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Do We Believe Pictures More or Spoken Words? How Specific Information Affects How Students Learn about Animals

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The popularity of science education is decreasing in certain parts of the world and negative attitudes toward science are common in learners from various cultures. Learners' interest in science and the effectiveness of their memory can be enhanced by utilizing modern concepts of an evolutionary-based approach in psychology. Survival-relevant information is, according to a number of authors, better retained than survival-irrelevant information. It is, however, unclear as to which degree the information retention is influenced by visual signs associated with danger. We experimentally manipulated danger information (genuine/ false information) and type of information (survival-relevant/survival-irrelevant) in a sample of 12-16 year old Slovak children. Information concerning dangerous animals was retained better than information about non-dangerous animals and survival-relevant information was retained better than survival-irrelevant information. The information itself, however, did not enhance memory scores, because false information about non-dangerous animals (i.e., presented as dangerous) led to lower scores than false information about dangerous animals (i.e., presented as non-dangerous). These results suggest that children adaptively retain survival-relevant information, but information retention is influenced by visual signs of danger. Utilisation of the evolutionary-based approach in science education is discussed.

Keywords: adaptive memory, animals, biology education.

INTRODUCTION

Science education plays an important role in the understanding of modern technologies which are applied to various parts of everyday lives (Lappan, 2000; Šorgo et al., 2012). It increases the public's ability to engage with scientific knowledge and scientific choices, for example, with choosing a healthy diet or environmentally friendly energy alternatives (Halder et al., 2012, 2013). As science education is one of the integrating parts of education in general scientific knowledge can contribute to general knowledge as a whole. General education is important for individual academic growth, employability, progress in careers and higher wages (Lavonen et al., 2008; Park et al., 2009). College graduates earned far more over their lifetimes than people who only graduated from high school (Tiffany and Kominski, 2011; HIES, 2012/13; IDA research project, 2008). Educational levels seem to have an influence on people's perception of nature, because people with a higher education have more positive attitudes to animals and are more willing to contribute to nature protection (Kellert, 1993; Martin- López at al., 2007; Prokop at al., 2008; Røskaft et al., 2007).

Science has become less popular for learners in Western countries over time (Ramsden, 1998; Randler et al. 2012; Osborne et al., 2003). As a response, numerous attempts to increase the popularity of science education have been made (Osborne and Dillon, 2008; Tunnicliffe, 2013). These include various activities

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State of the literature

- The popularity and quality of science education needs to be improved in order to enhance learners' interest in science
- Human memory is enhanced when people process information in terms of its fitness value. This means that information relevant to survival is retained better than survival- irrelevant information.
- The value of (survival-relevant) information may be confounded by visual signs associated with danger, e.g. animal teeth, claws. Information retention in danger-relevant and danger-irrelevant contexts still needs to be studied.

Contribution of this paper to the literature

- This study experimentally manipulated information about animal danger in biology education lessons. Information about dangerous animals was retained better than information about non-dangerous animals.
- Survival-relevant information was retained better than survival-irrelevant information.
- Information about dangerousness per se did not enhance information retention scores; instead, false information always resulted in a lower memory score. These results suggest that animal morphology plays a significant role in information retention in school-age children

realized via non-formal education (Žoldošová and Prokop, 2006; Braund and Reiss 2004; Roesch et al., 2015), introducing modern technologies to science courses (Hamilton et al., 2006; Chompu-Inwai & Doolen, 2008; Lewis et al., 2014), including ICT (Park et al., 2009; Plakitsi, 2013). Žoldošová and Prokop (2006) found that even short-term informal field science education has a positive effect on interest and ideas about science education with schoolchildren. Comparison between the knowledge gain effectiveness through the real and virtual field trip in the fields of biology and ecology showed minute differences. But students participating in real field trip were more able to use real tools in their observation compared to the students participating in virtual field trip, which were better skilled in accessing additional, more complex information via computer (Puhek et al., 2012). For many the field trip is an unforgettable experience that was also a key influence for those who continued to work in the field of biology (Braund and Reiss 2004). Practical work and practical application involving acquiring knowledge could have a positive impact on student outcomes. Park et al. (2009) found, for example, in a quasi- experimental study, that CAI (computer- assisted instruction) can help lower- achieving students obtain better results and may encourage an increased interest in science. In contrast, the influence of using mobile wireless technology on students' attitudes was affected by certain external conditions, for example, how strong the supportive infrastructure is (Chompu-Inwai & Doolen, 2008). Thus, any effect of the implementation of certain new technologies is questionable.

The major limitation of these efforts is that all of them are time-consuming and their realization often involves significant financial support (Dillon et al., 2006). Furthermore, teachers often ignore innovative methods making the investments less than meaningful (Woodward and Gersten, 1992, cited in Ferrari and McBride, 2011). Mainly older teachers are less favourable towards usage of modern technologies in education compared with younger ones (Puhek et al., 2013). The teaching materials used in everyday teaching need to be optimized in order to enhance learners' attention and interest in learning (Hidi, 2001; Potter and Rosser, 1992; Kloser, 2013). Unfortunately, the building of new curriculum is often not based on scientific knowledge, despite the fact that it could provide a better basis for effective teaching (Tokuhama and Espinosa, 2011).

A number of psychologists have suggested that human memory is enhanced when people process information in terms of itsfitness value (Nairne et al., 2007; Weinstein et al., 2008; Otgaar et al., 2010). The rationale for this claim is that the evolution of the human brain was influenced by survival problems in our ancestral past (Tooby and Cosmides, 1992). In other words, our adaptive memory and learning systems are induced by ancestrally-based problems, rather than by problems faced in modern environments (Nairne, 2010). Humans, for example, detect evolutionarily-relevant stimuli, such as snakes and spiders, more quickly than non-threatening stimuli (LoBue and DeLoache, 2008). The evolutionary paradigm of learning and memory is still, however, rarely utilized in science education (Prokop and Kubiatko, 2014). Prokop and Fančovičová (2014) found, for example, that children remembered more information about plants with fruit coloured red and black compared with fruits coloured green. In the same study, students remembered the toxicity of plant fruits better compared with their naming and occurrence. This suggests that colours associated with ripening and, therefore, more important for survival, may enhance learning. Similarly, Prokop et al. (2014) demonstrated that a knowledge of parasites was retained better by students than knowledge about hormones. These results, again, provide some support for adaptive learning, since knowledge about parasites (compared with knowledge about hormones) may help us avoid deadly disease and is thus survival-relevant information. Barett and Broesch (2012) (see also Štefaniková and Prokop, 2013) found that children remember more information about the possible danger caused by some animals relative to other survival-irrelevant information (i.e., naming and diet). This was found in children from both US and Ecuador providing some evidence about the universality of adaptive memory processing.

The present study makes a further step in the investigation of adaptive memory within the context of science education. We in particular attempted to disentangle the effects of survival-relevant information and animal morphology. More specifically, certain information may be retained better by children not only because these are survival-relevant, but also because it can be associated with animal teeth, claws and other organs which are potentially dangerous to humans. Disentangling the value of information and animal morphology may provide deeper insights into investigation of learning processes as well as their utilization in science education.

In this quasi- experiment we predict the following:

1. Schoolchildren obtain the highest score in the question about the danger of animals compared with fitness-irrelevant questions
2. The score in the dangerousness question will be higher when answering questions about the animals that were said to be dangerous
3. The main score from all the questions will be higher when answering about the animals that were said to be dangerous (genuinely or manipulated)

METHODS

Species Selection

We have selected 16 animals species exotic to Slovakia to decrease the possibility that schoolchildren have had any experience with them. Eight species were potentially dangerous for human in terms of toxicity or because they can cause a serious injury, and eight species were harmless (Tab. 1).

Participants

The convenience sample of 90 participants consisted of schoolchildren from six classes of three schools from western Slovakia. An additional eight participants were removed due to missing data. The age of the participants varied from 12 to 16 years (M = 14.11, SD =0.84, N = 90). The participants were randomly divided into two groups (group A and B) with an equal number of 45 participants.

Procedure

Each group of participants was presented with a Powerpoint presentation containing coloured pictures of all 16 species (one picture on each slide). All the pictures had been found via Google and the downloaded pictures were edited for the purposes of our research. The background was removed from each photograph and the size of pictures was standardized to a similar length and colour contrast.

While the pictures were on the screen the experimenter said the name of the animal and information about the environment in which the animal occurs, its diet and the danger it poses to humans. This

Table 1. List of Animal Species Used in the Experiment

English Name	Scientific Name	Dangerousness
Asian giant hornet	*Vespa mandarinia*	dangerous
Geography cone	*Gastridium geographus*	dangerous
Reef stonefish	*Synancea verrucosa*	dangerous
Spur- winged goose	*Plectropterus gambensis*	dangerous
African honey bee	*Apis mellifera scutellata*	dangerous
Blue-ringed octopus	*Haplochlaena lunulata*	dangerous
Fugu rubripes	*Japanese pufferfish*	dangerous
Southern cassowary	*Casuarius casuarius*	dangerous
Ocean sunfish	*Mola mola*	non-dangerous
Satanic leaf-tailed gecko	*Uroplatus phantasticus*	non-dangerous
Collared aracari	*Pteroglossus torrquatus*	non-dangerous
Tufted deer	*Elaphodus cephalophus*	non-dangerous
Leopard shark	*Triakis semifasciata*	non-dangerous
Horned marsupial frog	*Gastrotheca cornuta*	non-dangerous
Atlas moth	*Attacus atlas*	non-dangerous
Maned wolf	*Chrysocyon brachyurus*	non-dangerous

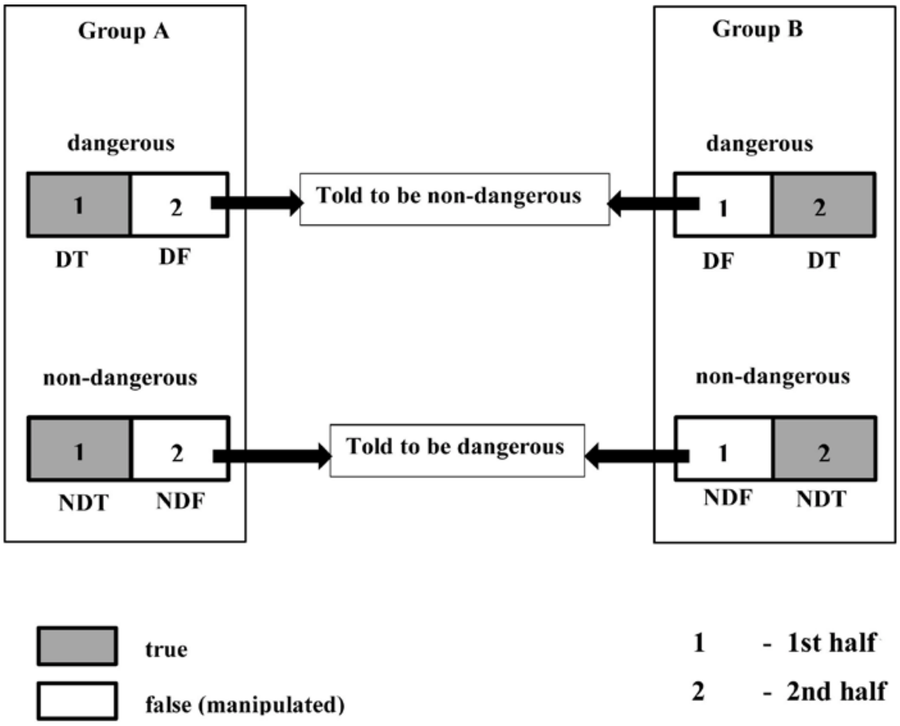

Figure 1. Experimental design

information was standardized to a similar length of text and there were only four types of information mentioned above. The schoolchildren did not see the text. This means that they had only two kinds of stimuli: the visual- image of the animal and the auditory- spoken text. The text was always read by the experimenter in order to avoid possible differences in introducing genuine and false information.

The information about dangerous was manipulated in order to see whether information influences per se participant's information retention. Design 2 (dangerous/non-dangerous) × 2 (genuine/false danger information) was used with 4 animal species in each part of the 2 × 2 design yielding 16 animals overall. There were consequently four types of animal dangerousness coding; dangerous said to be dangerous (DT- dangerous genuine), dangerous said to be nondangerous (DF- dangerous false), nondangerous said to be nondangerous (NDT- nondangerous genuine) and nondangerous said to be dangerous (NDF- nondangerous false). That is, one group of participants received genuine information about the dangerousness of some animals (e.g. this animal can pose serious injury to humans), while the other group received false information about the dangerousness of the same animals (e.g., this animal cannot pose serious injury to humans). The same procedure was applied to both groups of participants (group A and B) to ensure that each participant received both genuine and false information about both dangerous and non-dangerous animals equally (Fig. 1). Participants were asked not to write notes or make any other kind of records.

After the presentation each group had to fill in a short distraction questionnaire related to the previous presentation containing the following questions: Was this presentation of interest to you? Was this information new for you? Do you seek out new information about different kinds of animals in your free time? What kind of animals are you interested in? These questions were not the subject of our further analyses. The questionnaire took 4 minutes followed by a testing session. The participants were presented with the 16 photos of animals again in the same order, but no information about the animals was provided. The participants were instructed to write down answers to a prepared four questions applied to each animal (What is its name? What dœs it eat? Where dœs it live? Is it dangerous?). All the questions were open (write what you know, only the last one had only two possible answers, yes or no).

In each group of participants, the same surprise memory test was repeated one week later. The participants were not aware of the research goals of the research. After finishing the quasi- experiment, the participants were debriefed about our research goals and the manipulation of dangerousness information. Each participant received written materials with correct information about all the animals.

Table 2. Results of the Linear Mixed-Effects Model (MIXED) on the Mean Scores from Four Questions (Naming/Diet/Occurrence/Dangerousness)

Fixed predictors	Numerator df	Denominator df	F	P
Intercept	1	2,000	100.8	0.010
1. Dangerousness	1	2878	17	< 0.0001
2. Information type	1	2878	26.2	< 0.0001
3. Type of question	3	2878	347.4	< 0.0001
Interaction terms				
1 x 2	1	2878	5.1	0.024
1 x 3	3	2878	3.7	0.011
2 x 3	3	2878	7.8	< 0.0001
1 x 2 x 3	3	2878	14.9	< 0.0001

Scoring

Every answer was categorised as correct (1point) or false (0 point) according to the information which was provided to the participants during the presentation (real or manipulated). Therefore, if we said in group A that the animal is dangerous and in group B that (the same) animal is harmless, then the participants received only one point when their answers were in group A yes (the animal is dangerous) and in group B no (the animal is not dangerous) even though the animal was actually dangerous.

Statistical analyses

The linear mixed-effects model (MIXED) procedure in SPSS ver. 22.0 was used to analyse the data. Participant identity function was used to avoid pseudoreplication. Animal dangerousness (dangerous/non-dangerous), information type (genuine/false) and type of question (naming/diet/habitat/dangerousness) were defined as between-subject variables. The test/retest score was defined as a repeated-measures variable. The participant group (group A and B) was defined as the random factor. Scores obtained from the participant's answers on four questions (naming/diet/habitat/dangerousness) were dependent variables. The group of participants (group A and B) showed no significant effects on dependent variables (Wald Z = 0.99, p = 0.32). We therefore do not refer to this variable in the result section. Gender showed no significant effect on dependent variables and was therefore not included in the analyses. Partial eta2 was used in order to measure the effect size (0.01 was considered small, 0.04 moderate, and 0.1 large; Huberty, 2002). Cohen's d was calculated from means and SD, where d = 0.20 was considered as a small effect, d = 0.50 was considered as a medium effect, and d = 0.80 was considered as a large effect (Cohen 1988). P-values beyond the level 0.05 were considered statistically significant.

RESULTS

Participants Receive a Higher Score about the Dangerousness of Animals When Compared With Its Name, Occurrence and Food Habits

The results of the linear mixed-effects model (MIXED) (Tab. 2) showed as predicted, that participants received higher mean scores in questions regarding animal dangerousness compared with the remaining three questions (Table. 3 a, b). This pattern was also consistently significant in the retest (Wald Z = 37.9, P <0.001). This suggests that memory of dangerousness is stronger in both, the immediate memory test and the retest after one week.

The Score in the Dangerousness Question Will Be Higher When Answering Questions about Animals That Were Said To Be Dangerous

The results did not confirm the second prediction. A detailed analysis of the interaction terms showed that false non-dangerous animals (NDF) received a significantly lower mean score in the danger question in comparison with the three other groups of animals (analysis of contrasts, p < 0.001, Fig. 2). Although, as predicted, genuinely dangerous animals (DT) received the highest score, false dangerous animals (DF) scored similarly as genuinely non-dangerous animals (NDT) (Fig. 2).

The Main Score from All the Questions Will Be Higher When Answering about the Animals Which Were Said To Be Dangerous (Genuinely Or Manipulated)

Prediction 3 received mixed support. The genuinely dangerous animals (DT) received highest mean scores in all the questions (Tab. 3 a) and their scores were significantly different from both the genuine (paired t = 2.36, df = 89, p = 0.02) and false non-dangerous animals (paired t =2.96, df = 89, p = 0.004). In opposition to our prediction, false non-dangerous animals (NDF) received a lower mean score (even the lowest mean score of all) in all the questions according to false dangerous animals (DF) (paired t= 2.5, df= 89, p= 0.014). The genuinely non-dangerous (NDT) animals and the false dangerous animals (DF) did not differ significantly (Fig. 3).

Additional Analysis

Additional analysis of these data (one-way ANOVA with planned comparisons of contrasts) showed that dangerous animals (both genuine and false) received higher means scores in danger information compared with non-dangerous animals (both genuine and false) (F (1, 1422) = 9, 27, p = 0.02). This suggests that people tend to perceive the dangerousness of animals from their appearance more than from information per se.

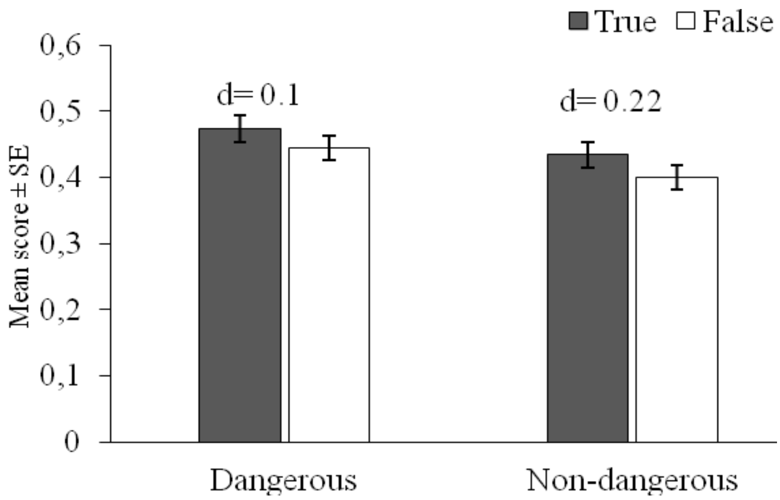

Figure 2. Mean score from the four groups of animals obtained in all the questions

Table 3. Means (SE in Parentheses) of Four Questions for Dangerous and Non-Dangerous Animals. A) Test, B) Retest

a) Test

	Naming	Food	Occurrence	Dangerousness	All questions
DT	0.36 (0.02)	0.33 (0.03)	0.44 (0.03)	0.76 (0.02)	0.47 (0.02)
DF	0.35 (0.02)	0.36 (0.03)	0.31 (0.03)	0.76 (0.03)	0.44 (0.02)
NDT	0.25 (0.03)	0.29 (0.03)	0.39 (0.03)	0.81 (0.02)	0.43 (0.02)
NDF	0.29(0.03)	0.35 (0.03)	0.37 (0.03)	0.59 (0.03)	0.40 (0.02)

b) Retest

	Naming	Food	Occurrence	Dangerousness	All questions
DT	0.38 (0.02)	0.24 (0.03)	0.36 (0.03)	0.67 (0.03)	0.41 (0.02)
DF	0.34 (0.02)	0.31 (0.033)	0.27 (0.03)	0.65 (0.03)	0.39 (0.02)
NDT	0.24 (0.03)	0.19 (0.026)	0.31 (0.03)	0.72 (0.03)	0.37 (0.02)
NDF	0.3 (0.03)	0.35 (0.026)	0.306(0.027)	0.5 (0.03)	0.37 (0.02)

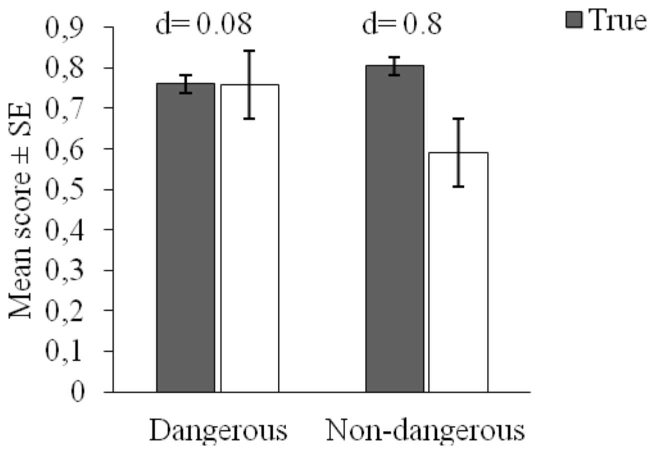

Figure 3. Mean score from the four groups of animals obtained in the danger questio**n**

DISCUSSION

Nairne and his colleagues (2007, 2010) suggested that adaptive memory and learning systems should be induced by ancestrally-based problems, rather than by problems faced in modern environments. This quasi-experimental study showed that, in line with the theory of adaptive memory, children's cognition and *memory* are dependent on context. In particular, children had much better memory tests if the topic was related to survival (i.e., animal dangerousness) compared with survival-irrelevant contexts (i.e., animal naming, diet and habitat). These results confirm previous research (Barrett and Broesch, 2012; Štefaniková and Prokop, 2013; Prokop and Fančovičová, 2014; Prokop et al., 2014). These results collectively support the idea of the existence of biased, adaptive learning (Nairne et al., 2007, Weinstein et al., 2008; Otgaar et al., 2010) in humans from various age groups and cultural origins.

The main purpose of this quasi- experiment was to determine, according to Barrett and Broesch's (2012) findings, whether the information about dangerousness is remembered on the basis of spoken information provided by the experimenter, or if it is more likely that this information is deduced from the picture of the animal alone (i.e., from their visible morphological signs). If participants would answer questions in the test according to information provided by the experimenter, the genuinely dangerous (DT) and false non-dangerous (NDF) animals are expected to obtain similar scores from the danger question (prediction 2) and also from all the questions together (prediction 3). These scores are expected to be higher than the scores of false dangerous (DF) and genuine nondangerous (NDT) animals. The results brought, however, mixed support for these predictions. False non-dangerous animals (NDF) obtained the lowest score in both the danger question and all the questions together, which means that, in opposition to our prediction, the false danger information did not increase information retention for dangerousness. It seems that false information was not believable for participants, because it did not correspond with the animal's appearance. Based on these findings, we suggest that animal's visible morphological signs, associated with danger, provide significantly stronger information to participants about the dangerousness of particular animals compared with spoken words. Prokop and Fančovičová (2014), for example, found that the naming and occurrence of plants was best answered by students for edible red fruits, while toxic plants were best remembered when their fruits were of a black colour. These results suggest that information retention varies greatly not only in terms of its relevance for survival, but also with the presence of morphological cues associated with danger.

The results of research on adaptive memory would be helpful in enhancing learner's interests (Ramsden, 1998; Osborne et al., 2003) and information retention. This study, for example, suggests that children retain better information about dangerous animals, compared with non-dangerous animals. We suggest that using animals that look potentially dangerous and using information about their potential danger to humans (or perhaps also to other organisms) may enhance learner's interests. Science teaching is not only about dangerous animals, of course, but better scores on questions regarding dangerous animals (compared with non-dangerous animals) in the present study suggest that information unrelated to danger may be better retained when they are presented in potentially dangerous animals.

This study has some limitations. We did not control the influence of the experimenters's and teachers's presence. Use of another research tool, e. g. a standardized online form accessible to every participant individually, might help control for these possible confounding factors. Secondly, we cannot generalize our results to all age categories or different cultures. An inter-cultural study on this topic would be beneficial. Furthermore, in-depth research is also needed to examine the effects of the presence of signs associated with danger on information retention. In addition, we also speculate whether these signs of danger are beneficial in terms of the willingness to protect animals by children, because the presentation of dangerousness may serve as double-edged sword. There is also the question, if (and then how) the specific appearance and posture (aggressive, or with visible dangerous signs compared with neutral, or even a cute posture) of an animal can influence the human perception of animal. Further works could be focused on the possibilities of practical applications of the results from this field of study to everyday biology lessons. Further research on these topics is clearly required before a firm conclusion can be made.

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