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INTRODUCION OF THE CONCEPT OF ADAPTIVE MEMORY TO SCIENCE EDUCATION: DOES SURVIVAL THREAT INFLUENCE OUR KNOWLEDGE ABOUT ANIMALS?

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Abstract. Cognitive abilities, namely memory mechanisms, are energy consuming and, thus, sensitive to survival-relevant information. Dangerous events are expected to receive greater attention than non-dangerous events because information processing about them and consequent behaviour ultimately increases the individual fitness. Biology textbooks provide a rich source of potentially dangerous and harmless animals. Here, we investigated whether potential danger from some animals influences school children memory about information relevant to survival. As predicted, participants scored better in information about dangerousness of animals relative to survival-irrelevant information (food and habitat requirement). Emotions (perceived disgust and fear) negatively correlated with participant willingness to protect them and there were some correlations (both positive and negative) between emotions and animal knowledge scores. Visual exposure to colour photographs of animals positively influenced willingness to protect them. Overall, science educators should pay attention when teaching about harmful animals because evolved memory systems may influence the learner perception of these animals.

Keywords: adaptive memory, animals, biology education, predators, parasites, emotions.

AIMS AND BACKGROUND

For students, learning is important for their educational success and future career promotion. The more knowledge people have, the more clever decisions they can make in their lives on our planet. Biology and environmental education are 2 of the key subjects that contribute to understanding of the impact of human actions[1] and knowledge seems to play an important role in enhancement of citizen environmental awareness[2–9]. Strengthening the student learning abilities, we can increase their comprehension of the real world[10,11]. However, recent results from the international survey OECD (Organisation for Economic Co-operation and Development), PISA (Programme for International Student Asessment) 2009 of scientific literacy showed that results of Slovak students are significantly lower than the average result of all participating countries[12] and interest in biology is

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continuously declining[13]. Therefore, there is still a need to work on improvement of student knowledge to increase environmental awareness.

Some evolutionary psychologists propose that our memory systems evolved to remember certain kinds of information better than others[14]. It is highly probable that there were many selective pressures and adaptive problems which fueled the development of human memory systems in our evolutionary history[15]. The concept of adaptive memory is the phenomenon which determines which information is important for survival or sustaining fitness and thus, worthy to remember and which is not. For example, predators and parasites have presented a serious survival threat for our ancestors. Therefore, the ability to remember how a dangerous animal looks and/or in what kind of environment does it live was a crucial advantage for individual survival. Even though the selective pressure of predators/parasites has currently decreased, parasites still significantly affect morbidity and mortality of humans[16,17].

Certain experiments[14,18–20] where participants were given a surprise recall task after they rated words for their relevance in survival, moving to a new house, planning a bank heist, pleasantness and other contexts, showed that participants always recalled most words in a survival scenario. Barett and Broesch[21] and Broesch et al.[22] found out that children in Ecuador and in the USA remembered information about the dangerousness of animals. A large survey of Slovak school children showed that although predators or disease-relevant animals received a more negative reputation, children had better knowledge about these animals than about non-predators and disease-irrelevant animals, providing indirect support for the idea about adaptive memory[23]. Otgaar et al.[24] supported the survival recall advantage[14,18–20] and the picture superiority effect[25] with a similar experiment. They compared remembering words with remembering pictures. It showed that participants recalled significantly more pictures in a survival scenario than in pleasantness context or moving context and, moreover, participants were more likely to recall pictures than words across all conditions. Some research showed that our memory processes are additionally influenced by the perceived disgust: disgusting stimuli are remembered better than stimuli that are not considered to be disgusting[26,27].

The willingness to contribute to protection of animals is, among other things, connected with the perceived fear of these animals. Brännlund et al.[28] on the sample of 2455 Sweden found that people who are afraid primarily of big carnivores are less willing to pay for their protection or are willing to pay a lower amount of money. The fear factor was equally important as the socio-economic factors. The research of Prokop and Fancovicova[29,30] also showed that the willingness to protect animals negatively correlated with expressed fear and disgust of animals.

In this study, we primarily examined whether knowledge about animals gained in formal school lessons is influenced by animal dangerousness. Our second aim was to examine whether the visual exposure to animals influences learner emotions

(namely fear and disgust), and whether emotions are associated with knowledge about these animals. Gender differences in willingness to protect animals produced mixed results[30], we therefore examined whether there are any gender differences in willingness to protect animals. Specifically, our predicions, predominantly derived from the theory of adaptive memory[14] were:

1. Memory questions about dangerous animals would be responded to more correctly than questions about control animals.

2. Dangerousness of animals would be remembered better than survival-irrelevant information.

3. Students would show better knowledge about animals in treatments with visual exposure to animals.

4. Females would score better in knowledge about dangerousness, males – in knowledge about food and habitat.

5. Females would score higher in perceived fear and disgust of animals and would show stronger support for animal conservation.

6. Animals that receive a higher score of fear and disgust would receive lower protection support; at the inter-personal level, willingness to protect animals would negatively correlate with perceived fear and disgust.

7. Willingness to protect animals and perceived fear and disgust of animals would be higher in treatments with visual exposure to animals.

8. Perceived fear and disgust of animals would positively correlate with the knowledge score.

EXPERIMENTAL

Participants. The sample of 102 participants (56 males and 46 females) consisted of 12–16-year old pupils (grade 7–8) from 2 schools. The mean age of the participants was 13.5 years (SE = 0.7). This age groups of participants was chosen because they were experienced with the zoology course that is taught in grade 6 (age 11/12). We collected adittional information about participants age, sex and grade of their study. Participants were divided into 2 groups. In the 1st group, pupils viewed a series of pictures with animals on a PPT presentation, but the names of animals were not shown (hereafter + PPT – animal name treatment). In the 2nd group, participants did not view any pictures of animals, but they were told only animal names (hereafter – PPT + animal name treatment). The former group consisted of 57 participants (31 males and 26 females) and the latter group consisted of 46 paricipants (25 males and 21 females). Participants in each treatment were tested in 3 independent school classes with 10–22 individuals.

Species selection and presentation. Species were selected from the actual biology textbooks list for 6th grade children[31]. The total number of species in the textbook was 209. We have chosen only native Slovak species with their full name and

information about feeding /nutrition and their habitat requirements described in the textbook. We have excluded non-native, foreign, domestic or bred species to standardise the sample of selected species. Finally, we have selected 7 dangerous (4 predators, 3 parasites) and 7 harmless species for our research purposes. The ratio of vertebrates and invertebrates was 7:7 (50:50). Potentially harmful species were: pork tapeworm (*Taenia saginata*), giant roundworm (*Ascaris lumbricoides*), German wasp (*Vespula germanica*), brown bear (*Ursus arctos*), common viper (*Vipera berus*), bed bug (*Cimex lectularius*), gray wolf (*Canis lupus*). Non-harmful species were: European ground squirrel *(Spermophilus citellus*), common chafinch (*Fringilla coelebs*), burrying beetle (*Nicrophorus vespillo*), leopard slug (*Limax maximus*), smooth newt (*Lissotriton vulgaris*), chamois (*Rupicapra rupicapra*), European mole cricket (*Gryllotalpa gryllotalpa*).

We presented a Powerpoint presentation with 14 coloured pictures of animals from freely available pictures downloaded from google.com. The background from each photograph was removed and the size of animals was standardised to similar length and colour contrast. Each slide contained one picture of one animal. Animals were presented in random order. While a picture was shown, participants should fill in a prepared one-page questionnaire answer or rank for 6 questions (see below). Before starting the presentation and testing, participants got this verbal information: how to fill in the questionnaire, all animals live in Slovakia, time for each picture is 50 s, repectively 12 min for questionnaire with species names. Participants were ensured that the research is not a test, just only our curiosity about what they think about some animals. After the resarch finished, participants were debriefed about our research goals.

Procedure. The questionnaire consisted of 6 questions. Three questions were open: (1) What is the name of the animal? (2) What does the animal eat? What kind of habitat does this animal require? Three more questions on perceived danger, disgust and governmental protection of the animal were closed and rated on 5-point Likert-type scale[32].

Scoring. Identification of an animal name was not scored in the + PPT – animal name group because these participants were aware of the names of the presented animals. Scoring of other questions was identical between the 2 groups. For open questions, we used a 3-point scale: (example of required habitat of European ground squirrel) 0 – missing or false answer (example: rocks, high mountains), 1 – partly correct answer (example: meadow), 2 – absolutely correct answer (example: field, meadow, pasture). The accuracy of an answer was determined according to information stated in the biology textbook. Scores for closed questions were given according to a rating on the scale (1–5 points).

Data from 2 participants were excluded from statistical analyses because of incomplete data.

RESULTS

First prediction: Memory questions about dangerous animals would be responded to more correctly than questions about control animals. A 2 (treatment: between-subject) × 2 (gender: between-subject) × 2 (type of animal: within-subject) × 3 (type of question: within-subject) analysis of covariance (ANCOVA) with age of participant defined as a covariate and mean scores of the 3 questions (food, habitat requirements and dangerousness) as dependent variables was used to test the first set of research questions. There were no significant differences in the mean memory scores between dangerous and control animals ($F(1.97) = 1.64$, $p = 0.20$, $\eta^2 = 0.02$), nor was an interaction between type of question and type of animal ($F(2.194) = 2.11$, $p = 0.12$, $\eta^2 = 0.02$ (Fig. 1)). The first prediction was not supported.

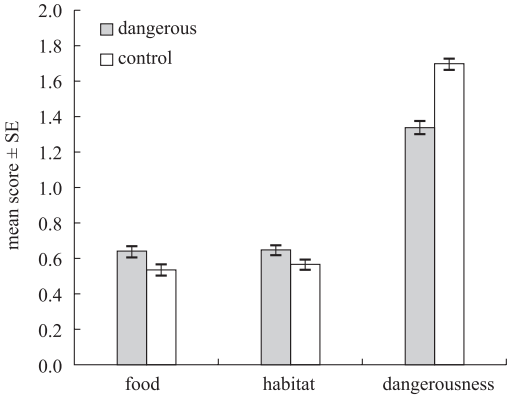

Fig. 1. Mean memory scores for 3 questions on dangerous and control animals

Second prediction: Dangerousness of animals would be remembered better than survival-irrelevant information. As predicted, there were significant differences in memory tests with respect to the type of question ($F(2.194) = 6.69$, $p = 0.0006$, $\eta^2 = 0.07$ (Fig. 1)). Tukey post-hoc test[33] showed that the mean scores for dangerousness of animals were higher than those for food ($p < 0.001$) or habitat requirement ($p < 0.001$). There were no differences between scores regarding food and habitat requirements ($p = 0.9$). Prediction 2 was supported.

The effect of treatment. There was no significant effect of treatment on mean scores from memory tests ($F(1.97) = 1.47$, $p = 0.23$, $\eta^2 = 0.01$). However, there was significant interaction between the type of animal × treatment variables ($F(1.97) = 5.17$, $p = 0.03$, $\eta^2 = 0.05$). This interaction suggests that participants had higher mean scores in memory tests when they responded to questions about dangerous animals in the – PPT + animal name treatment (Tukey post-hoc test[33], $p = 0.008$ (Fig. 2)). It is possible that information that can be deduced from the name of an animal could be helpful in predicting food, habitat or dangerousness of an ani-

mal. Otherway, the low mean scores in memory test about dangerous animals in + PPT – animal name treatment could be caused by disability to recognise some dangerous animals from the pictures (especially parasites) and thus, participants did not consider them dangerous (or they considered them less dangerous). Prediction 3 was not supported.

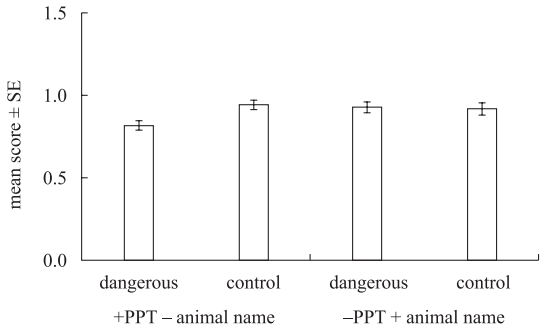

Fig. 2. Mean scores from memory tests with respect to type of animal and treatment

Gender differences in knowledge about animals. Gender differences in knowledge about animals were not significant ($F(1.97) = 0.49$, $p = 0.48$, $\eta^2 = 0.005$). There was no significant interaction between type of question × gender variable ($F(2.194) = 1.59$, $p = 0.21$, $\eta^2 = 0.02$). Prediction 4 was not supported.

Fear, *disgust and willingness to protect animals*. A 2 (treatment: between-subject) × 2 (gender: between-subject) × 2 (type of animal: within-subject) × 3 (type of emotion: within-subject) analysis of covariance (ANCOVA) with the age of participant defined as a covariant and mean scores of the 3 items (perceived fear, disgust and willingness to protect an animal) as dependent variables was used to test the second set of research questions. We found no significant effects of predictors on the dependent variables (all $p > 0.08$).

Effect of gender. Although the main effect of gender was not significant (see above), there was significant interactions between the emotion × gender variables ($F(2.194) = 9.31$, $p = 0.0001$, $\eta^2 = 0.09$). Females scored higher in perceived disgust (Tukey post-hoc test[33], $p = 0.01$) and their willingness to protect animals tended to be lower than in males ($p = 0.06$). Prediction 5 received mixed support.

Willingness to protect animals will be associated with emotions. Significant interaction between the type of animal × dangerousness ($F(2.194) = 10$, $p < 0.0001$, $\eta^2 = 0.09$) suggests that dangerous animals were perceived as more dangerous and more disgusting than control animals, and willingness to protect them was lower than protection of control animals (Fig. 3). All differences between subgroups were highly significant (Tukey post-hoc tests[33] all $p < 0.0001$). Interestingly, however,

willingness to protect animals correlated significantly and negatively only with perceived disgust of dangerous animals (partial correlation controlled for effect of age, gender and treatment, $r = –0.34$, $p < 0.001$), but other correlations were not significant. Prediction 6 received mixed support.

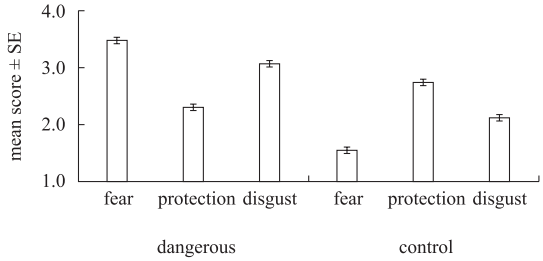

Fig. 3. Differences in perceived fear, disgust and willigness to protect dangerous and control animals

Effect of treatment. There was a significant interaction between the emotions × treatment ($F(2.194) = 4.78$, $p = 0.009$, $\eta^2 = 0.05$ (Fig. 4)). As predicted, visual exposure to animals increased willingness to protect them (Tukey post-hoc test, $p < 0.05$). Differences between fear and disgust did not differ between the 2 treatments (Tukey post-hoc tests, all $p > 0.2$). Prediction 7 received mixed support.

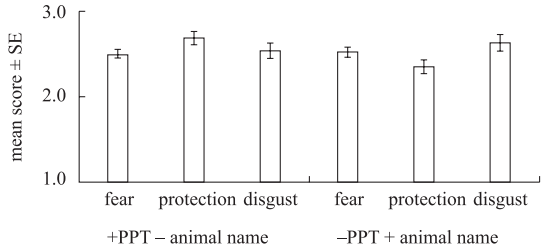

Fig. 4. Differences in perceived fear, disgust and willigness to protect animals with respect to type of treatment

Emotions would positively influence memory score. Partial correlations where the effect of treatment, gender and age were controlled, were used to examine whether there are correlations between emotions (4 variables: summed fear and disgust of dangerous and control animals) and memory tests (6 variables: mean score of food, habitat requirements and dangerousness of dangerous and control animals). Fear and disgust of dangerous animals positively correlated with knowledge about dangerousness in dangerous animals ($r = 0.94$ and 0.41, both $p < 0.001$, respectively). Fear of control animals negatively correlated with the score from food, habitat requirements and with knowledge of dangerousness in

control animals ($r = –0.26$, –0.31 and –0.36, all $p < 0.01$, respectively). Prediction 8 received mixed support.

DISCUSSION

This study examined how evolved predisposition to select and remember information important for survival influences participant knowledge and emotions towards animals. Our research was based exclusively on information gained in formal biology lessons and thus, the results are applicable in the field of science education. The 8 predictions tested here showed mixed support for the theory of adaptive memory[4,14].

First, we examined whether knowledge about dangerous animals will be better remembered than knowledge about control animals (Prediction 1) and whether information about dangerousness will be better retained than other kinds of information (Prediction 2). We found no support for the first prediction, which contradicts with some studies[23]. In contrast, dangerousness of animals received high superiority in participant memory tests which would be explained as a result of evolutionary pressures on human cognitive structures[14,18]. The failure to support the first prediction can be explained by a relatively lower importance of knowledge about the diet and habitat requirements of dangerous animals. Barrett and Broesch[21], for example, also found only better scores for dangerousness of animals, but their naming and diet did not vary between treatments. Another explanation lies in our memory test: while authors generally examined short-term retention, here we present data on long-term retention, because memory tests contained information that our participants received 1 or 2 years ago. Of course, these data are largely correlational, and how and whether all required information about each animal was received by participants is an open question.

Knowledge of animals was better in treatments with no visual exposure to animals (Prediction 3), but this result was probably contaminated by knowing the names of these animals; at least some information about habitat or diet could be deduced from the name of the animals and thus, we do not suggest that there was any effect of visual exposure on knowledge about the animals. However, visual exposure to animals increased willingness to protect them (Prediction 7). It is hard to believe that the lack of information about the names of the animals would be responsible for this result; instead, it seems that some morphological features (e.g. colour, size) would enhance willingness to protect at least some animals over others[30,34]. Visualisation generally seems to be beneficial for learners[35] and we also recommend its use in biology education. Interestingly, however, emotions (fear and disgust) showed similar scores between the treatments. Some research also showed that scores from paper-and-pencil tests may be different from scores obtained by behavioural tests (i.e. with real contact of a participant with any emotion-inducing

stimuli)[36] suggesting that visual stimuli should be preferred in this kind of research over paper-and-pencil tests. Gender differences in emotions (females score higher), knowledge (equal between the sexes) willingness to protect animals (females score similarly as males) (Predictions 4 and 5) support our previous research research[23,30,37] and contradict with some previous suggestions[38]. Our data suggest that there are no gender differences in willingness to protect animals.

Emotions showed significant impact on willingness to protect animals (Prediction 6). Namely, perceived disgust showed negative correlations with willingness to protect animals which support our current findings[30]. Interestingly, this study showed that the dangerousness of animals is more important in predicting willingness to protect, compared with individual differences in perceived disgust or fear. Dangerous animals received lower support which agrees with lower willingness to protect unpopular animals like spiders, insects or reptiles in comparison with mammals and birds[30,39].

Emotions showed significant, but inconsistent correlations with the knowledge about animals score. There were both positive and negative correlations providing no exact support for the idea that 'negative' emotions like disgust would enhance information retention[26,27]. However, it is important to know that correlations between these variables exist and need to be further examined by researchers (e.g. in a controlled conditions where all participants will receive the same information) before a definite conclusion can be made. For example, some studies showed that high perceived disgust of animals or practical work with them correlates negatively with learning outcomes[40–42]. However, it is not clear how the positive effect of disgust on information retention[42] is related to low achievement on the other side.

CONCLUSIONS

To conclude, knowledge, emotions and willingness to protect animals seem to be at least partly influenced by their dangerousness. Participants were better in remembering information about dangerousness than other kind of information and dangerousness of animals negatively influenced willingness to protect them. The visual exposure of animals (pictures in the PPT presentation) and low perceived disgust of animals positively influenced willingness to protect them. Knowledge about animals showed some significant correlations with perceived emotions towards them (predominantly with perceived disgust). Science educators are encouraged to keep in mind that learning about dangerous animals can be different from learning about harmless animals[43,44] and that information about dangerousness of animals itself seems to be attractive, or at least easily memorable by children. Perhaps, more detailed information about historical or recent threats of some animals would enhance children attention and willingness to learn about them more because humans should be ultimately motivated to collect/remember information

about objects or subjects that pose a survival threat. Future research should integrate and evaluate the proposed 'survival threat approach' with individual differences in willingness to protect biodiversity for the future. This implies that research on human protection of animals should use visual exposure to pictures of animals because it stimulates protection of them.

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