ELSEVIER

Evolution and Human Behavior 30 (2009) 66 – 73

Evolution and Human Behavior

Spiders are special: fear and disgust evoked by pictures of arthropods☆

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Initial receipt 7 January 2008; final revision received 15 August 2008

Abstract

Because all spiders are predators and most subdue their prey with poison, it has been suggested that fear of spiders is an evolutionary adaptation. However, it has not been sufficiently examined whether other arthropods similarly elicit fear or disgust. Our aim was to examine if all arthropods are rated similarly, if only potentially dangerous arthropods (spiders, bees/wasps) elicit comparable responses, or if spiders are rated in a unique way. We presented pictures of arthropods (15 spiders, 15 beetles, 15 bees/wasps, and 15 butterflies/moths) to 76 students who rated each picture for fear, disgust, and how dangerous they thought the animal is. They also categorized each animal into one of the four animal groups. In addition, we assessed the participants' fear of spiders and estimates for trait anxiety. The ratings showed that spiders elicit significantly greater fear and disgust than any other arthropod group, and spiders were rated as more dangerous. Fear and disgust ratings of spider pictures significantly predicted the questionnaire scores for fear of spiders, whereas dangerousness ratings of spiders and ratings of other arthropods do not provide any predictive power. Thus, spider fear is in fact spider specific. Our results demonstrate that potential harmfulness alone cannot explain why spiders are feared so frequently.

Keywords: Spider phobia; Biological preparedness; Evolution; Fear; Disgust; Estimated risk

1. Introduction

For humans, spiders are among the top five most feared animals; in the UK, about 30% of women and 20% of men are anxious, nervous, or frightened when confronted with a spider (Davey, 1994a). A specific phobia (see Hofmann, Alpers, & Pauli, 2009) of spiders has been documented to be the most prevalent phobia related to animals, with a prevalence rate of 3.5% (Jacobi et al., 2004). Moreover, spiders are preferentially processed in the visual system by those who fear them (e.g., Alpers et al., in press; Gerdes, Alpers, & Pauli, 2008).

The observation that some stimuli, such as spiders and snakes, are feared with higher probability than other animal groups or objects is often explained in terms of biological preparedness (Seligman, 1971). This hypothesis is based on the fact that most spiders and many snakes are predatory animals and possess venom to immobilize their prey. They are thus thought to have been potentially hazardous for our pretechnological ancestors. Seligman defined *prepared fear learning* by the following criteria: learning is specific to selective cues, is noncognitive, is highly resistant to extinction, and can be acquired in one trial. For example, laboratory-raised rhesus monkeys are less afraid of snakes compared with those raised in the wild (Mineka, Keir, & Price, 1980), but they acquire this fear easily (Mineka, Davidson, Cook, & Keir, 1984) and retain it (Mineka & Keir, 1983; Mineka et al., 1980).

Further support for the preparedness hypothesis comes from conditioning experiments (Öhman, Erixon, & Lofberg, 1975). When pictures of spiders and snakes served as conditioned stimuli that predicted mildly aversive shock, participants showed stronger and lasting skin

☆ We acknowledge the support given by the Research Group Emotion and Behavior, which is sponsored by the German Research Society (DFG), and its speakers Fritz Strack and Paul Pauli.

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1090-5138/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.evolhumbehav.2008.08.005

conductance responses (an index of emotional activation) than when flower or mushroom pictures were paired with the shock. In addition, the conditioned fear to these stimuli was significantly more resistant to extinction (Öhman et al., 1975). Based on the resistance to extinction documented for experimentally acquired responses (McNally, 1987), the preparedness hypothesis has been widely accepted and entered almost every textbook on biological psychology and abnormal psychology, although evidence for other characteristics of preparedness (ease of acquisition, irrationality, and belongingness) is much more limited (McNally, 1987).

From an evolutionary perspective (for overviews, see Nesse, 1990), readily associating spiders with fight-or-flight responses should have a selective advantage for humans because spiders are potentially hazardous. Indeed, most arthropods, such as arachnids (e.g., spiders and scorpions) and hymenoptera (bees, wasps, ants), are venomous. However, although arthropods make up 75% of the world's animal species, only few come in direct contact with humans and even fewer cause significant medical problems. As to spiders, of all known species (about 38,000), very few (approximately 0.1%–0.3%) are considered to cause significant morbidity or mortality (Foelix, 1996; Maretić, 1987; Steen, Carbonaro, & Schwartz, 2004). Since spiders generally prey upon insects or other spiders, their venom has not evolved to harm large vertebrates such as humans. Spiders rarely use venom in response to vertebrates for defense and generally do so as a last resort (Foelix, 1996). Moreover, most studies of spider bites have been retrospective and bites have not been confirmed by eyewitnesses (Diaz, 2004). For example, 80% of suspected cases of spider bites in Southern California were caused by other arthropods, mostly ticks and reduviid bugs (Russel & Gertsch, 1982).

The other potentially hazardous arthropod group is the order Hymenoptera (bees, wasps, ants). Many have evolved highly specialized poison glands that are generally used for defense and, by some, to overcome prey. Overall, even potent honeybee or wasp venom did not evolve to kill but to repel large vertebrates trying to intrude onto nests (Schmidt, 1990). Hence, the response to the venom is very fast and partly caused by activated pain receptors that cause pain out of proportion to the wound inflicted (Schmidt, 1990). Although the dose that causes mortality in 50% of nonallergic human individuals (lethal dose=50) was estimated to be 500–1500 bee stings (Camazine, 1988; Michener, 1975), Mejia, Arbelaez, Henao, Sus, and Arango (1986) reported that receiving more than 1000 stings can indeed be lethal. Stings of bees and wasps are a significant hazard because of their high incidence and ability to produce fatal anaphylactic reactions or respiratory dysfunctions at least in hypersensitive humans (Habermann, 1974; Habermehl, 1987). Compared with spider stings, bee and wasp stings are aggravated by the facts that humans encounter bees and wasps more often, encounters usually occur in swarms (Maretić, 1987; Schmidt, 1990), and encounters often occur near food sources.

Despite the low mortality risk from stings, spiders and bees/wasps (Hymenoptera) still differ from other groups of small animals in terms of potential harmfulness, which may have resulted in a selective advantage for avoidance responses and increase in fear. Surprisingly, there hardly exists any information on fear of arthropods other than the highly prevalent fear of spiders. A small number of single case reports show that these fears (e.g., fear of wasps or other insects) exist but that their prevalence may be very low (Brown, Abrahams, & Helbert, 2003; Elsesser, Heuschen, Pundt, & Sartory, 2006; Jones & Friman, 1999). Contrary to this observation, the underlying rationale of the preparedness hypothesis would lead us to expect a stronger overlap of fear of spiders and other venomous arthropods. Alternatively, disgust instead of fear may play a special role in the common aversive behavior toward spiders (Davey, 1992). The disgust hypothesis postulates that emotional responses to spiders are culturally transmitted (Davey, 1994b) because these animals were historically associated with disease and infection from medieval times onward. However, it is unclear why mainly spiders, and not other "creepy crawlies," have been considered to be responsible for infections and disease.

Contrary to spiders, some beetles infest food items, and preparedness for aversive responses to them, specifically the experience of disgust, is plausible. Taken together, it has not been convincingly documented that specific spider cues should be prepared for conditioning of fear or disgust in humans. Other arthropods that are comparable in terms of venomousness, appearance, or behavior to spiders may elicit similar reactions, but cultural transmission may exert strong biases on verbal labeling. Individuals who report being afraid of spiders may stick with a cultural stereotype ("fear of spiders is common"), although their fears may be much less specific than commonly thought. A variety of arthropods may elicit fear or disgust (e.g., beetles), but "fear of spiders" may merely be a culturally accepted verbal label for a wide spectrum of animal fears (see Wenegrat, 2001).

A necessary first step is therefore to investigate if *different* kinds of arthropods are perceived similarly, if only a subset (i.e., poisonous ones such as spiders and bees/wasps) elicits comparable responses, or if spiders are special. To this end, we compared ratings of fear and disgust elicited by grayscale pictures of spiders (Araneae), bees and wasps (Hymenoptera), beetles (Coleoptera), as well as butterflies and moths (Lepidoptera). Because it is not known as to what extent individuals are aware of the degree of harmfulness of the depicted animals, we collected estimates of harmfulness for each animal. Possible discrepancies between high fear ratings and low estimates for harmfulness could be interpreted as evidence for the irrationality of a fear (Seligman, 1971). Because individuals with high levels of fear of spiders (i.e., phobic fear) may be particularly prone to generalize all creepy crawlies as fear evoking, we also assessed self-reported fear of spiders separately from the picture ratings.

2. Methodology

2.1. Participants, materials, and rating procedure

Seventy-six entry-level psychology students (22.4% were male, n=17) participated in the investigation [age: mean ±SD=21.44±3.20 years, range=19–41 years; one participant did not indicate his/her gender]. We projected 60 grayscale pictures of arthropod species [15 spiders (Araneae), 15 beetles (Coleoptera), 15 bees/wasps (Hymenoptera), and 15 butterflies/moths (Lepidoptera)] in a lecture hall (See Appendix A for a complete species list). The gray-scaled pictures depicted a variety of phenotypes within each animal group. We adjusted the pictures' sizes to a standard body length and used Photoshop to adjust contrast and brightness.

The pictures were presented in random order. Each picture was presented for 4 s, and participants were given 10 s to rate fear, disgust, and how dangerous they thought the animal is, each on a 10-point scale (0=*not at all* to 9=*extremely*). The participants also categorized each animal into one of the four animal groups. At the end, we asked how anxious the participants were in general (0=*not at all* to 9=*extremely*) and for an estimate of fear of spiders using the German version of the Fear of Spiders Screening (SAS; range=0–24; Rinck et al., 2002). The mean anxiety score was 3.53±1.87. The participants' (N=76) mean score on the SAS was 9.08±6.79, and 13 participants (17.57%, all female) had a score of 18 or higher, which is the normative mean of diagnosed patients (Rinck et al., 2002).

2.2. Statistical analyses

An analysis of variance (ANOVA) was performed to investigate possible differences in correct classification for the animal groups. To examine possible differences in fear, disgust, and danger ratings between arthropods, we computed a multivariate ANOVA including the four animal groups (spiders, bees/wasps, beetles, and butterflies/moths) as independent variables and the scores on the ratings (fear, disgust, and danger) as dependent variables. Separate ANOVAs for each rating scale and pairwise post hoc Tukey tests were performed to compare the animal groups for each rating.

To determine which of the ratings predicts the level of spider fear (as measured by the SAS), we performed a multiple linear regression analysis with the predictors fear, disgust, and danger ratings of all animal groups. In order to explore which animal rating apart from spider ratings might also predict levels of spider fear, we conducted a second linear regression analysis entering the mean fear, disgust, and danger ratings of all animal groups except for spiders.

3. Results

3.1. Classification

Almost all pictures were classified correctly (Table 1). There was no significant difference in correct classification between animal groups (Kruskal–Wallis test: χ^2=1.84, N=304, p=.606). For the following analyses, we removed all misclassified items, resulting in a total number of 4339 ratings instead of 4560.

3.2. Ratings

Mean ratings of fear, disgust, and danger for all four animal groups are shown in Table 1. The multivariate ANOVA revealed that there was a significant main effect of animal group on each rating scale ($F_{3,73}$=89.44, p<.001). Follow-up ANOVAs for each rating scale confirmed these main effects (fear: $F_{3,225}$=122.04, p<.001; disgust: $F_{3,225}$=152.19, p<.001; danger: $F_{3,225}$=152.19, p<.001). Post hoc Tukey tests demonstrated that spider pictures were rated significantly higher than all other pictures on all three variables (Table 2). Furthermore, bees/wasps were rated significantly higher than beetles on fear and danger (p<.001 for all) but not on disgust (p=.890). However, bees/wasps were always rated higher on all variables compared with butterflies/moths (p<.007 for all). Butterflies and moths were rated lowest of all animal groups for disgust (p<.007 for all) but were not different from beetles in fear and danger ratings (p>.166 for both).

3.3. Prediction of spider fear

We analyzed whether mean ratings of fear, disgust, and danger for all four animal groups predicted the level of fear of spiders as established from the SAS. The fear and disgust ratings for spider pictures were identified as the only significant predictors of the questionnaire scores for fear of spiders (F_{75}=48.86, p=.003). Fear and disgust ratings of spiders were positively correlated with the questionnaire score for fear of spiders (fear: b=.34, t=3.07, p=.003; disgust: b=.31, t=2.09, p=.041). All other variables were

Table 1
Ratings of fear, disgust, and estimated dangerousness for spiders (Araneae), bees/wasps (Hymenoptera), butterflies/moths (Lepidoptera), and beetles (Coleoptera)

	Rating			
Animal group	Fear	Disgust	Danger	Correct classification (%)
Spiders	3.61±2.44	4.80±2.46	3.56±2.06	94.12
Bees/Wasps	2.09±1.70	1.99±1.77	2.56±1.65	94.12
Beetles	0.50±2.13	2.21±1.73	0.59±1.26	96.40
Butterflies/Moths	0.27±0.75	1.04±1.01	0.22±0.54	95.96

Mean and standard deviation (mean±SD) are given. The percentage of correctly classified animals is reported for 76 participants who rated 15 pictures of each category.

Table 2
Post hoc Tukey test results for differences between ratings (N=76) of fear, disgust and estimated danger for the four animal groups

Variable	Animal group		Mean difference	p
Fear	Spiders	Bees/Wasps	1.52	<.001
		Beetles	2.54	<.001
		Butterflies/Moths	3.06	<.001
	Bees/Wasps	Beetles	1.02	.001
		Butterflies/Moths	1.54	<.001
	Beetles	Butterflies/Moths	0.53	.201
Disgust	Spiders	Bees/Wasps	2.81	<.001
		Beetles	2.60	<.001
		Butterflies/Moths	3.76	<.001
	Bees/Wasps	Beetles	−0.21	.890
		Butterflies/Moths	0.95	.007
	Beetles	Butterflies/Moths	1.16	.001
Estimated danger	Spiders	Bees/Wasps	1.00	<.001
		Beetles	2.65	<.001
		Butterflies/Moths	3.13	<.001
	Bees/Wasps	Beetles	1.66	<.001
		Butterflies/Moths	2.14	<.001
	Beetles	Butterflies/Moths	0.48	.166

Positive scores indicate that the animal in the first column is rated as more fear evoking or disgust evoking or as more dangerous.

removed from the analysis (p>.197). The complete model explained 56.1% (corrected R^2) of the variance of fear of spiders (SAS). A second multiple regression, which was run with the ratings of the other animals only (no spider picture), did not reveal any significant predictor.

3.4. Individuals with a high level of fear of spiders

Comparing the ratings of participants with high SAS scores (≥18, n=13) with those of participants with average or low SAS scores (<18, n=63) shows that the above-reported pattern of ratings remains stable within both groups (Fig. 1). The t tests carried out between the groups show significant differences on all rating scales for all animal groups. Participants with a high level of fear of spiders gave higher ratings of fear, disgust, and danger for all animal groups. Nevertheless, spiders received the highest ratings on all scales within both groups (Table 3).

Table 3
Mean ratings (and standard deviations) of fear, disgust, and danger for all four animal groups separated for participants with a low level (SAS<18) and those with a high level (SAS≥18) of fear of spiders

Animal group	Rating scale	SAS<18 (n=63)	SAS≥18 (n=13)	t (df=74)	p
Spiders	Fear	3.04 (2.14)	6.38 (1.93)	5.21	<.001
	Disgust	4.26 (2.29)	7.40 (1.32)	4.77	<.001
	Danger	3.22 (1.88)	5.21 (2.18)	3.38	.001
Bees/Wasps	Fear	1.89 (1.70)	3.09 (1.36)	2.40	.019
	Disgust	1.71 (1.71)	3.36 (1.42)	3.26	.002
	Danger	2.37 (1.60)	3.50 (1.62)	2.31	.024
Beetles	Fear	0.86 (1.08)	2.10 (1.14)	3.71	<.001
	Disgust	2.00 (1.76)	3.21 (1.22)	2.37	.020
	Danger	0.78 (0.83)	1.54 (1.20)	2.80	.007
Butterflies/Moths	Fear	0.42 (0.67)	1.15 (0.87)	3.36	.001
	Disgust	0.88 (0.93)	1.82 (1.03)	3.23	.002
	Danger	0.34 (0.51)	0.86 (0.70)	3.15	.002

3.5. Sex differences

The level of fear of spiders differed significantly between male and female participants, with higher scores among female participants [SAS: male (n=17), 3.82±3.52; female (n=58), 10.66±6.80; t_{73}=−3.97, p<.001]. Accordingly, all 13 participants who scored 18 or higher in the questionnaire

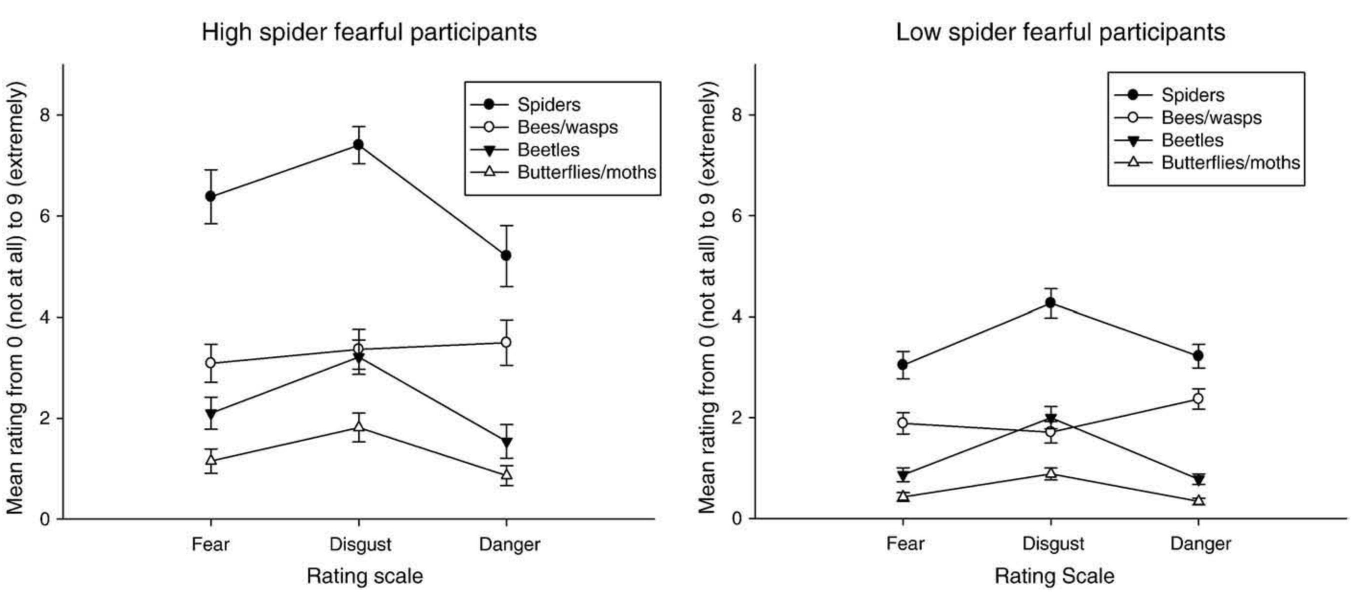

Fig. 1. Mean ratings (and standard errors) of fear, disgust, and danger for all four animal groups on a scale ranging from 0 (*not at all*) to 9 (*extreme*) separated for participants with a high level and those with a low level of fear of spiders.

were female. There were also differences in trait anxiety between the sexes, again with higher mean levels for females [male (n=17), 2.65±1.50; female (n=58), 3.84±1.8; t_{73}=2.44, p=.017]. Correspondingly, differences between the ratings were also significant. Female participants rated spiders and wasps with higher fear and disgust levels and as more dangerous than did male participants (p<.001 for all). Fear and danger ratings for the beetle pictures also differed between the sexes, with higher ratings among female participants (p<.009 for both). No difference was found for the disgust ratings of beetles or between fear, disgust, and danger ratings of butterfly/moth pictures.

4. Discussion

The preparedness hypothesis has been used to explain why fear of certain animals (typically snakes and spiders) is very common. Although there is empirical evidence for this perspective from conditioning experiments comparing pictorial representations of these animals with benign objects, there are surprisingly few studies comparing responses with other animal groups. The ratings of subjective responses to a range of arthropods enabled us to examine some of the basic tenets of the preparedness hypothesis.

Our study demonstrates that there is a substantial difference in the subjective response to various arthropod groups: Spiders were rated highest on fear and disgust (emotional) as well as on danger (cognitive), followed by bees/wasps. Fear and disgust were very low in response to beetles and butterflies/moths, and not a single participant reported average fear ratings higher than 5. The questionnaire scores suggest that a number of participants (all of them were women) may have met criteria for spider phobia in a more detailed assessment (for a detailed discussion of typical sex differences, see Craske, 2003). These participants showed a similar but elevated response pattern compared with nonphobic participants. The response to spiders is indeed special, which suggests that there is no general aversion against arthropods.

The relatively strong fear reactions toward spiders compared with all other arthropods may support the notion that responses to potentially harmful organisms have been shaped by natural selection and seem to confirm the assumptions of the preparedness hypothesis. This explanation should also include bees/wasps since they are likewise potentially harmful. Instead, bees/wasps elicited significantly less fear and were estimated to be less dangerous than spiders. Beetles and butterflies/moths were clearly not estimated to be harmful by our participants, and they were also hardly feared. Thus, there seems to be a correspondence between *subjective* danger estimates and fear. However, the participants' fear ratings do not correspond with the objective harmfulness of spiders. Harmfulness today is not likely to be different from that in the past because morphological characteristics of spiders have not changed much since the advent of modern man (Coddington & Levi, 1991; Selden, Anderson, Anderson, & Fraser, 1999) and the different types of venom found in spiders did not evolve to harm human beings. Bees and wasps should rank higher than or at least similar to spiders because their stings are the most common envenomation (Daunderer, 1995; Foelix, 1996; Vetter & Visscher, 1998) and encounters with them are more frequent (Maretić, 1987; Schmidt, 1990) than those with spiders.

Because differences between spiders and bees/wasps cannot be explained by differences in objective risk, other possible explanations need to be considered. Although the extent to which bees/wasps were recurrent threats to our ancestors is unknown, the relationship between bees and humans dates back to ancient hunter–gatherer cultures (Maderspacher, 2007); honey was an important part of their diet (Cordain et al., 2005). Therefore, one difference between spiders and bees could be that humans have more experiences of being stung by bees, while the experience of spider bites is relatively rare (see Diaz, 2004). Frequent encounters with bees and the experience or observation that bee stings can be survived from without serious consequences in nonallergic people may reduce fear by means of habituation (see Marks & Adolf, 1990). Beyond the experience that sporadic bee stings do not inflict fatal harm, interaction with bees promises benefits (e.g., to obtain honey). Cultural transmission of this benefit may be similarly adaptive as the transmission of information on risks. In contrast, there is no obvious advantage or benefit of approaching spiders, which leads to a lack of first-hand experience with spiders and their bites. On one hand, this may have contributed to the myths about spiders and their bites (Ibister, 2004). These myths may contribute to informational fear acquisition (Field & Lawson, 2003; Muris, Bodden, Merckelbach, Ollendick, & King, 2003).

The error management theory offers a related explanation (Haselton & Buss, 2006). It assumes that biases are adaptive because they helped ancient humans survive. There is a clear cost asymmetry between false-positive and false-negative errors; the cost of avoiding a harmless spider is lower than the cost of not avoiding a rare dangerous spider. This should bias toward errors that are less costly—namely, avoiding all spiders. At least for bees, this should not lead to a bias, because the cost asymmetry is less with respect to a potentially useful animal.

Apart from harmfulness, spiders may be associated with unpredictable and uncontrollable behavior. Rapid or abrupt movements have been reported to produce fear (Bennett-Levy & Marteau, 1984; Schneirla, 1965). Armfield and Mattiske (1996) stated that animal fears are associated with the inability to exert influence over the movement, approach, or behavior of an animal. However, rapid and unpredictable movements are not only characteristic of spiders: they can be observed in beetles, bees/wasps, and butterflies/moths as well. The latter categories may be particularly uncontrollable because they can fly. Indeed, Armfield (2007) found that unpredictability was significantly associated with fear of spiders, snakes, cockroaches, and rats.

Consistent with other studies, our data show that spiders elicit not only enhanced fear or anxiety but also intense disgust responses (Mulkens, De Jong, & Merckelbach, 1996; Woody, McLean, & Klassen, 2005). While fear has been linked with escape, disgust has been thought to reinforce avoidance. Although bees/wasps also elicited elevated fear ratings compared with beetles and butterflies/moths, with respect to disgust, spiders and bees/wasps were even more fundamentally different. Interestingly, disgust ratings did not predict estimated harmfulness. In response to spiders, disgust exceeded ratings of fear; in response to beetles, disgust ratings were as high as those for bees/wasps, although their harmfulness was estimated to be much lower than that of bees/wasps.

Davey (1994b) suggested that high disgust reactions may be plausible because spiders have long been thought to be a source of contamination. However, beetles are probably much more closely associated with human settlements, and some of them specialize on storage products such as seeds and meat. Disgust in response to beetles helped avoid disease vectors and contaminated food much more effectively than disgust in response to spiders.

A further consideration, as suggested by one reviewer, why spiders may be experienced as more disgusting concerns the prototypical behaviors associated with fear and disgust. Bees and wasps actively pursue and attack living organisms that disturb their nests and can move quickly over substantial distances; therefore, a fear response such as flight is an adequate defense reaction. In contrast, spiders cannot fly and only defend themselves in cases of direct contact. Action tendencies associated with disgust, such as turning away from or repelling the disgusting object, could be more adaptive in confrontations with spiders. However, this perspective does not explain why many people experience fear of spiders.

These hypotheses, including the preparedness hypothesis, cannot convincingly explain why fear of spiders is relatively high compared with fear of other animals even in those participants who scored low on the spider fear questionnaire. Moreover, according to the preparedness hypothesis, fear of spiders should be very specific, but experimental examinations had been exclusively done on spiders and snakes and compared with plants or mushrooms (Öhman et al., 1975): Previous studies did not investigate reactions toward other animal groups. Furthermore, we found that the ratings of individuals who judged themselves to be spider fearful were elevated in response to all the arthropods but that their patterns of ratings across the four arthropod groups did not differ from those of individuals with a low level of fear of spiders. Additionally, the level of fear of other arthropods elicited by an individual did not help predict questionnaire scores on fear of spiders, which were well predicted by the ratings for spider pictures (see comment below).

Because studies on fear of spiders entail the risk of assessing stereotypical responses, we presented pictures of a variety of spiders and asked participants to rate each specific stimulus. Moreover, by presenting pictures of species with a wide variability in body shape within each animal group, we avoided allowing participants to give stereotypical ratings of prototypes of these animal groups. Since the pictures we presented were not animated, we did not examine direct responses to the mobility pattern, which may strongly affect the reaction toward specific animal groups. A further limitation could be that the ratings were collected in a group assessment. Thus, social interactions and influences on the ratings could not entirely be ruled out. However, such a procedure is not uncommon (see Somerville & Whalen, 2006). A further extension of the present study would be to ask more detailed questions on what the participants actually fear or what kind of danger they anticipate when confronted with the animals. More detailed questions and individual experiments that additionally investigate responses to specific behavioral properties are planned.

Although our data do not address issues of learning, like the conditioning studies that have found limited support for the preparedness hypothesis (McNally, 1987), we were able to gather information on the theoretical prerequisites of this perspective. Our skeptical conclusions are in correspondence with other recent contributions that question some of the previous claims of behavioral correlates of prepared threat cues. For example, while some have found that spiders can be automatically detected in search tasks, which may help the organism quickly respond to impending danger (Öhman & Mineka, 2001), others argue that this is not specific to spiders and is observable for other animal pictures (Lipp, Derakshan, Waters, & Logies, 2004).

Because our data clearly demonstrate that spiders are rated significantly higher in fear and danger and fundamentally differ in disgust ratings compared with other harmful arthropods, we conclude that responses to spiders are indeed special, but the existing explanations for spider fear are not yet well founded or rather insufficient. To which degree reactions toward spiders can be better explained by cultural transmission than by biological preparedness needs further investigation (see Davey et al., 1998). Most likely, a conclusive explanation combines both, cultural and biological, factors. First, biologically evolved psychological mechanisms that preferentially process cultural information pertaining to dangerous animals may exist (Barrett, 2005). Second, the activity of a biologically evolved psychological mechanism specific to spider avoidance may be enhanced by cultural information. Finally, either a general dangerous-animal mechanism or a specific spider-avoidance mechanism could stabilize cultural beliefs (Sperber, 1996) about the dangerousness of spiders.

Two lines of investigations are required in order to assess the origin of animal fear and disgust: (1) detailed cross-cultural studies and (2) studies that focus on the specific morphological and behavioral traits that trigger fear and disgust.

Acknowledgments

We thank the students who participated in this study. We also thank Mario Fix for his help in adjusting the pictures' characteristics.

Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version, at doi:10.1016/j.evolhumbehav.2008.08.005.

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