and wasp resembling the so-called low-predatory fear-relevant category (Davey, 1994a; Ware *et al.*, 1994) of dry, non-slimy invertebrates (Arrindell, 2000). The second group was formed of 'mouse-like' animals, that is, the mouse, rat, and bat. It is noteworthy that these animals too are significant transmitters of very dangerous pathogens that can be deadly for humans. Rodents are known to be direct vectors of several zoonotic infections such as leptospirosis, hantavirus, or lassa and haemorrhagic fever (CDC, 2017), similar to bats that carry human-infecting viruses including rabies, SARS, or even may be the original hosts of Ebola and Nipah viruses (Luis *et al.*, 2013). This is in further support of the disease-avoidance model of animal phobias. The third clearly separated factor included the two snakes with a little contribution of the lizard in the case of disgust. The fourth factor grouped together human exo- and endoparasites, that is, the louse, tapeworm, and roundworm, with additional significant loading of the maggot in the case of disgust. And finally, familiar farm or pet mammals and birds, such as the horse, bull, dog, cat, or rooster, belonged to the fifth factor together with the red panda used as a control. This corresponds to the 'farm animals' category found by Arrindell (2000). These animals in general evoked only very low fear and disgust among the respondents.

We have demonstrated that not only the mean overall fear and disgust rating but also some subscale scores composed of items identified in the factor analyses were significantly affected by gender. In general, women self-reported higher fear and disgust towards the animals than men which is a common pattern found in all anxiety-related studies (McLean & Anderson, 2009). Our data show that the most striking differences between the sexes were in fear and disgust evaluation of the group of non-slimy invertebrates and repulsive human parasites. This is again in accordance with the evolutionary theory claiming that women as a sex with higher reproductive cost need to be extra careful of pathogens threatening not only their health but also the one of their children (Tybur, Bryan, Lieberman, Hooper, & Merriman, 2011).

Additionally, we observed rather strong negative associations between fear and pet-related injuries and between disgust and dog-related injuries. Both cats and dogs transmit several important parasites, for example, *Toxoplasma* and *Bartonella*, and contact with pets, and especially sustaining pet-related injuries, has strong impacts on both physical and mental health of the general population (Flegr, 2017; Flegr & Hodný, 2016; 2018 & Balatova, 22018; Flegr & Vedralová, 2017). Our results, namely the negative association between phobias and animal-related injuries, suggest that fear and disgust could protect subjects against harm even in our modern environment.

Limitations

We are well aware of certain limitations of the study. Some of them are associated with the method of data collection. Even though online studies recruiting people through Internet communities can often boast with large sample size that would be hardly achieved in face-to-face research, the data gathered this way are less reliable. Already, self-reports are generally prone to be corrupted by demand characteristics, and moreover, in distant research we have no control over the respondents' behaviour during the test. Indeed, the subjects may be more likely within the anonymous setting behind the screen to provide untrustworthy, randomly fabricated answers that are difficult to be identified. Or, they might have just misunderstood some tasks/items but have no chance of getting a further clarification. Second, under no circumstance can our sample be considered as representative in terms of basic demographic characteristics such as age, gender, or educational level. The average age of respondents in the Facebook group we have used is 34 years with more than twice as many women as men and most of the people with completed high school education or higher. Moreover, the subjects in this kind of survey are self-recruited, therefore a bias towards participants interested in the given topic due to various reasons is expectable.

Another limitation pertains to the selection of the tested animals and administered scales. We aimed to devise a list of the most common phobic animals; however, as real prevalence rates of concrete animal phobias in the general population are unknown, we used the amount of available information in the encyclopaedia of phobias by Doctor *et al.* (2008) as an indicator. Obviously, this method may not necessarily be accurate and it remains questionable how the results (especially the factor analyses) might have changed had another animals been selected. For example, human parasites came out as one group eliciting disgust in this study; however, there is evidence that endo- and exoparasites form two distinctive categories. While the former ones usually enter the host organism through the oral cavity and thus evoke core disgust associated with nausea and vomiting as an effective defence strategy, exoparasites attach themselves to the body surface where feeling sick would not help a lot. Instead, itchiness and grooming behaviour is more appropriate reaction (for a review, see Hart, 1990 and Kupfer & Fessler, 2018). Similarly, we used popular, widespread measures of fear and disgust which had been already standardized in Czech (apart from the FSS and SPQ) and that would allow for drawing comparisons with previous research, although there might have been other appropriate scales providing different outcomes. As suggested by some authors (Cusimano, Royzman, Leeman, & Metas, 2018 or Royzman & Sabini, 2001), it is especially the assessment of disgust that needs careful consideration. Finally, even though we argue that using picture rather than verbal stimuli is an asset in terms of their potential to elicit an appropriate emotional response, there are opposing views pointing out that the depicted particular representatives of the phobic object may be for some reason missing the key features that make it threatening for a given individual (Kindt *et al.*, 2000; van den Hout *et al.*, 1997).

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the appropriate institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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Supporting Information

The following supporting information may be found in the online edition of the article:

Table S1. A list of the tested animals.

Table S2. Spearman rank correlation coefficients between ratings of fear and disgust of the tested animals and total/subscale scores on the completed questionnaires.

Table S3. Results of the GLMs for the individual factor scores of fear and disgust as dependent variables and selected demographic or personal experience variables.