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The effect of hands-on activities on children's knowledge and disgust for animals

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ABSTRACT
Research has shown that hands-on activities in biology/science education tend to improve children's attitudes towards science. These hands-on activities can influence children's interest in various ways, perhaps because they invoke varying emotions. We used a sample of 10–12-year-old children (n = 142) to examine the effect of hands-on activities with living snails on children's achievements and disgust sensitivity. Children with living snails received significantly higher knowledge scores about snails measured with both a knowledge test and with analyses of drawings as compared with control children who received a traditional lecture without living snails. Disgust sensitivity was significantly lower in the experimental group and children who scored higher on the disgust scale received a lower knowledge test score. It would seem that the emotion of disgust negatively correlates with achievement.

KEYWORDS
Achievement; emotion; hands-on activities; disgust for animals

Introduction

Decline in interest in biology in schools has been documented (Randler, Osti, and Hummel 2012) and hands-on work in biology lessons has been recognised as a powerful method for improving students' perception of science (e.g. Bergin 1999; NABT 2005; Prokop, Tuncer, and Chudá 2007) and achievement (Dieser and Bogner forthcoming; Kamisah and Kaur 2014; StohrHunt 1996). Indeed, both empirical (Holstermann, Grube, and Bögeholz 2010; Uitto et al. 2006), and experimental work (Prokop, Tuncer, and Kvasničák 2007; Thompson and Soyibo 2002) have revealed that hands-on activities enhance positive attitudes towards science and scientists. By analysing self-reports of students' experiences and interests with various hands-on activities, Holstermann, Grube, and Bögeholz (2010) found that there were *no* significant differences in interest between adolescents with experience and those without for most of the examined activities. This suggests that the performance of various hands-on activities can influence differently interest on the part of students.

Although the role of children's emotions in education has been underestimated, there is a considerable shift in the attention of researchers in this field (Alsop and Watts 2003; Prokop and Kubiatko 2014; Randler, Ilg, and Kern 2005). Feelings of disgust are evoked by certain species as being connected mainly with the factors 'illness and infection' (e.g. rats), 'slime or faeces' (e.g. snails) and/or with traditional negative stimuli (e.g. spiders) (Davey 1994). This emotion evolved to protect human bodies against pathogens (Curtis, Aunger, and Rabie 2004; Tybur, Lieberman, and Griskevicius 2009).

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Disgust influences learners' willingness to engage in hands-on activities and their motivation to learn (Fančovičová, Prokop, and Lešková 2013). Bixler and Floyd (1999) have shown, for example, that students with high disgust sensitivity expressed a lower preference for activities requiring contact with organic materials. As might be expected, there were no differences between the two groups on the observation-only activities. It was found that high disgust negatively correlated with interest, but positively with boredom suggesting that the emotion of disgust influences student motivation (2013; Randler, Wüst-Ackermann et al. 2012). Disgust may also influence the teacher's decision to exclude disgusting-looking animals from science education settings (Wagler and Wagler 2012). In two experimental studies, more disgusted students saw themselves as less effective at mastering the dissection (Holstermann, Grube, and Bögeholz 2009) and reported a lower interest in dissection than students who were less disgusted (Holstermann et al. 2012). Since interest and learning motivation strongly influence learning outcomes (Ainley, Hidi, and Berndorff 2002; Schiefele 1999; Tobias 1994), perhaps the emotion of disgust influences cognitive processes in biology lessons. As far as we are aware, however, research in this field is scarce.

This study experimentally investigated the effects of hands-on activities with living snails (Randler, Hummel, and Wüst-Ackermann 2013) on children's knowledge of snails. Previous research has shown that hands-on activities with snails reduce disgust for snails (Randler, Hummel, and Prokop 2012) and that children hold a number of alternative conceptions and a low understanding of the internal anatomy of snails (Rybska, Tunnicliffe, and Sajkowska 2014). We hypothesise that hands-on activities with living snails enhance knowledge about snails (Hypothesis 1) and reduce disgust sensitivity amongst children (Hypothesis 2).

With respect to Hypothesis 2, we did not investigate exclusively a specific disgust for snails (Randler, Hummel, and Prokop 2012) but asked more generally whether disgust for pathogen-connoting cues (pathogen disgust, Tybur, Lieberman, and Griskevicius 2009) and disgust for various animals (both vertebrates and invertebrates) is decreased by hands-on activities which could have deeper implications for both theory and practice.

We hypothesise that more disgust-sensitive children gain less knowledge about snails compared with less disgust-sensitive children (Hypothesis 3), thereby providing empirical evidence of the relationship between the emotion of disgust and cognitive processes in biology lessons. Gender differences were included in the statistical models to determine if our research supported earlier research by other authors (Curtis, Aunger, and Rabie 2004; Prokop and Jančovičová 2013; Tybur, Lieberman, and Griskevicius 2009) that females are more disgust sensitive than males. Knowledge of snails was investigated with both a knowledge test and with analyses of children's drawings, because these two methods need not necessarily correlate (Prokop and Fančovičová 2006), thereby providing a more valid measurement of children's cognitive processes.

Methods

Participants

The research was carried out in October–November 2014 at three primary schools in and near Trnava, Slovakia. A convenience sample of 148 children (6 of them were removed due to missing data) was used to test the research hypotheses. A total of 63 children were females. The mean age of the children was 10 years(range: 10–12, SE = 0.04) and all were in the 5th Grade. The full classes were randomly assigned to experimental ($n = 76$, three classes) and control ($n = 66$, three classes) groups.

Measures

Knowledge test

Knowledge of snails was investigated with 13 self-constructed items (example item: Snails cannot hear [true]). The validity of the knowledge test was established by two independent zoologists from

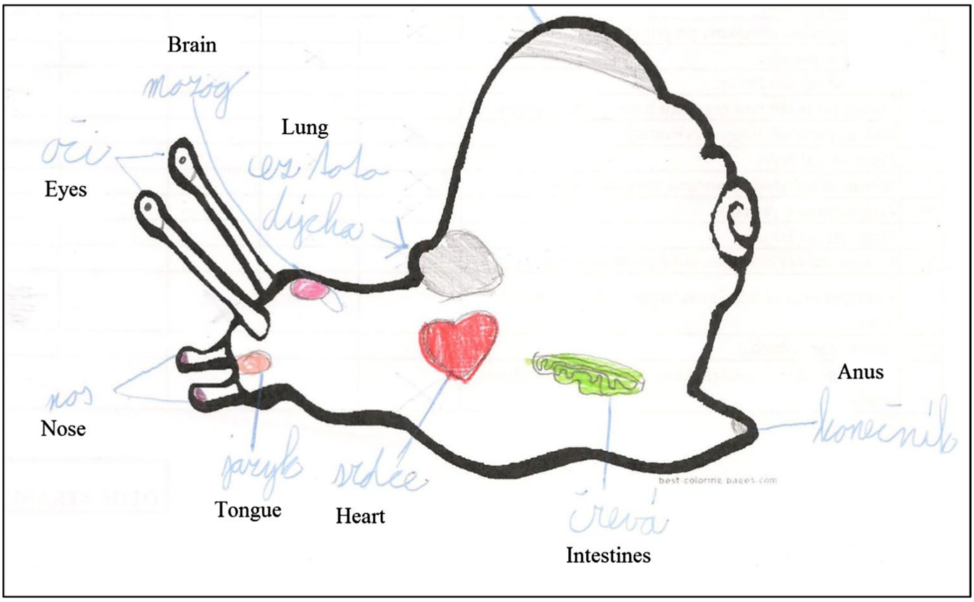

Figure 1. Year 10 children's drawing of a snail with organ systems scored on Level 2.

the university. Items were scored on the five-point Likert scale from absolutely disagree (1) to absolutely agree (5). Negatively worded items were scored in reverse order. The average scores were used in statistical analyses.

Drawings

The organ systems were analysed on a 7-level scale (Prokop et al. 2007; Tunnicliffe and Reiss 1999, 2001) where Level 1 is defined as 'no representation of the internal structure' and Level 7 is defined as 'a comprehensive representation with four or more systems indicated out of … circulatory, digestive, gaseous exchange, reproductive, excretory and nervous' (see the drawing example in Figure 1). Because snails are invertebrates, the skeletal system was not evaluated. The drawing method was used to analyse the children's ideas concerning what is inside animals since it is a reliable tool on how data about children's ideas can be effectively and easily obtained (Tunnicliffe and Reiss 1999, 2001).

Pathogen disgust

Pathogen Disgust refers to disgust elicitors caused by sources of various pathogens (example item: stepping in dog excrement). We used the Pathogen Disgust domain (Cronbach α = 0.75) adopted from Tybur, Lieberman, and Griskevicius (2009). This domain consists of seven Likert scale items ranging from 1 (not at all disgusting) to 5 (extremely disgusting). We calculated the individual scores of pathogen disgust by averaging the responses to the constituent items.

Disgust for animals

Children rated their disgust for animals on a five-point scale identically as pathogen disgust (see above) (Cronbach α = 0.84). The selected animals were both invertebrates (snails, earthworms) and vertebrates (mice, snakes, bats). We calculated the individual scores of animal disgust by averaging the responses to the constituent items.

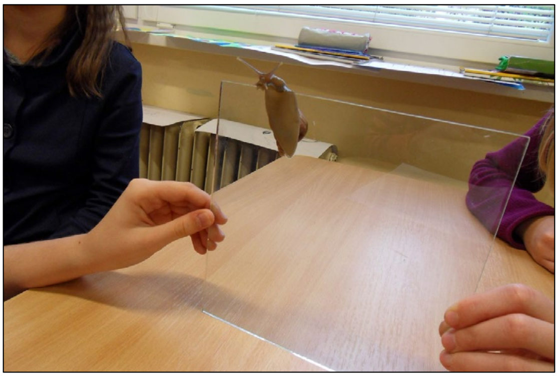

Figure 2. An example of experiments with snail.

Procedure

Prior to the testing, the children's parents received a description of the planned experiment and after the parent's written, signed consent was received, the experiment was conducted. All the parents agreed with the participation of his/her children in the experiment. Pre-test and post-test (identical questionnaires) were applied before (October) and after the treatment (November), respectively. The experiment took place in one biology lecture. A trained prospective teacher taught children with the traditional, transmissive approach which still persists in the majority of Slovak schools. The experimental group worked with live giant African snails *Achatina reticulata* commercially available in pet shops. The participants were divided into 5–6 working groups consisting of 4–5 children. At the beginning of the lecture, children received written instructions, worksheets and the tools necessary for performing four simple experiments/observations. Each working group received one live snail. Instructions regarding each consequent experiment were communicated to the children by the teacher to ensure that all the children understood the experimental procedure.

Before the hands-on activities began, the children received oral instruction from the teacher in the appropriate methods of animal handling. Students were specifically instructed to touch snails exclusively on the shell, avoid any irritation of the snail with their hands or other objects, and be very careful not to drop them. No snail was damaged or killed and after the experiment was completed, the snails were returned to a local pet shop.

The first activity was designed to investigate adhesive properties and movement patterns of snails on glass (Figure 2). The second activity examined whether snails are able to climb over sharp and edgeless edges (a knife). The teacher assisted in performing the second activity to ensure the safety of children. The third activity examined snails' abilities to hear and smell and the final observation dealt with the foraging behaviour of snails. Children made written notes and finally discussed their findings with the teacher. The control group received one lecture about snails with a traditional approach. In this case, however, the teacher worked only with a textbook, not with live snails. Thus, both the experimental and control group received a similar amount of information, but hands-on activities were only conducted in the experimental group.

The children in the experimental group were asked to describe the morphology of the snail with a special focus on the mouth and radula which was visible through the glass, tentacles, eyes and shell. Rybska, Tunnicliffe, and Sajkowska (2014) showed that children very often incorrectly think that the majority of a snail's internal organs are located in its foot. To address this common misconception, the teacher encouraged discussions with the children about the placement of the heart, stomach, kidney and lungs. Correspondingly, children were encouraged to look at

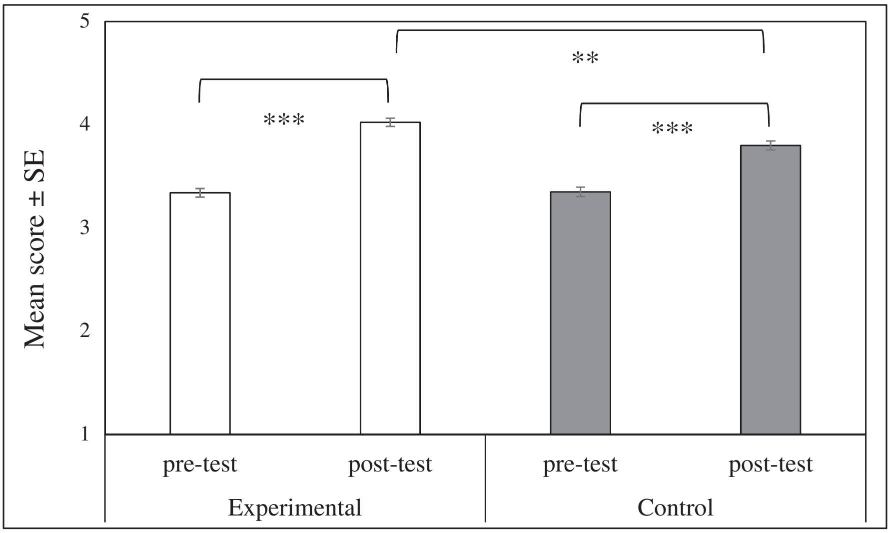

Figure 3. Mean scores from the knowledge test in the experimental and control group.
Note: Asterisks (*) denote significant differences based on the Tukey *post hoc* test ($^{**}p < 0.01$, $^{***}p < 0.001$).

the internal anatomy of the snail in the biology textbook. The children in the control group only worked with the biology textbook.

Results

Knowledge of snails: knowledge test

As predicted, children working with live snails received a higher knowledge score about snails compared with children from the control group (Hypothesis 1). Gender differences were not significant, however (repeated-measures ANOVA, $F(1,138) = 4.75$ and 2.78, $p = 0.03$ and 0.6, respectively). Pre-test knowledge scores were significantly lower than post-test knowledge scores ($F(1,138) = 266.1$, $p < 0.001$). The Tukey *post hoc* test revealed that knowledge scores increased both in the control and in the experimental group (Figure 3). The interaction of term knowledge × treatment ($F(1,138) = 11.32$, $p = 0.001$) suggests that there was no difference in mean pre-test knowledge scores between treatments although the experimental group received a higher post-test score than the control group (Figure 3). Other differences were not significant (all $p > 0.14$).

Knowledge of snails: drawings

Children working with live snails received a higher drawing score about snails compared with children from the control group (Hypothesis 1). Gender differences were not significant (repeated-measures ANOVA, $F(1,138) = 63.29$ and 1.83, $p < 0.001$ and 0.18, respectively). The pre-test knowledge scores were significantly lower than the post-test knowledge scores ($F(1,138) = 8.12$, $p < 0.01$). The interaction term of gender × treatment ($F(1,138) = 5.64$, $p < 0.05$) suggests that there were no gender differences in the control group (Tukey $p = 0.9$) although females scored better in the experimental group compared with males (Tukey $p < 0.05$). The experimental group scored better in the post-test compared with the pre-test, while no significant shift towards better scores was observed in the control group (Figure 4). It is not apparent why the experimental group had higher pre-test scores than the control group (Tukey $p < 0.001$).

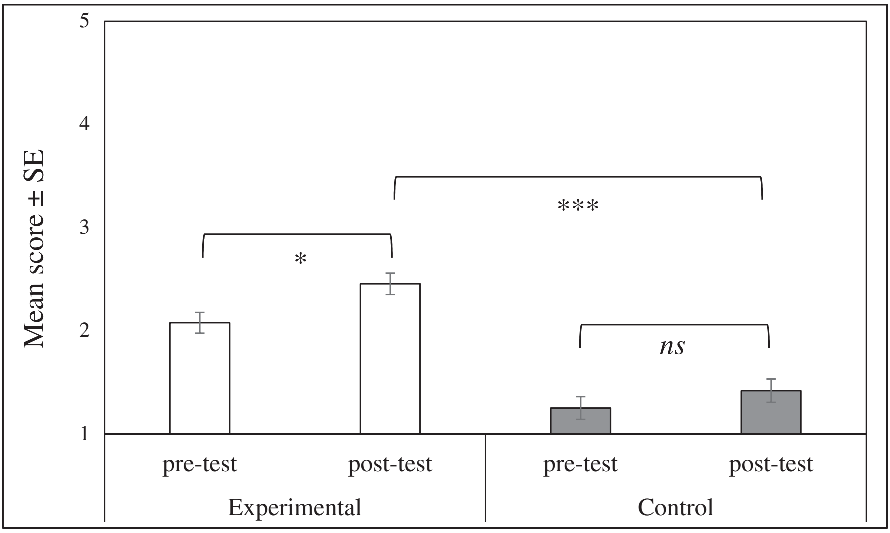

Figure 4. Mean scores from the drawings in the experimental and the control group.
Note: Asterisks (*) denote significant differences based on the Tukey *post hoc* test ($^{*}p < 0.05$, $^{***}p < 0.001$, ns = not statistically significant).

The relationship between the knowledge test and the drawings

There was no correlation between the knowledge test score and the drawing score in the pre-test or in the post-test (a partial correlation controlling for the effect of treatment, $r = -0.02$ and 0.02, both $p > 0.79$, $n = 142$, respectively).

Disgust for animals

Disgust for several vertebrates and invertebrates correlated. We therefore pooled data from these variables. Children working with live snails received a lower animal disgust score compared with children from the control group, and girls scored higher than boys (repeated-measures ANOVA, $F(1,138) = 6.13$ and 8.32, $p < 0.05$ and 0.01, respectively). Disgust ratings were generally lower in the post-test compared with the pre-test ($F(1,138) = 4.04$, $p < 0.05$). The pre-test scores were similar between the control and the experimental group (Tukey $p = 0.21$) and post-test scores tended to be lower in the experimental group (Figure 5). Other differences were not significant (all $p > 0.3$, Figure 4). With respect to pathogen disgust, the experimental group scored lower than the control group ($F(1,138) = 12.9$, $p < 0.01$) although other differences were not significant (all $p > 0.06$). These results provide statistical support for Hypothesis 2. Pathogen disgust and animal disgust correlated both in the pre-test and post-test (partial correlation controlling for the effect of treatment, $r = 0.51$ and 0.5, both $p < 0.001$, respectively).

Relationship between disgust and knowledge

We performed a series of partial correlations on pre-test and post-test scores from both knowledge tests and drawings with pathogen disgust or disgust for animals controlled for the effect of treatment.

Knowledge of snails measured with the knowledge test was negatively influenced by animal disgust in both the pre-test and post-test (partial $r = -0.28$ and -0.18, $p = 0.001$ and $p < 0.05$, respectively). Pathogen disgust revealed similar associations with the knowledge score in both the pre-test and post-test (partial $r = -0.13$ and -0.25, $p = 0.13$ and $p < 0.01$, respectively). This provides statistical support for Hypothesis 3.

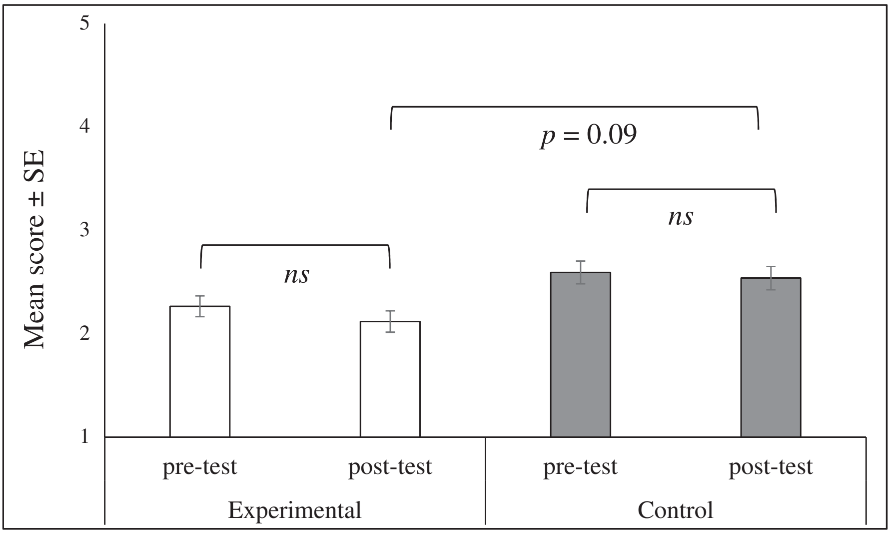

Figure 5. Mean animal disgust scores in the experimental and the control group.
Note: Comparisons are based on the Tukey *post hoc* test (ns = not statistically significant).

Drawings of snails were not influenced by animal disgust or by pathogen disgust (all correlations ranged between −0.09 and 0.13, all $p > 0.1$).

Discussion

Recent research indicates that hands-on activities in biology are recommended by scientists, because they have positive influences on children's attitudes towards science (e.g. Holstermann, Grube, and Bögeholz 2010; Prokop, Tuncer, and Chudá 2007; Prokop, Tuncer, and Kvasničák 2007) as well as on achievement (Dieser and Bogner forthcoming; Kamisah and Kaur 2014). Students who have limited opportunities to handle materials and engage in scientific activities may show lower achievement in science (StohrHunt 1996). An absence of handling living animals may further negatively influence the perception of slimy animals such as snails, which are important parts of natural ecosystems. This study investigated three hypotheses which suggested that hands-on activities with living snails enhance knowledge acquisition (Hypothesis 1) and decrease disgust (Hypothesis 2) and that disgust sensitivity negatively correlates with knowledge of snails (Hypothesis 3). All the hypotheses received statistical support.

Concerning Hypothesis 1, knowledge of snails measured with two independent methods (knowledge test and drawings) significantly increased after the treatment and this increase was significantly higher in the experimental group compared with the control group. This suggests that manipulation with live snails significantly contributes to better information retention compared with the control conditions. We suggest that knowledge acquisition was mediated by increased interest about living snails in the experimental group. In related research with harvest mice, Wilde et al. (2012) did not find any significant differences in knowledge acquisition between the experimental group with authentic learning experiences compared with the control group which was presented with short film clips on laptop computers. It is possible that short films had more positive effects on knowledge acquisition compared with traditional lessons that were treated as the control group in the present research. Overall, these results are in line with research showing that mere exposure to wildlife (e.g. contact with snakes or amphibians) can change children's knowledge positively (Morgan and Gramann 1989; Randler, Ilg, and Kern 2005; Tomažič 2008).

Children's ideas about the anatomy of snails significantly increased after hands-on activities with the live snail. We suggest that children were more motivated to learn about snails compared with children from the control group and this resulted in better drawing scores. Indeed, lower disgust scores could promote better learning (2012c; Holstermann, Grube, and Bögeholz 2009; Randler, Ilg, and Kern 2005). There is, however, one additional alternative that can explain better scores from drawings in the experimental group. Prokop et al. (2007) found that when pictures of animals (i.e. 2D representations) were used to examine children's ideas about what is inside animals, the mean scores of children's drawings were lower compared with children who were shown taxidermically prepared animals (i.e. 3D representations). We acknowledge that the results obtained here could be at least partly influenced by these influences; however, the knowledge scores obtained from the knowledge text were higher in the experimental group supporting a positive link between interests enhanced by hands-on activities and acquired knowledge.

Interestingly, although two independent methods for assessment of children's knowledge of snails were used (knowledge test and drawings) and both showed similar patterns with respect to the effects of treatment (the scores significantly increased in the experimental group), no correlation between them was found. Prokop and Fančovičová (2006) similarly failed to find any correlation between knowledge test scores and drawing scores when they investigated university students' ideas about the human body. It could be that drawings measure predominantly anatomical knowledge, while knowledge tests are more influenced by the researcher who developed them.

Certain researchers demonstrated that disgust or fear can be reduced after exposure to unpopular animals such as amphibians (Tomažič 2008), snakes (Ballouard et al. 2012, 2013; Morgan and Gramann 1989) or snails (Randler, Hummel, and Prokop 2012) (Hypothesis 2). Wilde et al. (2012) showed that after hands-on activities with harvest mice, children's interest/enjoyment, perceived competence, and perceived autonomy increased compared with the control group. We extend this knowledge by measuring pathogen disgust (Tybur, Lieberman, and Griskevicius 2009) which is a more general measurement of individual differences of pathogen avoidance. Both animal disgust, a measure which contained an item concerning specific disgust of snails, and pathogen disgust scores were lower in the experimental group compared with the control children. This suggests that exposure to live snails decreases disgust sensitivity in general, not only disgust towards a specific organism. Considering that disgust negatively influences people's willingness to protect animals (Jacobs et al. 2014; Prokop and Fančovičová 2013; Prokop et al. 2016) we recommend incorporating direct contact with live animals into conservation activities, if possible.

Our third hypothesis concerned the disgust–knowledge relationship. Randler, Ilg, and Kern (2005) found that increased boredom and anxiety correlated negatively with knowledge about amphibians amongst German children. Here we found that disgust (both animal and pathogen) showed an inverse relationship with the knowledge of snails score measured with the knowledge test. The emotion of disgust seems to be influential not only in terms of decreased learners' motivation or interest (Holstermann, Grube, and Bögeholz 2009; Holstermann et al. 2012; Randler, Wüst-Ackermann et al. 2012; Randler, Hummel, and Wüst-Ackermann 2013), but also negatively influences achievement. We hypothesise that, once again, children's interest may be a possible mediator of these relationships (Randler, Hummel, and Wüst-Ackermann 2013). High disgust may decrease children's attention and consequently the acquisition of any knowledge about the disgust elicitor.

To conclude, although snails are slimy and (therefore) disgusting animals, activities with them have an extremely positive impact on children's emotion and cognition. Exposure to live snails reduces disgust sensitivity and enhances learning in terms of information retention. Experiments with live snails need not be restricted to *A. reticulata*, but could be easily performed with different species of available snails. Of course, the welfare of living organisms should be a priority when planning activities with living animals.

Educational implications

- Snails can be easily handled and bred in a captive environment and, thus, are good candidates for simple observations in biology lessons.
- If snails with shells are used for observations, be very careful not to drop them, particularly from a high height.
- Manipulation with slimy, disgusting animals, such as snails, seems to reduce children's disgust sensitivity. This may consequently improve children's attitudes towards other, unpopular, but biologically important animals.
- Observations of living animals in the classroom enhance knowledge acquisition amongst children.
- Check regulations of your country about the breeding and keeping of snails given that some are prohibited in many countries.

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References

Ainley, M., S. Hidi, and D. Berndorff. 2002. "Interest, Learning, and the Psychological Processes that Mediate their Relationship." *Journal of Educational Psychology* 94 (3): 545–561.

Alsop, S., and D. M. Watts. 2003. "Science Education and Affect." *International Journal of Science Education* 25 (9): 1043–1047.

Ballouard, J. M., G. Provost, D. Barré, and X. Bonnet. 2012. "Influence of a Field Trip on the Attitude of Schoolchildren toward Unpopular Organisms: An Experience with Snakes." *Journal of Herpetology* 46 (3): 423–428.

Ballouard, J. M., R. Ajtic, H. Balint, J. Brito, J. Crnobrnja-Isailovic, E. L. Elmouden, M. Erdogan, et al. 2013. "Schoolchildren and One of the Most Unpopular Animals: Are They Ready to Protect Snakes?" *Anthrozoos: A Multidisciplinary Journal of the Interactions of People & Animals* 26 (1): 93–109.

Bergin, D. A. 1999. "Influences on Classroom Interest." *Educational Psychologist* 34 (2): 87–98.

Bixler, R. D., and M. F. Floyd. 1999. "Hands on or Hands off? Disgust Sensitivity and Preference for Environmental Education Activities." *The Journal of Environmental Education* 30 (3): 4–11.

Curtis, V., R. Aunger, and T. Rabie. 2004. "Evidence that Disgust Evolved to Protect from Risk of Disease." *Proceedings of the Royal Society B: Biological Sciences* 271 (Suppl_4): S131–S133.

Davey, G. C. L. 1994. "Self-reported Fears to Common Indigenous Animals in an Adult UK Population: The Role of Disgust Sensitivity." *British Journal of Psychology* 85 (4): 541–554.

Dieser, O., and F. X. Bogner. forthcoming. "Young People's Cognitive Achievement as Fostered by Hands-on-Centred Environmental Education." *Environmental Education Research*.

Fančovičová, J., P. Prokop, and A. Lešková. 2013. "Perceived Disgust and Personal Experiences are Associated with Acceptance of Dissections in Schools." *Eurasia Journal of Mathematics, Science & Technology Education* 9 (3): 311–318.

Holstermann, N., D. Grube, and S. Bögeholz. 2009. "The Influence of Emotion on Students' Performance in Dissection Exercises." *Journal of Biological Education* 43 (4): 164–168.

Holstermann, N., D. Grube, and S. Bögeholz. 2010. "Hands-on Activities and Their Influence on Students' Interest." *Research in Science Education* 40 (5): 743–757.

Holstermann, N., M. Ainley, D. Grube, T. Roick, and S. Bögeholz. 2012. "The Specific Relationship between Disgust and Interest: Relevance during Biology Class Dissections and Gender Differences." *Learning & Instruction* 22 (3): 185–192.

Jacobs, M. H., J. J. Vaske, S. Dubois, and P. Fehres. 2014. "More than Fear: Role of Emotions in Acceptability of Lethal Control of Wolves." *European Journal of Wildlife Research* 60 (4): 589–598.

Kamisah, O., and S. J. Kaur. 2014. "Evaluating Biology Achievement Scores in an ICT Integrated PBL Environment." *Eurasia Journal of Mathematics, Science & Technology Education* 10 (3): 185–194.

Morgan, J. M., and J. H. Gramann. 1989. "Predicting Effectiveness of Wildlife Education Programs: A Study of Students' Attitudes and Knowledge toward Snakes." *Wildlife Society Bulletin* 17 (4): 501–509.

NABT (National Association of Biology Teachers). 2005. Role of Laboratory and Field Instruction in Biology Education. NABT Position Statement. Accessed November 19, 2008. http://www.nabt.org/sites/S1/index.php?p=67
Prokop, P., and J. Fančovičová. 2006. "Students' Ideas about the Human Body: Do They Really Draw What They Know?" *Journal of Baltic Science Education* 5 (2): 86–95.
Prokop, P., and J. Fančovičová. 2013. "Does Colour Matter? The Influence of Animal Warning Coloration on Human Emotions and Willingness to Protect Them." *Animal Conservation* 16 (4): 458–466.
Prokop, P., and M. Jančovičová. 2013. "Disgust Sensitivity and Gender Differences: An Initial Test of the Parental Investment Hypothesis." *Problems of Psychology in the 21st Century* 7 (5): 40–48.
Prokop, P., and M. Kubiatko. 2014. "Perceived Vulnerability to Disease Predicts Environmental Attitudes." *Eurasia Journal of Mathematics, Science & Technology Education* 10 (1): 3–11.
Prokop, P., M. Prokop, S. D. Tunnicliffe, and C. Diran. 2007. "Children's Ideas of Animals' Internal Structures." *Journal of Biological Education* 41 (2): 62–67.
Prokop, P., G. Tuncer, and J. Chudá. 2007. "Slovakian Students' Attitude toward Biology." *Eurasia Journal of Mathematics, Science & Technology Education* 3 (4): 287–295.
Prokop, P., G. Tuncer, and R. Kvasničák. 2007. "Short-term Effects of Field Programme on Students' Knowledge and Attitude toward Biology: A Slovak Experience." *Journal of Science Education & Technology* 16 (3): 247–255.
Prokop, P., W. Medina-Jerez, J. Coleman, J. Fančovičová, M. Özel, and P. Fedor. 2016. "Tolerance of Frogs among High School Students: Influences of Disgust and Culture." *Eurasia Journal of Mathematics, Science and Technology Education* 12 (6): 1499–1505.
Randler, C., A. Ilg, and J. Kern. 2005. "Cognitive and Emotional Evaluation of an Amphibian Conservation Program for Elementary School Students." *The Journal of Environmental Education* 37 (1): 43–52.
Randler, C., E. Hummel, and P. Prokop. 2012. "Practical Work at School Reduces Disgust and Fear of Unpopular Animals." *Society & Animals* 20 (1): 61–74.
Randler, C., J. Osti, and E. Hummel. 2012. "Decline in Interest in Biology among Elementary School Pupils during A Generation." *Eurasia Journal of Mathematics, Science & Technology Education* 8 (3): 201–205.
Randler, C., P. Wüst-Ackermann, C. Vollmer, and E. Hummel. 2012. "The Relationship between Disgust, State-anxiety and Motivation during a Dissection Task." *Learning and Individual Differences* 22 (3): 419–424.
Randler, C., E. Hummel, and P. Wüst-Ackermann. 2013. "The Influence of Perceived Disgust on Students' Motivation and Achievement." *International Journal of Science Education* 35 (17): 2839–2856.
Rybska, E., S. D. Tunnicliffe, and Z. A. Sajkowska. 2014. "Young Children's Ideas about Snail Internal Anatomy." *Journal of Baltic Science Education* 13 (6): 828–838.
Schiefele, U. 1999. "Interest and Learning from Text." *Scientific Studies of Reading* 3 (3): 257–279.
StohrHunt, P. M. 1996. "An Analysis of Frequency of Hands-on Experience and Science Achievement." *Journal of Rearch in Science Teaching* 33(1), 101–109.
Thompson, J., and K. Soyibo. 2002. "Effects of Lecture, Teacher Demonstrations, Discussions and Practical Work on 10th Graders' Attitudes to Chemistry and Understanding of Electrolysis." *Research in Science & Technological Education* 20 (1): 25–37.
Tobias, S. 1994. "Interest, Prior Knowledge, and Learning." *Review of Educational Research* 64 (1): 37–54.
Tomažič, I. 2008. "The Influence of Direct Experience on Students' Attitudes to, and Knowledge about Amphibians." *Acta Biologica Slovenica* 51 (1): 39–49.
Tunnicliffe, S. D., and M. J. Reiss. 1999. "Students' Understandings about Animal Skeletons." *International Journal of Science Education* 21 (11): 1187–1200.
Tunnicliffe, S. D., and M. J. Reiss. 2001. "What's inside Bodies? Learning about Skeletons and Other Organ Systems of Vertebrate Animals." In IOSTE, Science and Technology Education: Preparing for Future Citizens, April 29–May 2. Vol. 2. 84–94. Paralimni, Cyprus.
Tybur, J. M., D. Lieberman, and V. Griskevicius. 2009. "Microbes, Mating, and Morality: Individual Differences in Three Functional Domains of Disgust." *Journal of Personality and Social Psychology* 97 (1): 103–122.
Uitto, A., K. Juuti, J. Lavonen, and V. Meisalo. 2006. "Students' Interest in Biology and Their out-of-school Experiences." *Journal of Biological Education* 40 (3): 124–129.
Wagler, R., and A. Wagler. 2012. "External Insect Morphology: A Negative Factor in Attitudes toward Insects and Likelihood of Incorporation in Future Science Education Settings." *International Journal of Environmental and Science Education* 7 (2): 313–325.
Wilde, M., J. Hussmann, S. Lorenzen, A. Meyer, and C. Randler. 2012. "Lessons with Living Harvest Mice: An Empirical Study of Their Effects on Intrinsic Motivation and Knowledge Acquisition." *International Journal of Science Education* 34 (18): 2797–2810.