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The Importance of Being Colorful and Able to Fly: Interpretation and implications of children's statements on selected insects and other invertebrates

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Children have served as research subjects in several surveys on attitudes to insects and invertebrates. Most of the studies have used quantitative scoring methods to draw conclusions. This paper takes a different approach as it analyzes children's free-text comments to gain an understanding of their viewpoints. A total of 246 children aged 9–13 completed a standard questionnaire regarding their attitudes toward 18 invertebrates indigenous to Switzerland. Fourteen insect species and four other invertebrates were individually presented in a color photograph without any further background information. The children were given the opportunity to provide comments on each animal to explain the attitude score they had awarded. Nearly 5,000 comments were coded and categorized into 7 positive and 9 negative categories. A significant correlation between fear and disgust was not detected. Based on a hierarchical cluster analysis, we concluded that flying in the air versus crawling on the ground was a major differentiator for attitude and underlying reasons, only being trumped by the fear of getting stung. The visualization of our findings in a cluster heat map provided further insights into shared statement categories by species. Our analysis establishes that fear and disgust are separate emotions with regard to insects and other invertebrates. Based on our findings, we believe that prejudice-based fear and culturally evolved revulsion can be overcome. We suggest promoting environmental education programs, especially if they allow for personal experience, provide information in emotion-activating formats, and include content that resolves existing misinformation and myths.

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Introduction

Background and Research Questions

There is little doubt that insects and invertebrates are important. They constitute the largest and most diverse animal group on this planet and perform substantial ecosystem functions (Black, Shepard, & Allen, 2001). In the USA, wild insects alone deliver a value of nearly 60 bn USD p.a. through pollination, pest control, dung removal, and as food for wildlife (Losey & Vaughan, 2008).

However, most insects are not appreciated. Many people find insects disgusting and abhorrent (Scudder, 2009), and view invertebrates with aversion, fear and ignorance (Kellert, 1993). These reactions are provoked by their multiplicity, parasitism, monstrosity and autonomy (Hillman, 1988) as well as their perceived mindlessness (Kellert, 1993). This experience of fear and disgust is well documented (Kellert, 1993; Prokop & Fančovičová, 2013; Prokop, Tolarovičováb, Camerikc, & Peterkovάb, 2010; Prokop, Usak, Erdogan, Fančovičová, & Bahar, 2011; Randler, Hummel, & Prokop, 2012). Some research on the influencing mechanism between fear and disgust also considers invertebrates (Davey, 1994b; Davey, Cavanagh, & Lamb, 2003).

This paper aims to improve the understanding of how children perceive different invertebrate species, allowing decision-makers to define specific actions in science education concerning zoology of invertebrates and their ecologic role. Our research on insects and invertebrates looks for further evidence regarding the relationship between fear and disgust and tries to understand if they are separate emotions which only occur simultaneously in special cases. Addressing children aged 9–13, our analysis was guided by three detailed questions: Which statement categories appear when children are asked to comment on pictures of various invertebrate species? What kind of groups emerge based on the statement categories? Are fear and disgust correlated?

What is Disgust?

Emotions can be defined as 'response tendencies that prepare the organism for the interaction with the environment' (Vaitl, Schienle, & Stark, 2005, p. 3). Fear and disgust belong to the six universal basic emotions (Ekman, 1999a), together with anger, sadness, happiness and surprise (Jack, Garrod, & Schyns, 2014).

Disgust is considered the evolutionarily newest and most advanced emotion (Herz, 2012). Originally, it was the human brain's solution to the evolutionary need to avoid damage from parasitic infection (Curtis, 2012). This protective function remains active and can be measured since interviewees mention disgust as a reaction when quizzed on their understanding of germs and microbes; some younger pupils even draw insects when asked to sketch germs (Jones & Rua, 2006). However, over time, its function shifted into a complex emotion of civilization (Rozin, Haidt, & McCauley, 2008). It has been shaped by evolutionary, cognitive, social and cultural factors (Bixler & Floyd, 1999) and its fundamental pattern implies the experience of unwanted nearness (Menninghaus, 2003).

A disgusted person experiences a decelerated heart rate, reduced blood pressure, possibly nausea, and aims to shut out the unpleasant stimulus, reduce sensory acquisition of it, and pull away or get rid of what is causing the feeling (Herz, 2012; Rozin & Fallon, 1987; Vernon & Berenbaum, 2002). While disgust reactions are ruled by biology (Rozin, Haidt, & McCauley, 1999), the content and range of what is disgusting are determined by nurture and culture, and have expanded over time (Miller, 1997; Rozin & Haidt, 2013). As disgust is a reaction that has to be learned over time, it can only be fully experienced after the age of 8 (Curtis & Biran, 2001; Herz, 2012; Miller, 2004; Rozin & Fallon, 1987). The initial disgust-generating experience happens around the age of 3 with toilet training. Subsequent acquisition mechanisms are generalizations of perceptual characteristics, evaluative conditioning ('Do I like this or not?') and social learning, that is, transmission from one person to another (e.g. parent to child) through facial expression and verbal communication (Bixler & Floyd, 1999; Miller, 2004; Rozin & Fallon, 1987; Rozin et al., 2008; Woody & Teachman, 2000).

Different cultures set their own specific disgust events with universal themes (Ekman, 1999b), but the non-organic is not experienced as disgusting (Kolnai, 1929/2004). At the same time, disgust is an ambivalent emotion since what is considered disgusting attracts as well as repels and can even trigger curiosity (Kolnai, 1929/2004; Korsmeyer, 2011; Miller, 1997). Disgust aims to protect the self and hence rejects otherness (Miller, 2004).

What is Fear?

Fear is the reaction toward imminent threat with the intense urge to defend oneself (Muris, 2007; Öhman, 2008). Physical reactions to fear are pupil dilatation, increase in heart rate, respiration and muscle tension, eventually triggering a 'fight or flight' response (Hüther, 2001; Muris, 2007; Öhman, 2008). The typical facial expression enhances sensory acquisition (Susskind et al., 2008) and allows those affected to take in as much information on the stimulus as possible (Vernon & Berenbaum, 2002).

Fear is the learnt connection between a stimulus and its negative consequences and is acquired through personal experience (conditioning) or social learning (observation and instruction) (Olsson & Phelps, 2007; Rachman, 1977). The list of potentially fear-causing threats depends on cognitive abilities to conceptualize threats and hence increases with age; for example, children develop a fear of strangers at 9 months, fear of animals starts at the age of 3 (Muris, 2007) while animal phobias do not arise before the age of 7 (Öst, 1987).

Four major fears exist which all represent situations relevant for human evolution (Öhman, 2008). Among the fear of animals, the fear of spiders and snakes fits into the preparedness theory; these fears are biologically prepared and, hence, learned faster, independent of cognitive learning. They are also selective in their cause and persistent, which can make them seem 'irrational' (Öhman, 2008; Öhman & Mineka, 2003; Seligman, 1971). Fear-evoking properties of animals have been described as size, eyes, type of movement and their living in dark places (Davey, 1992; McNally & Steketee, 1985). Spiders and snakes both have sudden, jerky, unpredictable movements, tend to hide in dark places (Hüther, 2006; McNally & Steketee, 1985), and have unusual body features such as hairy multi-leggedness.

What is the Relationship between Fear and Disgust?

Disgust and fear have some commonalities: They are both defense reactions and have external objects in their focus (Kolnai, 1929/2004); they are negatively valued, highly arousing and withdrawal-related (Woody & Teachman, 2000), and they create a strong startle reflex eye-blink (Yartz & Hawk, 2002). There is intertwined terminology, such as *threat* of contamination (Woody & Teachman, 2000) and *fear* of contamination (Arrindell, 2000; Arrindell, Mulkens, Kok, & Vollenbroek, 1999). Fear of contamination is associated with disgust (Deacon & Olatunji, 2007; Olatunji, Sawchuk, Lohr, & de Jong, 2004), with microbes playing a major role (Jones, Gardner, Lee, Poland, & Robert, 2013).

As a defense reaction, the two emotions differ in terms of speed. Fear protects against fast predators and disgust against slow contamination: 'Fear is automatic no matter where your mind is, but in order to feel disgusted, you have to think and pay attention' (Herz, 2012, p. 80). Furthermore, they are distinctly different: fear induces the frightened subject to change, that is, leaving the location of danger, while disgust leads to changing the object, for example, cleaning it or weeding out what is disgusting (Kolnai, 1929/2004). It therefore seems natural that disgust is implicated in certain anxiety disorders and phobias (Davey et al., 2003; Rozin et al., 2008; Woody & Teachman, 2000), which are special variations or extreme cases of fear. Within animal fear, spiders and snakes are anomalous animals that evoke both disgust and fear (danger) (Rozin et al., 2008).

Interesting findings on the subject were published by G.C.L. Davey and his coauthors (Davey, 1992, 1994a, 1994b; Davey, Forster, & Mayhew, 1993; Matchett & Davey, 1991): Aversion to anomalous animals may be based more on disgust than fear and could be explained with a disease avoidance model. Fear of spiders might not be caused by personal experience (conditioning), although levels of disgust sensitivity within a family (social learning) may play a role. Also, fear inducers like size, harmfulness and dark places score low while disgust triggers such as legginess, hairiness and creepy-crawliness rank rather high. Evolutionary pressure might have shaped disgust response to animals to prevent transmission of disease. However, Davey also states the question why evolution and cultural learning did not make humans afraid of mosquitoes instead of spiders, because the former are more harmful vectors. Vernon and Berenbaum (2002) took a multi-method approach to better understand the connection of fear and disgust with regard to spiders. They analyzed self-reported fear and disgust from a standardized questionnaire as well as facial expressions when participants encountered a caged live tarantula. They concluded that no overlap of the two emotions exists.

Equipped with these findings, we analyzed the data collected from the children's comments.

Method

Survey, Questionnaire and Comments

The printed questionnaire used in Schlegel, Breuer, and Rupf (2015) formed the basis of this paper. The qualitative responses of 246 German-speaking pupils from 14 Swiss primary school classes regarding their affinity toward 18 different invertebrate animal species were analyzed. All of the species are currently found in Switzerland; they are large enough to be observable and have been chosen broadly across invertebrate groups to allow for gradient results (Schlegel & Rupf, 2010). The pupils were fifth and sixth graders at the age of 9–13 years (mean 10.55 years, sd 0.91), consisting of 108 boys and 138 girls. The questionnaire contained separate color photographs of 14 insect species, 1 snail species, 1 crayfish species, 1 arachnid species and 1 Millepede species (Table 1).

Table 1. List of the 18 invertebrates evaluated, taken from Schlegel et al. (2015)

Superclass/class	Superorder/order	Species	
Gastropoda	Pulmonata	Edible Snail	*Helix pomatia*
Malacostraca	Decapoda	European Crayfish	*Astacus astacus*
Myriapoda		Millepede	Diplopod (species not specified)
Arachnida	Araneae	Ladybird Spider	*Eresus kollari*
Insecta	Dermaptera	Common Earwig	*Forficula auricularia*
	Orthoptera	Field Cricket	*Gryllus campestris*
		Green Leek Grasshopper	*Mecostethus parapleurus*
	Hemiptera	Firebug	*Pyrrhocoris apterus*
	Coleoptera	Stag Beetle	*Lucanus cervus*
	Odonata	Banded Demoiselle	*Calopteryx splendens*
		Sombre Goldenring	*Cordulegaster bidentata*
	Neuroptera	Owly Sulphur	*Libelloides coccajus*
	Lepidoptera	Apollo	*Parnassius apollo*
		European Peacock	*Inachis io*
		Dark Green Fritillary	*Argynnis aglaja*
		Six Spotted Burnet Moth	*Zygaena filipendulae*
	Hymenoptera	Bumblebee	*Bombus sp.* (species not specified)
	Diptera	Hoverfly	*Helophilus sp.* (species not specified)

While Schlegel et al. (2015) analyzed the quantitative scores given by the pupils, this paper focuses on the qualitative input. Similar to the 'free option method' (Muris, Merckelbach, Mayer, & Prins, 2000), the children were invited to explain why they had chosen a certain attitude. Three lines on the left and right sides of the questionnaire were provided to comment on the respective positive and negative rating given.

Coding Methodology and Framework

A maximum of 3 statements was coded for each dataset. Thus, 13,284 statements were theoretically possible (246 children × 18 animals × 3 statements = 4,428 data sets × 3 statements). The statements were classified as positive or negative comments based on the attitude score, with 47 exceptions where a negative attitude score was given, although the comment was clearly positive and written on the left side of the page (e.g. 'pretty color') and vice versa. In these 47 cases, the statement was coded according to its content.

The coding framework aimed to be as detailed and close to the original comment as possible and hence was created in an iterative process, jointly conducted by the four authors. Typing the statements onto the datasheet provided an overview of the richness and scope of the statements. Based on this initial impression, a hierarchical 3-digit-coding framework was created in collaboration, including all logically possible subcategories. It was tested with a small sample ($n = 42$ data sets), discussed and adjusted by the authors, applied for all questionnaires, retested, rediscussed and readjusted until all statements were allotted to appropriate statement categories with meaningful headers. The minimum number of statements for a category to be created was set at 5. Statements that occurred less than five times were integrated into the most suitable category, that is, where the noun or the adjective of the statement was represented. Due to this iterative process and eradication of certain codes, the final coding sheet did not contain successive numbers.

At the end of the coding process, the resulting 156 subcategories were subsumed into 16 main categories: 7 positive categories ('pretty', 'positive coloration', 'positive body', 'positive entertainment value (PEV)', 'useful', 'positive emotional attribute (PEA)', 'positive other') and 9 negative categories ('ugly', 'negative coloration', 'negative body', 'negative entertainment value (NEV)', 'harmful', 'negative emotional attribute (NEA)', 'fear', 'disgust', 'negative other') (Table 2).

These main categories were derived by allocating the statements primarily according to the type of adjectives used. For example, statements were assigned into the main category 'pretty' when they contained 'pretty', 'beautiful', 'elegant', 'appealing', 'awesome' in a stand-alone fashion or when these words were used as adjectives together with nouns for body form, color or pattern, that is, 'pretty body', 'elegant wings' or 'beautiful pattern'.

When a child had only written, for example, 'red' or 'antlers', the statement was coded into the respective category 'positive coloration' or 'negative coloration' and 'positive body' or 'negative body', depending on which side of the questionnaire the comment was written on. This was done on the basis that the child had indicated

Table 2. Labels and content of main categories

Positive categories	Negative categories
Pretty Statements that include adjectives describing prettiness or the verb 'to like', stand-alone or in connection with a specific feature of the animal	*Ugly* Statements that include the adjectives 'ugly/not pretty', or the verb 'to dislike'
Positive coloration Positive statements that mention color or pattern that either lack an adjective completely or are conclusive regarding prettiness or interestingness intention (e.g. 'bright color'). A statement 'red dots' was counted in 1 statement while 'color and pattern' was counted in two statement categories	*Negative coloration* Negative statements with color or pattern that either lack an adjective completely or are conclusive regarding intention toward ugliness or boringness (e.g. 'too little color')
Positive body Positive statements that name body features without using emotional adjectives. If a body part is described with color or pattern, it is included in *Positive Coloration* (especially valid for butterfly wings)	*Negative body* Negative statements that name body features without using emotional adjectives. If a body part is negatively described with color or pattern, it is included in *Negative Coloration*
PEV Positive statements that describe fascination and point to curiosity and play	*NEV* Negative statements that indicate lack of interest or indifference as well as annoyance
Useful Positive statements that relate to ecosystem services such as honey, nectar gathering, pollination, eating of pests or edibility	*Harmful* Negative statements that relate to disease-bearing and eating/destroying of garden produce
PEA Positive statements on emotions (e.g. 'happy') caused by the species or comparisons (e.g. 'like a fairy')	*NEA* Negative statements which deem the species 'not friendly' as well as 'not like it [this animal]/hate it [this species]' *Fear* Negative statements that include the word 'fear' explicitly or give explanations for fear *Disgust* Negative statements that include the word 'disgust' alone or together with body parts that are deemed disgusting. Also negative experiences of body contact are included in this category, i.e. 'it was crawling up my leg' or 'it could crawl into my ear'
Positive other Positive statements that do not fit into any of the above-listed categories, e.g. 'because cancer is my zodiac sign' (European Crayfish), or are illegible	*Negative other* Negative statements that do not fit into any of the above-listed categories, e.g. 'it is somehow stiff' (Banded Demoiselle), or are illegible

that something had caught his or her attention although he or she had not specified in exactly what way, if these antennae were thought to be interesting or pretty for example.

Furthermore, statements were allocated to the main category 'PEV' if the child had written, for example, 'interesting', 'exciting', 'mysterious', 'watching it', 'playing with it', 'catching it'. The categories 'PEA' and 'NEA' display statements with strong emotional content that did not fit in other categories. A few extraordinary or (even potentially) ambiguous statements with their respective coding were adjusted by the authors.

As a result, the children's comments reflect perceived attributes of the invertebrates tested. Our data analysis seeks patterns that allow further interpretation of underlying emotions regarding invertebrates.

Data Analysis

Statistical analysis was performed in the R statistical environment (R Foundation of Statistical Computing, 2013). Results were considered significant with $p < .05$. To test for differences between the categories, a test of equal proportions (ETHZ, 2013) was carried out based on Pearson's chi-squared test statistics (Köhler, Schachtel, & Voleske, 2007). We also tested for correlations between categories using Spearman's rank correlation (Hollander & Wolfe, 1973): Given $p < .05$, a correlation was accepted when it was no less than medium-sized with rho > 0.3 (Arrindell et al., 1999).

In order to suppress spurious effects of unbalanced numbers of entries in the particular categories for different animals, mean and variance scaling was applied (Bishop, 2009). To establish similarities among the different animals in respect of the comments they had received, the raw data were normed. They were shifted according to their mean values and scaled by their standard deviation, an operation which left animal-specific patterns regarding perceived attributes unchanged.

As we were interested in uncovering underlying patterns in the data, we created (1) a dendrogram with data scaled by animal species to illustrate the relative positions of the animals and (2) a heat map with data scaled by categories to show the distribution of categories over all animal species investigated. The heat map provides added value because it visualizes the species-relative profiles with regard to perceived attributes.

To create the dendrogram, the normed data were analyzed with clustering techniques to uncover similarity structures in high dimensional data (Bishop, 2009). In order to capture all relevant details, the dendrogram was constructed with detailed coding data based on 156 subcategories. We applied the hierarchical clustering as included in the statistics software environment R (R Project, 2013) in the function 'hclust' (Everitt, Landau, & Leese, 2001; Gordon, 1999; McQuitty, 1966). Therein, we chose the 'complete linkage' method, which aims to find clusters of comparable diameters (Everitt et al., 2001). The resulting groups of objects (with their similarity of pattern) were then visualized in the dendrogram.

In accordance with usual convention, the 'complete linkage' method was also applied for the cluster heat map analysis (Warnes et al., 2013). The heat map was based on the aggregated coding framework and used the 16 major categories (instead of 156 subcategories) to allow for a clear visual message. The cluster heat map facilitates inspection of rows, columns and joint cluster structures for moderately large matrices (Wilkinson & Friendly, 2009), and orders data according to similarities in rows as well as in columns. We used it to plot rows (species) versus columns (categories). High statement counts for the respective categories were signaled by 'hot' areas with their warmer colors, and larger areas of the same color indicated category patterns shared by particular species.

Results

Statement Counts

Out of the 4,765 statements received, 2,726 statements were classified as positive and 2,039 as negative; 85% of datasets were accompanied by at least one comment, 19% with 2 statements and 4% with 3. The number of statements per species all reached similar levels, ranging from 225 for the Six Spotted Burnet Moth to 317 for the Ladybird Spider (mean = 264.7, sd = 21.9). Figure 1 displays the composition of the statement categories for each species in detail.

At main category level, the counts per category varied between 686 (for 'pretty') and 38 (for 'harmful'), the residual categories 'positive other' and 'negative other' having 31 and 33 counts, respectively. 'PEV' was awarded 17% of all positive statements and 'NEV' achieved 14% of all negative ones. Table 3 provides an overview.

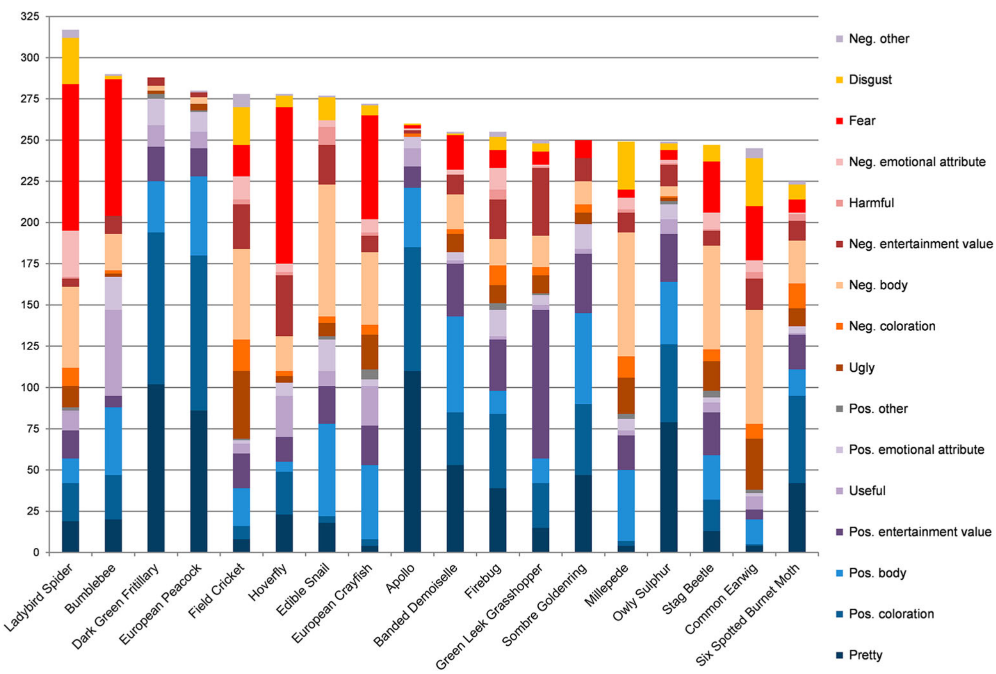

Figure 1. Statements by categories for 18 invertebrate species, based on 246 questionnaires ($n = 4{,}765$)

Table 3. Counts and shares of statement categories, based on 246 questionnaires, aggregated for the 18 invertebrate species investigated ($n = 4{,}765$)

Positive statement categories	Statement counts	Statement share (%)	Negative statement categories	Statement counts	Statement share (%)
Pretty	686	25.2	Ugly	219	10.8
Positive coloration	623	22.9	Negative coloration	117	5.7
Positive body	582	21.3	Negative body	587	28.8
PEV	450	16.5	NEV	280	13.7
Useful	199	7.3	Harmful	38	1.9
PEA	155	5.7	NEA	104	5.1
			Fear	485	23.8
			Disgust	176	8.6
Positive other	31	1.1	Negative other	33	1.6
Sum	2,726	100	Sum	2,039	100

Fear and Disgust

When we tested for a correlation between the categories of 'fear' and 'disgust' using Spearman's rank correlation, we found a weak but not significant connection with rho = 0.292 and $p = .240$, as depicted in Figure 2. Low values for fear and disgust occur hand in hand, while very high values for either fear or disgust are not reflected by the respective counterpart, except in the case of the Ladybird Spider.

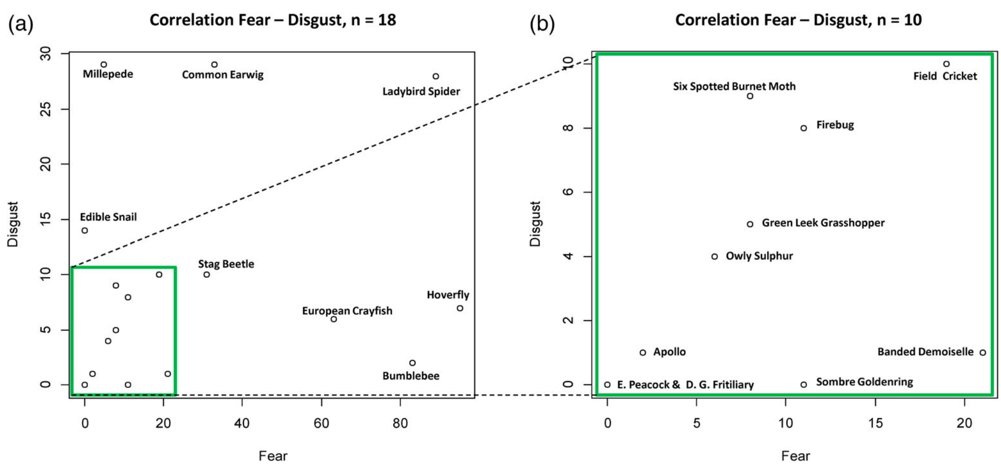

Figure 2. Correlations between 'disgust' (y-axis) and 'fear' (x-axis), based on 246 questionnaires: (a) for each of the 18 invertebrate species, (b) limited to 10 species after omitting species with the highest number of statements referring to 'disgust' and 'fear' (i.e. omitting species outside the green frame in Figure 2(a))

Not taking into account the 8 species with more than 10 statements referring to disgust and more than 21 statements referring to fear, the correlation for the 10 remaining species (green frame) achieves rho = 0.484. The *p*-value of .156, however, remains insignificant.

Groupings Based on Cluster Analysis

The dendrogram in Figure 3 shows two clearly distinct groups. While (A) contains all the species with real or perceived flying abilities, (B) rounds up all the species that move and live on the ground. Positioned underneath (A1) is the group with the longest arm in the dendrogram, signaling that the Bumblebee species and the Hoverfly species share the most distinguishing features. The next distinct group among the 'flyers' is (A2), containing the Firebug and the Six Spotted Burnet Moth. Although the Firebug cannot fly, the pattern on its back may have been interpreted by the children as wings. The next cluster of animals (A3–A6) is less distinct, sharing some attributes while differing in detail. The Banded Demoiselle has its own group, separate from the other dragonfly species, the Sombre Goldenring. Considering the distinctness of the groups, the Sombre Goldenring is more closely connected to the Owly

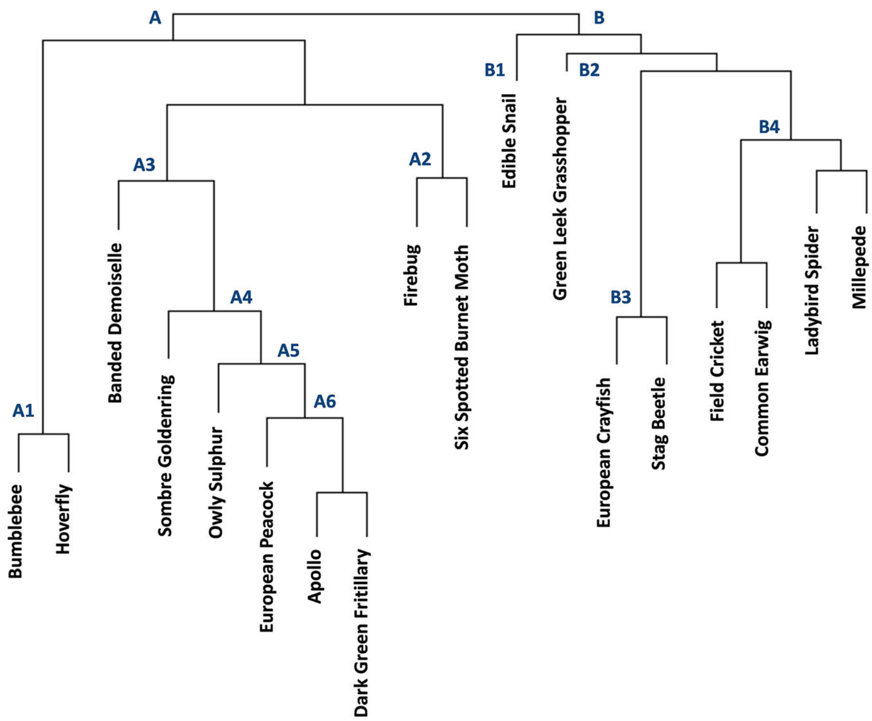

Figure 3. Cluster analysis with dendrogram of 18 invertebrate species, 'complete linkage' method, based on the comments provided by 246 children ($n = 4{,}765$) and categorized into 156 detailed categories, containing 90 positive and 66 negative subcategories

Sulphur and to the butterfly species. The closeness of the butterflies European Peacock, Dark Green Fritillary and Apollo has already been indicated in Figure 1. On the left side of the (B) groups, the Edible Snail and the Green Leek Grasshopper quickly branch out into subsequent nodes on separate arms of the dendrogram. The middle group consists of the European Crayfish and the Stag Beetle, which form a joint and very distinct group.

The remaining four species fall into two close subgroups, shown under node (B4). The group on the left contains the Field Cricket and the Common Earwig, while the group on the right consists of the Ladybird Spider and the Millepede species.

Visualization in a Cluster Heat Map

The cluster heat map was based on the scaled data of the 16 aggregated categories in order to analyze the distribution of animal species over the attribute categories of our coding framework (Figure 4). The results of the heat map closely match the structure of the dendrogram (Figure 3), which was based on subcategory data and scaled by animal species.

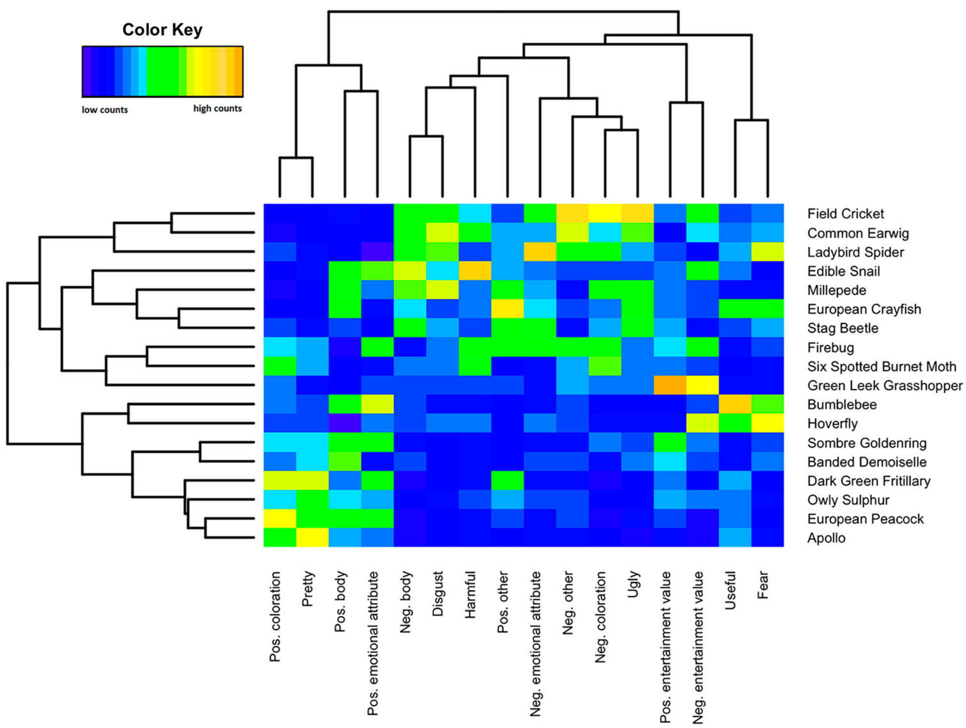

Figure 4. Cluster heat map, based on statements in 246 questionnaires ($n = 4{,}765$). The statements were divided into 16 main categories for the 18 invertebrate species, and the data by species were scaled by category. The number of statements per category and species are arranged by hierarchical clustering. Bright colors correspond to a high number of statements

Reading the heat map from left to right, the categories ‘positive coloration’, ‘pretty’, ‘positive body’ and ‘PEA’ receive a relatively high number of hits for the three butterfly species, the Owly Sulphur, and the two dragonfly species, which therefore form a close group. The Bumblebee species achieves a high number of hits for ‘positive body’, ‘PEA’ and for ‘useful’ and ‘fear’. The Hoverfly species also gains high counts on the latter two and also scores highly in the category ‘NEV’. Rated as highly entertaining are the Green Leek Grasshopper and the Sombre Goldenring.

The species deemed ugly are the Stag Beetle, the Crayfish, the Millepede species, the Common Earwig and the Field Cricket, joined by the Edible Snail and Ladybird Spider in the ‘negative body’ category. The Crayfish, the Millepede species and the Edible Snail also accumulate a relatively high number of statements in the ‘positive body’ category. The species evoking fear are the Ladybird Spider, the Crayfish, the Bumblebee species and the Hoverfly species. Disgust unites the Millepede species, the Edible Snail, the Ladybird Spider, the Common Earwig and the Field Cricket.

Overall, the heat map visually confirms that different species share various features, even in categories perceived as contradictory (e.g. ‘PEA’ and ‘fear’ for the Bumblebee).

Discussion

Entertainment Value

The two entertainment value categories ‘PEV’ and ‘NEV’ captured the children’s statements regarding curiosity as well as their need for action and exploration, which are important drivers for learning and understanding (Herrmann, 2004). Hence, these categories might allow for a new approach when evaluating the attitudes of children toward insects and invertebrates in general. ‘PEV’ and ‘NEV’ are relevant with their 17% and 14% share of positive and negative statements, respectively (Table 3), and hence worth further consideration. Experiences of movement, sound or potential interaction might drive sympathy, while a lack thereof can lead to rejection. Chasing insects with butterfly nets is one opportunity to experience insects through excitement and fun (Kawahara & Pyle, 2013; Pyle, 2009).

Fear and Disgust

In light of the descriptions of disgust and fear reviewed above, the number of statement counts and the lack of correlation between fear and disgust are conclusive. Regarding their position in the fear/disgust coordinate system, our 18 invertebrate species fall into four groups: (1) The Apollo, European Peacock, Dark Green Fritillary, Owly Sulphur, Six Spotted Burnet Moth, Sombre Goldenring, Banded Demoiselle, Green Leek Grasshopper, Firebug and Field Cricket are pleasant, confidence-inspiring species with low to very low counts for both fear and disgust, (2) the Common Earwig, Millepede and Edible Snail are species evoking disgust, (3) the Hoverfly, Bumblebee, European Crayfish and Stag Beetle are species causing fear and (4) the Ladybird Spider shows high counts for both disgust and fear.

The species considered pleasant and confidence-inspiring have firm bodies and perceived flying abilities. Butterflies symbolize beauty and pleasure in life (Lewis, New, & Stewart, 2007), and receive higher attitude scores than other insects (Schlegel & Rupf, 2010). Dragonflies also have high appeal (Samways, 2013). The fear-inducing species are united by their perceived or actual pain-creating body features such as stings or pincers. However, getting stung is not related to disgust (Bixler & Floyd, 1999).

In our survey, the spider induced the highest counts of fear and disgust. Out of 246 children, 231 recognized the Ladybird Spider as a spider. Every fifth child (48 children) called it Black Widow, Tarantula or poisonous spider: 62 out of the 89 fear statements refer to poison, danger or being deadly. Misidentification as an exotic and toxic spider might be due to media exposure, which favors virtual animals (Ballouard, Brischoux, & Bonnet, 2001). The potency of spiders to create high levels of both fear and disgust has been discussed above, and our results are in line with previous studies. Spiders generate a specific fear (Gerdes, Uhla, & Alpers, 2009), and even entomologists are not immune to fear of spiders, their reasons also showing the presence of disgust (too many legs, the way spiders move) and fear (the unexpectedness and biting capability of spiders) (Vetter, 2013).

Gerdes et al. (2009) tested for fear, disgust and danger that arthropods produced in survey participants. Our results compare well to the fear and disgust ratings they tested for butterflies/moths (low/low), beetles (low/medium) and spiders (high/high). However, they received mid-level fear and disgust ratings for bees/wasps, while our survey found high fear and low disgust values for the Bumblebee and the Hoverfly species. Since the literature generally assumes low disgust levels for bees, the elevated disgust reported by Gerdes et al. (2009) might have been caused by wasps being included in their survey.

Groupings Resulting from Cluster Analysis

The hierarchical cluster analysis sheds more light on the intrinsic groupings that occur on the basis of the qualities the children awarded to the invertebrate species investigated. We assume that the Hoverfly and the Bumblebee species were unified by their perceived stinging capability. The Hoverfly species was misidentified by 68% of the children (167 out of 246) and frequently mistaken for a bee (86 times) or a wasp/hornet (73 times). The high number of stinging-related statements in respect of the Hoverfly and the Bumblebee species account for 28% and 33%, respectively, of all statements given (Table 4).

Many children experience the pain of getting stung by a bee or a wasp or see it happen within their group of family and friends. Thus, fear of getting stung can occur either through conditioning or social learning. With adults, wasps and bees have also achieved top rankings in fear scores, namely positions 2 and 8, respectively, out of 35 animals (Arrindell, 2000; Davey, 1994b). However, flies were not deemed disgusting by adults (de Jong & Muris, 2002).

Table 4. Stinging-related statements on the Bumblebee and Hoverfly species selected, shown under (A1) in Figure 3

Statements related to stinging capability	Statement code	Bumblebee: # of statements per code	Hoverfly: # of statements per code
The sting	555	8	6
Stinging	703	65	82
Painful sting	704	7	5
The sting is dangerous	708	2	0
Sum		82	93
All comments per species		290	278
Share of all comments		28%	33%

The Hoverfly species selected represents one of the many hoverflies that apply mimicry of more dangerous wasps and bees in shape, color and behavior to ward off predators. Sometimes, even an experienced researcher needs to look twice (Ball & Morris, 2013; van Veen, 2010). Bumblebee species share the ability to sting with other Apidae, e.g. honeybees. However, while honeybees are rather aggressive when encountered, most Bumblebee species are not prone to stinging. Hence, fear of both the Hoverfly and Bumblebee species is somewhat unfounded.

The Firebug and the Six Spotted Burnet Moth share perceived ways of movement, coloration and body features. The Firebug cannot fly in real life, but the shape of the coloring on its back might have been interpreted as wings by the children who completed our survey. Both species have red-black coloring, a longish body shape and long antennae. In the animal kingdom, the color red serves as aposematic color (Prokop & Fančovičová, 2013), while implying negative insect association through body features (Shepardson, 2002).

Butterflies, dragonflies and the Owly Sulphur are united by the comments received on their wings and coloration. The wings of the Owly Sulphur, Sombre Goldenring and the Banded Demoiselle received statements for their transparency, the latter also regarding its shiny blue body. The European Peacock was rated differently from the Dark Green Fritillary and Apollo, which might be due to its slightly darker coloration or its distinct eye-like pattern.

The Edible Snail and the Green Leek Grasshopper are positioned closely together, although their body surfaces and shapes differ strongly. The closeness of their position in the cluster analysis might be explained by their individual ways of locomotion, which can be attention-catching. While the grasshopper is a quick jumper, the shell-bearing snail moves very slowly. Both movement styles might be considered as either entertaining or annoying.

The European Crayfish and the Stag Beetle have pincers, resembling antlers in the latter case. Both belong to the identified male invertebrate species of Schlegel et al. (2015). These species live on the ground and they look rather unfamiliar (alien), which could signal otherness even though their hard carapaces may prevent them from evoking disgust (Kolnai, 1929/2004).

The Field Cricket and the Common Earwig are paired together, both species suffer from prejudice. They are thought either to be a beetle/cockroach or to crawl into one's ear. Of the 146 children who could not identify the Field Cricket, 91% considered it to be a beetle, the most frequent name listed being 'Dung' beetle. This name suggests an unpleasant smell, feces and decay, all of which trigger disgust. The Common Earwig, however, received 25% of the statements related to fear, triggered by its pincer-like tail, and disgust, mainly due to a displeasing thought of contact, especially when imagined as crawling into one's ear. Because disgust is connected to the skin, crawling into the ear constitutes a violation of the body envelope (Miller, 2004). At the same time, the Common Earwig has an unusual body shape, which could stand for otherness, also an elicitor of disgust. The threat of involuntary body contact with an animal evoking disgust could thus produce fear of contamination, as explained above.

Based on the correlation results and our respective discussion, we would have expected the spider to achieve a stand-alone position, or at least be closely connected to the 'weaponized' species European Crayfish, Common Earwig and Stag Beetle. The Ladybird Spider formed a low-level subgroup in the cluster analysis together with the Millepede species. While the spider was predominant in the fear category with a total of 89 statements, the Millepede species gained only 5 statements. However, they both received the same level of disgust statements, 28 for the Ladybird Spider and 27 for the Millepede species. The obvious features shared between the two species are presumed disgust elicitors: their prominent and numerous (more than 6) legs and their specific (yet differing) way of movement.

The groupings found in our cluster analysis suggest that invertebrates, and insects in particular, could be divided into four units: (1) the fear-inducing stinging species (node A1), (2) the charming colorful flying species (nodes A3–A6), (3) the peculiar ones (A2, B1, B2), and (4) the disgust-evoking crawling ones (B3, B4). For insects with similar body features, color is a distinguishing attribute that can be decisive for attitude scores (Breuer, Schlegel, & Rupf, 2015).

The cluster heat map depicts all the points discussed above (Figure 4). Three units stand out, that is, the colorful fliers (lower left), the dull crawlers (middle, top) and the stingers (middle, right border). However, the peculiar ones (Firebug, Six Spotted Burnet Moth, Edible Snail and Green Leek Grasshopper) (middle, right) have only little illumination power, which might be due to the sample chosen for this survey. We are not aware that the heat map tool has previously been applied to plot attitude components of species. We believe this tool provides visual support to convey public perceptions of flora and fauna, especially regarding polarizing species such as invertebrates. Based on this improved knowledge, environmental education could be improved by more tailored measures.

Coding Methodology and Framework

To ensure accuracy of interview transcripts and respective coding of data, an assessment of interrater reliability can be applied to determine the level of deviation due to subjective evaluation, involving two independent coders (Wirtz & Caspar, 2002).

Jones and Rua (2006) orally conducted semi-structured interviews and had 20% of their transcripts read and coded by an independent reviewer. While we also coded free text, our data consisted of only single written words, which were already pre-structured by the children as they wrote them on the provided lines in the structured questionnaire. The coding methodology, sample datasets as well as extraordinary or (even potentially) ambiguous statements, were discussed thoroughly among the authors and the codes and categories jointly decided upon. (In total, only 90 potentially ambiguous cases out of 4,765 datasets had to be discussed.) We considered this approach more adapted to our already pre-structured data than following a sequential approach involving two completely independent coders.

Conclusion

We would advise future research projects to conduct multi-method studies to gain improved insights into emotions and attitudes toward nature relevant topics. Pre-phrased questionnaires bear a risk of imprecise emotional labels (Woody & Teachman, 2000). For example, increased disgust might be communicated as increased fear when participants are not given other more accurate choices to report their distress, here multi-modal approaches offer additional insights to explain results (Vernon & Berenbaum, 2002). Interdisciplinary studies might be helpful to tame the complex issues of emotions from different angles, including approaches from the philosophical, anthropological, psychological, neurological, nature conservational and educational sciences. A new theoretical concept based on systems science while embracing the various disciplines has recently been called for by neuroscientists (Tretter & Kotchoubey, 2014).

Our results show that children are afraid of insects and invertebrates that can potentially cause pain or are thought to do so, and are disgusted by species that crawl on the ground. We believe environmental educators should tackle these misunderstandings in order to activate increased support for local nature conservation and sustainable ecosystem management.

Fear of stinging insects can be mitigated through improved lesson content and accurate information. Pupils should be able to identify species and know, for example, the difference between wasps, bees, bumblebees and flies (von Hagen, 1988), understand their behavior and appreciate their ecosystem functions (Randler, 2008). Even young children have the capacity to memorize a plethora of details as shown by the Pokemon example (Balmford, Clegg, Coulson, & Taylor, 2002).

Disgust is a shining example of how biological evolution is affected by culture, while culture is created and maintained by social learning (Olsson & Phelps, 2007). This implies, in our case, that when children are disgusted by creepy-crawlies, this revulsion is based on a biological preparedness (Seligman, 1971) or predisposition (Curtis & Biran, 2001) which has been nurtured by education at school and socialization at home. Social learning as a transmission mechanism offers the opportunity to change the perception of disgust elicitors through providing information directly to children and through influencing their role models, teachers and parents.

Recent research has translated the established concepts of teaching and social learning developed by Herder (Herder, 1800/1972) and Bandura (Bandura, 1977) into science education with clear implications for environmental teaching. Attitudes and beliefs of science teachers are crucial for the quality of science education (Jones & Leagon, 2014). Hence, both science content and outdoor experience need to be integrated into teacher education programs in order to improve their effectiveness as role models (Lindemann-Matthies et al., 2011), especially for early childhood educators (Torquati, Cutler, Gilkerson, & Sarver, 2013). At the same time, science instructions and knowledge transmission are more effective when conducted outdoors on schoolyard sites compared with classroom settings (Cronin-Jones, 2000); the intrinsic motivation to learn about nature increases in the green classroom (Drissner, Haase, & Hille, 2010) as well as the connectedness with nature (Kossack & Bogner, 2012). Science education improves knowledge and interest when executed lively, be it with living animals or animated film (Hummel & Randler, 2012).

Storytelling should be leveraged into classroom teaching since it offers personal association (Blaustone, 1992; Kerry, 1997; Woodside, Sood, & Miller, 2008), strongly activates humor (Gálvez, 2012), and makes facts easier to both memorize and believe (Herbst, 2008; Loebbert, 2003). A neurodidactic school curriculum can introduce fourth graders to holistic ecologic concepts, and provide children with the degrees of freedom for exploration necessary to develop a feeling of self-efficacy (Arnold, 2002). Furthermore, experience of nature offers the chance for epiphanic moments (Lorimer, 2007), creates excitement about flora and fauna (Chawla, 2006; Lindemann-Matthies, 2006), and supports the healthy intellectual and physical development of children (Kellert, 2002). Engaging with insects and invertebrates in theory and practice fosters better understanding of the species themselves, their respective roles and importance in ecosystems (Lindemann-Matthies, 2012) as well as thinking in networks and systems (Frischknecht-Tobler, 2012).

Broadly speaking, colorful flying insects do not trigger disgust, while dull or dark colored and earth-bound 'creepy-crawlies' do. At the same time, disgust has the unique quality of being closely linked to curiosity—the otherness perceived is interesting and tempting (Kolnai, 1929/2004; Miller, 2004). The children's statements in our study indicate an impressive level of curiosity with subsequent disappointment in a lack of exciting features, as demonstrated by the substantial number of statements in the 'PEV' and 'NEV' categories. We believe that the 'PEV' is related to a term coined by the brain scientist Valentino Braitenberg. He used the term 'urge to understand' ('Kapiertrieb') (Schnabel, 2002, 2013) to describe biochemical rewards which are produced when understanding occurs (Braun & Meier, 2004; Roth, 2002; Schultz, 2011).

In the long run, environmental education can therefore help to overcome the disgust triggered by crawling invertebrates. Encouraging evidence already exists: Although children name spider fear as their number one fear (Muris et al., 2000), this fear can be conquered by gaining knowledge and personal experience (Kleinknecht, 1982; Randler et al., 2012; Vernon & Berenbaum, 2004). Since we believe spider distress to be mostly driven or initiated by disgust, the disturbing otherness can be mitigated through emotional and humanizing information, for example, on brood care (Prokop et al., 2010). Eventually, once the fear has been overcome, strong positive attachment to spiders can be achieved (Kleinknecht, 1982). In a science classroom setting, positive attitude changes have been achieved through direct experience with ambiguous species such as amphibians (Tomažič, 2008). This gives rise to the hope that aversive reactions to other invertebrate species can also be mitigated with appropriate measures. Consequently, based on better understanding of the ecological role of invertebrates and correspondingly higher levels of sympathy (Shardlow, 2013), nature conservation can be expected to find greater support from a wider group of citizens.

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Supplemental data

Supplemental data for this article can be accessed here 10.1080/09500693.2015.1099171.

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