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MENTAL REPRESENTATIONS OF PRESCHOOL CHILDREN ABOUT DIFFERENT ANIMALS

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Abstract. *Adequate mental representations of animals are important for children's personal development, because they result in their appropriate treatment of such animals, which would not, for example, compromise either animals' or children's safety. By using a convenient sample of 101 six- to seven-year old children, this research examined these representations regarding animals' names, feeding habits, body coverings, and dangerousness. The representations were assessed using a questionnaire referring to 18 animals, and the research focused on the frequency of correct responses and gender differences in these responses for each animal. It was found that whereas the naming of animals was very successful, the mental representations of animals' feeding habits and body coverings were less mature, including some misconceptions not found in previous studies. In addition, the participants' explanations about why animals are dangerous or harmless revealed that their mental representations about different animals were correct to a moderate degree. Finally, gender differences in the mental representations were almost missing. Some implications for school or kindergarten work with children are given (e.g., reducing misconceptions about and fear of some animals).*

Keywords: *didactically modeled activities, mental representations of animals, preschool children, preschool education.*

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Introduction

Adequate mental representations of animals are important for children's personal development (Geerdts, Van De Walle, & LoBue, 2016; LoBue, Bloom Pickard, Sherman, Axford, & DeLoache, 2013; Kubiatko, 2012). This is because these representations result in children's appropriate treatment of such animals, which would not, for example, compromise either animals' or children's safety. Let us give some examples. Cat can be cuddled, but the same act would hurt the butterfly. Dogs and bees may attack if they or their litters/hives are threatened in some way. If an animal is fed with the wrong food, its life may be threatened, which may result in its unwanted (and possibly dangerous) behavior. Clearly, as Kubiatko (2012) underlines, improved perceptions of animals would make the borderline between "good" and "bad" animals less strict.

Recent Findings

With regard to the distinction between "bad" and "good" animals, there seems to be a globally recognized interest in considering the origins of the human fear of and attitude towards animals (e.g., Prokop, Ozel, & Usak, 2009; Prokop, Usak, & Erdogan, 2011). This distinction seems to have its roots in the process of evolution and natural selection because animals that survived were those who managed to avoid or escape animals that might harm them. Furthermore, research has shown that respondents aged between one and three years paid more attention to animals when their parents were close than when their parents were absent (LoBue *et al*, 2013).

Regarding attitudes towards animals, several studies reported gender differences. For example, boys may like wild and exotic animals, whereas girls tend to prefer pets (Lindemann-Matthies, 2005). This general pattern is in accord with Hummel *et al.* (2015), who found that boys express more positive attitudes towards less popular animals such as bats, rats, and predators, whilst girls prefer squirrels, rabbits, and small birds. These differences may be explained by the fact that males have a tendency to take more risks than females, in order to display their physical abilities to them (Tomažič, 2011).

The attitudes and beliefs of adults with whom children are in regular contact have an impact on the formation of the attitudes and beliefs of children, in addition to content available to them through different me-

dia. During research of the types of causal explanatory information that commercial storybooks about animals provide children with, an almost exclusive focus on social-emotional experiences was noticed, as opposed to biological explanations. This may inadvertently encourage anthropocentric reasoning (Geerdts, Van De Walle, & LoBue, 2016).

Research has rarely examined the mental representations of preschool children about different animals. An exception is, for example, the research of Kubiatko (2012). He examined the perception of animals in 5- and 6-year old children and found that (1) children were able to distinguish between good and bad animals regarding appearance and fear, and (2) the influence of age and gender on children's answers was not found. His research evidences that children are indeed prone to divide animals into those that are good and those that are bad, or those that they are afraid of and those that they are not afraid of.

Theoretical Framework

Because studies on the mental representations of preschool children of different animals are quite rare, it is not clear which theoretical frameworks may support such studies. As these mental representations often reflect that animals' characteristics are linked through associative complexes, it seems that Vygotsky's (1962) approach to concept development may be appropriate. This approach, among other things, assumes that these complexes are building block for pseudo-concepts, which in turn support the development of genuine (scientific) concepts. This approach may, to some extent, be recognized in research studies that make use of precursor models, which are, in brief, cognitive entities with a limited number of elements and relationships compared with relevant scientific models (e.g., Ntalakoura & Ravanis, 2014; Ravanis, Christidou, & Hatzinikita, 2013). This comparison may remind the Reader of the distinction between mental models and conceptual models (Greca & Moreira, 2000), which would become more similar through carefully designed modeling activities. However, the approach that relies on the distinction between these and those models may not be appropriate for preschool children because their mental representations are still developing in the direction of (pseudo-)concepts. Note that the relevance of carefully designed modeling activities to conceptual change in general is also emphasized in Jonassen (2006). For example, children may be encouraged to examine an ant, butterfly or bee in a closed jar, or to learn about lions, snakes or penguins by using videos or computer animations, which would reduce or eliminate possible misconceptions, such as the penguin eats ice and its body is covered by fur, the ant eats soil, and butterflies have feathers.

Main Problem, Previous Findings, Possible Research Improvements, Research Questions

As the previous discussion evidenced, it is important to examine to what extent preschool children's mental representations of different animals are adequate, and whether there are some gender differences regarding these representations. As already mentioned, Kubiatko (2012) found that although 5- and 6-year children were able to distinguish between good and bad animals regarding look and fear, gender differences were not found.

To reduce the possible limitations of his research (a small sample and a small number of animals), this research used a larger sample and more animals, hoping to find gender differences as well. Furthermore, to understand its outcomes better, this research referred to Vygotsky's (1962) approach to concept development.

Having in mind the research context presented above, this research addressed the following two questions: (1) To what extent are preschool children's mental representations about different animals correct? and (2) Are there gender differences in these representations?

Methodology of Research

General Description

The representations studied in this research dealt with animals' names, feeding habits, body coverings, and dangerousness/harmlessness. These four issues were examined for each of eighteen animals included in the research. In addition, for each of the four issues, gender differences were considered for each of these animals. The research was done in the period of two months, between February and April 2016.

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Sample

This research used a *convenient* sample of 101 six- to seven-year old children: 55 girls and 46 boys. This sample came from three different kindergartens in Belgrade and may represent preschoolers of that age in large urban areas in Serbia. Regarding ethical issues, the author obtained relevant approvals for the implementation of this research and the use of the planned test from the responsible personnel in these preschool institutions. Although the questionnaire was administered through an interview with each participant, apart from recording the child's gender, other personal data were not collected.

Design and Variables

Because this research focused on correct responses and gender differences in these responses, it dealt with the percentages of correct responses (a frequentative design), and comparing those percentages for two groups (a factorial design).

This research used six binary variables: one independent and five dependent. The independent binary variable was *gender* (with values 1-boy, and 2-girl).

For each animal examined, five dependent binary variables were:

- *naming* (values: 1-correct, 0-incorrect or not known);
- *feeding* (values: 1-correct, 0-incorrect or not known);
- *covering* (values: 1-correct, 0-incorrect or not known);
- *dangerousness* (values: 1-dangerous, 0-harmless);
- *explanation* i.e. explanation of dangerousness/harmless (values: 1-correct, 0-incorrect or not provided).

Instrument and Procedure

To assess mental representations, this research used a questionnaire referring to 18 animals. These animals were (in the order of appearance in the questionnaire): cat, dog, fish, bird, lion, bee, butterfly, ant, spider, snake, bear, frog, goat, lizard, penguin, turtle, snail, and hedgehog. To be able to compare the results of this research with those of other research, the selection of animals was made according to previous research.

Next to the picture of each of these animals, a star was given. Children had to color each star depending on the animal's dangerousness (red for dangerous, or green for harmless). Furthermore, for each animal, each child had to answer questions regarding the animal's name, feeding habits, body coverings, and why he or she perceived the animal as dangerous or harmless. The administrator of this questionnaire was the author of this research, who, for each animal, wrote down the children's answers to these four questions.

The average duration of the interview with each child was 30 minutes, and appeared to be a quite demanding task for participants. To combine intellectual and fine motor activities, they were asked to color the star next to the picture of each animal while answering the questions asked by the researcher.

To enable children to concentrate enough and participate in this survey the best they could, the interviews were conducted from 9:00 AM to 11:00 AM. The research was done in the period of two months, between February and April 2016.

Because the participants were preschoolers, the administrator valued all correct answers respecting the child's age. For example, for the picture of a cat, both a cat and a kitty were considered as the correct answer. Similarly, for a dog, the administrator also accepted the answer "doggy" as correct. When the child stated the exact name of the breed shown in the picture, the administrator also accepted this name as a correct answer (e.g., dog – Alsatian). A random sample of the completed instruments was examined by a teaching assistant. Her scoring was almost identical to that of the administrator.

Research Results

The five figures below summarize the outcomes regarding the percentages of correct responses for each animal with respect to the five dependent variables name, feeding, covering, dangerousness, and explanation. For dangerousness, the relevant figure shows the percentage of children who indicated the animal in question to be dangerous.

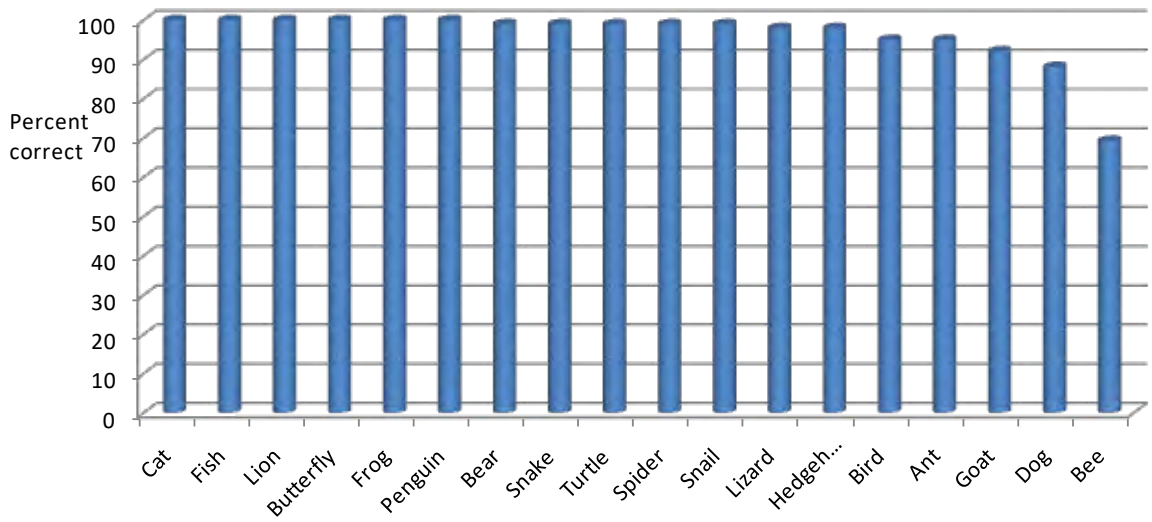

Figure 1: Percent correct for variable *name* (naming the animal correctly).

When the naming of animals is in question, the participants' mental representations about different animals were correct to a considerable degree. Apart from dog and bee, the participants named the remaining animals with a great success (at least 90% correctly). Gender differences were only found for *dog* (80.4%-boys, 94.5%-girls; $\chi^2 = 4.764$, $df = 1$, $p = .024$). The effect size (phi φ) was 0.22, or 0.54, when, instead of 1, the maximum possible correlation were used as the comparison standard as suggested by Breaugh (2003).

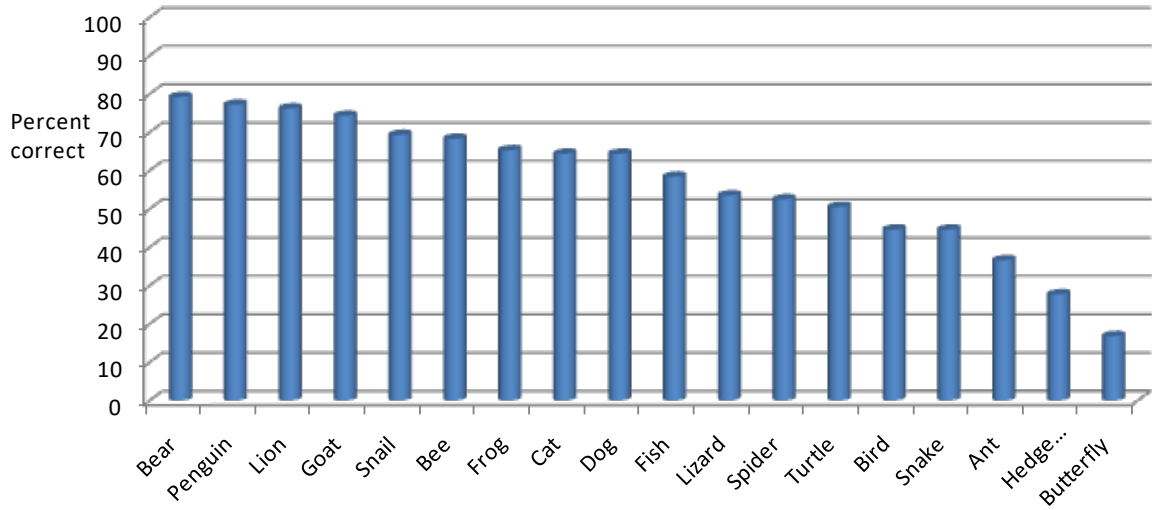

Figure 2: Percent correct for variable *feeding* (stating the animal's feeding habits correctly).

Regarding animals' feeding habits, the participants' mental representations about different animals were correct to a moderate degree (the mean percentage was 57%; the median percentage was 61%). Gender differences were only found for *bee* (78.3%-boys, 60%-girls; $\chi^2 = 3.859$, $df = 1$, $p = .049$; $\varphi = 0.20$, $\varphi_{corrected} = 0.26$), and *lizard* (67.4%-boys, 41.8%-girls; $\chi^2 = 6.584$, $df = 1$, $p = .010$; $\varphi = 0.26$, $\varphi_{corrected} = 0.26$).

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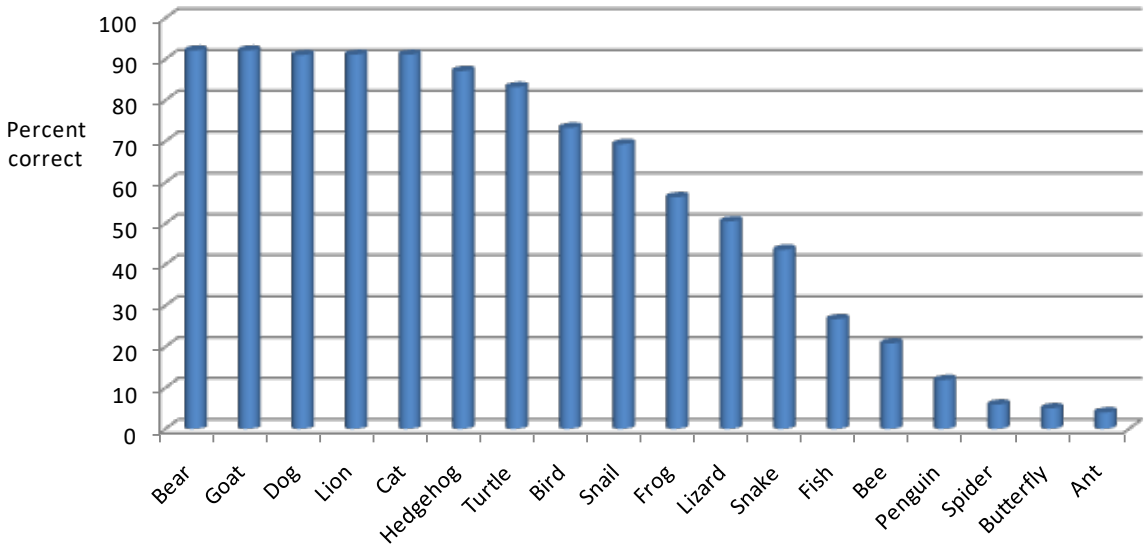

Figure 3: Percent correct for variable *covering* (stating the animal's body coverings correctly).

When an animal's body covering is considered, the participants' mental representations about different animals were correct to a moderate degree (the mean percentage was 55%; the median percentage was 63%). Gender differences were not found.

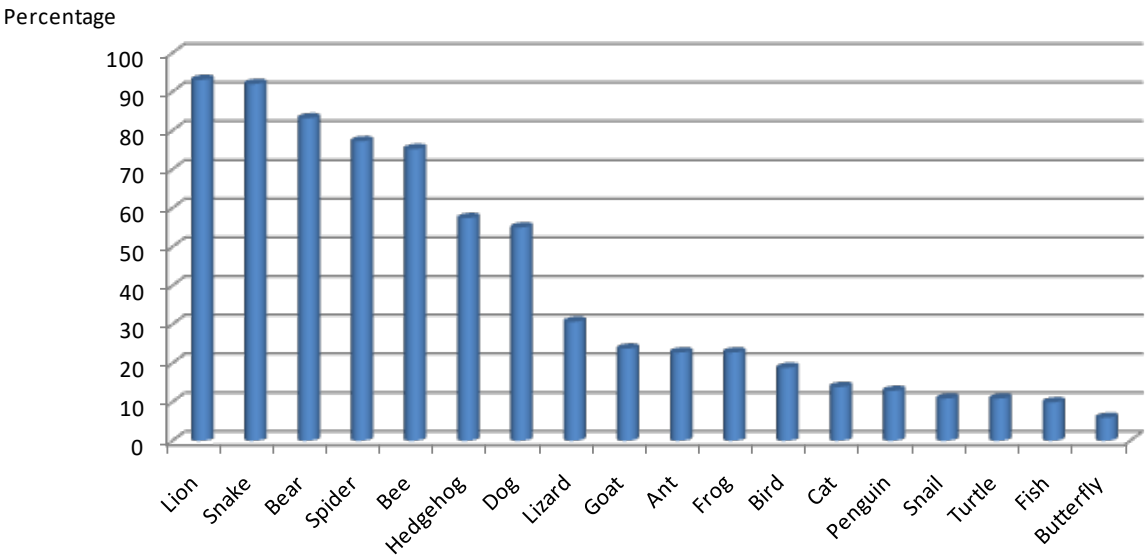

Figure 4: From dangerous to harmless animals: the percentage of children who indicated that animal was dangerous.

When animals' dangerousness was in question, the participants' mental representations about different animals evidenced, on average, rather a low level of dangerousness (the mean percentage was 40%; the median percentage was 23%). However, bee, spider, bear, snake, and lion were dangerous animals for more than two-third of the participants. Gender differences were only found for *lion* (87%-boys, 98.2%-girls; $\chi^2 = 4.893$, $df = 1$, $p = .027$; $\varphi = 0.22$, $\varphi_{corrected} = 0.74$).

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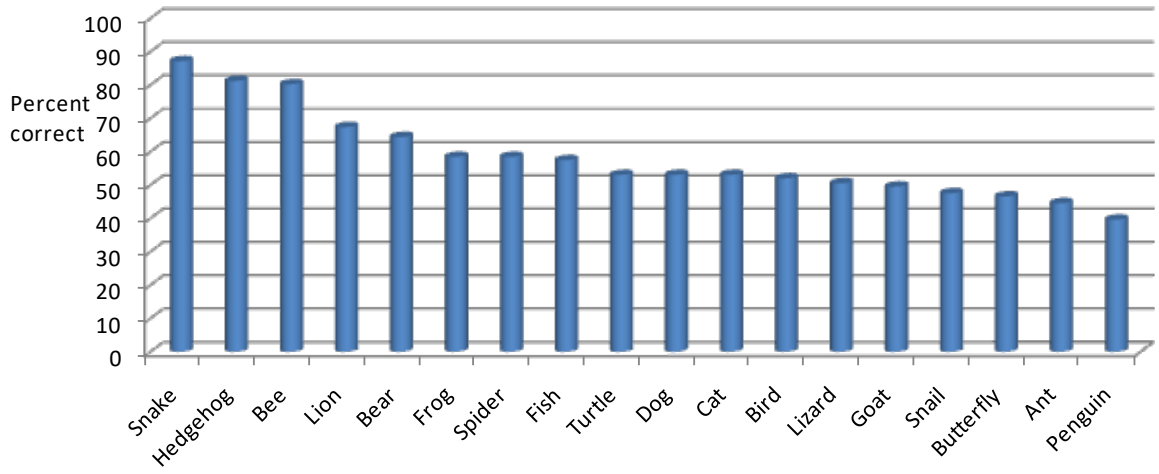

Figure 5: From correct to wrong explanation: percent correct for variable *explanation* (giving a correct explanation of the animal's dangerousness or harmlessness).

Considering the participants' explanations about why animals are dangerous or harmless, their mental representations about different animals were correct to a moderate degree (the mean percentage was 58%; the median percentage was 53%). Gender differences were only found for *spider* (69.6%-boys, 49.1%-girls; $\chi^2 = 4.323$, $df = 1$, $p = .038$; $\varphi = 0.21$, $\varphi_{corrected} = 0.22$).

Discussion

Naming Animals

As shown in Figure 1, several animals were named correctly by all children: cat, fish, lion, butterfly, frog, and penguin. For spider, snake, bear, lizard, turtle, snail, and hedgehog, the percentage of correct answers was 98% or 99%. Why was the percentage lower for some animals, such as ant (95%), goat (92%), dog (88%), and bee (69%)? The ant was imprecisely named by some children as "bug", and the goat was mainly confused with a sheep. Such responses could be attributed to the age of the respondents. Children were 6- to 7-years old and had not adopted a precise terminology. The respondents were members of an urban population of children, most of whom had not had the opportunity to see a goat or a sheep live. They also confused the two animals, because their color in the picture books is white. What surprised us was the poor recognition of the dog, which, like the cat, was an animal very close and well-known to them. Contrary to girls, a number of boys thought that the picture showed a wolf. Because of that, there were gender differences for dog (80.4%–boys, 94.5%–girls). The most poorly named animal was the bee, because a number of the respondents thought that a wasp was shown on the picture.

Despite a high percentage of correct answers, children's mental representations supporting the naming of animals were not fully developed. Due to their age, there was still no clear differentiation between a species and its breed, i.e. between the basic concept/level (e.g., it's a cat) and the subordinate concept/level (e.g., it's Persian). Because of that, we accepted as correct some answers referring to breeds instead of their species as expected. [For example, when the picture of dog was shown, children usually gave the answer *Alsatian* instead of *dog* (or *doggy* – also acceptable because of the respondents' age). For the picture of a bird, many children said that it was a parakeet, which indeed was the case.] Preschool children may prefer to label object at a particular level (subordinate: "it's Alsatian"), but, when suitable prompts are used, they may, as Waxman and Hatch (1992) found, label it at other levels as well (basic: "it's a dog"; superordinate: "it's an animal"). Because of perceptual similarities, children may spontaneously use one basic level instead of other (e.g., wasp instead of bee), or use a superordinate level (e.g., bug instead of ant), which may, in Vygotsky's terms (1962), be evidence of an associative complex, possibly supporting a pseudo-concept rather than a concept.

As in this research, the naming of different animals by 5- and 6-old preschoolers was successful in the research of

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Kubiatko (2012), who also reported labeling animals at different taxonomic levels than intended (e.g., cobra instead of snake). Possible reasons for this confusion, mentioned in the previous paragraph, may help us improve matters.

Animals' Feeding Habits

As shown in Figure 2, two-third of children knew what a bear, penguin, lion, goat, snail, and bee eat.

Just 17% of children knew what a butterfly eats. It was a surprise to see that dogs and cats were placed in the middle of the figure (their scores were 64%). Having in mind the measures of central tendency of percent correct (the mean percentage was 57%; the median percentage was 61%), it was clear that the responses of around 40% of the participants were incorrect. However, most of these responses, such as bee eats flowers, could not be classified as misconceptions.

Many children stated that a dog eats dog food, a cat eats cat food, or that these animals eat biscuits for dogs and cats. These responses were not evaluated as correct, because we expected children to name a specific kind of food, not focusing on cans or bags with food for pets. Interestingly, a similar situation occurred for bird and fish. Many children replied "bird food", and "fish food", which was also evaluated as incorrect. (Such interesting answers, probably not reported elsewhere, were obviously cased by a quite limited experience of children from urban areas.) When children gave such answers, these were registered, and they were then encouraged to give a concrete answer to what exactly cat / dog / bird / fish like to eat. If they then gave answers such as meat or mice, their answers were finally accepted as correct. Regarding misconceptions, some children thought that ant eats soil (about 7% of the participants), a penguin eats snow or ice (5%), an ant drinks people's blood (3%), and a spider eats its cobweb (3%). Although these misconceptions occurred rarely, they have not been, to the author's knowledge, reported in the literature so far. Regarding the misconception that ant drinks people's blood, a similar, more frequent misconception was found for older children elsewhere (e.g., bats' food is blood; Kubiatko & Prokop, 2007).

Research has usually described misconceptions about animals, and indicated their frequencies for particular groups of students. Little has been said, in general, about possible reasons for these misconceptions. Concerning misconceptions in biology in general, the reasons may be more psychological than biological in nature, although, when present, experience with live organisms may considerably affect children's knowledge (Prokop, Kubiatko, & Fančovičová, 2007). Because of a limited live experience with some organisms, the mental representations of some children were only partially developed, possibly being comprised of many associative complexes.

Regarding gender differences, only two were found: for bee (78.3%-boys, 60%-girls), and lizard (67.4%-boys, 41.8%-girls). As noted in Hummel *et al.* (2015), boys may have more positive attitudes towards less popular animals than girls. Because of that, an explanation for these differences could be that, when playing in nature, boys paid more attention to bees and lizards, thereby recognizing the feeding habits of these animals.

Animals' Body Coverings

The percentages represented on Figure 3 show that the participants knew best the body coverings of bear, goat, dog, lion, cat, hedgehog, and turtle. For each of these animals, the percentage correct was greater than 80%. The correct responses were low for fish (27%), and bee (21%), and very low for penguin (12%), spider (6%), butterfly (5%), and ant (4%). Surprisingly, when not sure about answer, most of the participants did not even try to guess at it, or offer an arbitrary answer.

The greatest number of mistaken answers was recorded for the body covering of penguins. Over a third of the preschoolers included in this research (35.6%) thought that the body of penguins was covered with fur. Similar, more frequent misconceptions about penguins were observed among primary school pupils, when as many as 75% of them, thought that instead of feathers, the body of penguins was covered with hair, or just bare skin (Kubiatko & Prokop, 2007). Another research revealed that "only 25% of children knew that the penguin's body is covered by plumage, not by hair (32%) or uncovered skin (43%)" (Prokop, Kubiatko, & Fančovičová, 2007; p. 398). The next frequent misconception of our preschoolers was that the body of a butterfly was covered with feathers. Such a response was given by about 7% of participants. Other misconceptions about the butterfly were that its body was covered with silk, fur, hairs, patterns, and stripes. Another typical misconception of our preschoolers was that the body of the goat was covered with wool. Approximately 6% of children gave that answer. Being unable to formulate an answer to the question about this animal's body covering, a number of the children tried to provide a response in the form of specifying a concrete color, stripes, or patterns. Overall, the participants' mental

representations about animals' body coverings were correct to a moderate degree. There was no animal for which gender differences in correct responses were present. Gender differences were also not found in the research of Prokop, Kubiatko, and Fančovičová (2007), who examined concepts about birds of children in grades 2–9.

Animal's Dangerousness / Harmlessness and Reasons for It

As shown in Figure 4, the butterfly was considered to be the most harmless of the animals given. Only 6% of our preschoolers considered it to be dangerous. On the other hand, a lion was considered to be the most dangerous of these animals. As many as 93% of our preschoolers thought that. A snake was the second most dangerous animal (92%), which coincides with a research on the attitudes of students towards snakes in Slovakia and Turkey (Prokop, Ozel, & Usak, 2009). Other more dangerous animals were the bear (83%), spider (77%), and bee (75%). Similar findings emerged in international studies involving preschoolers: children were most afraid of sharks, bears, snakes, and spiders (Kubiatko, 2012). In an earlier research on the fear of snakes, researchers found that human infants associate snakes with fear (DeLoach & LoBue, 2009). Note that gender differences were only found for *lion* (87%-boys, 98.2%-girls), meaning that boys were less afraid of this animal than girls; an expected outcome in the light of previous studies (e.g., Hummel *et al*, 2015; Tomažič, 2011).

As Figure 5 shows, our preschoolers were most able to explain why they think the snake is a dangerous or harmless animal (almost 90% of them). Their poorest verbalization and argumentation was found when explaining why a penguin was considered to be a dangerous or harmless animal (just 40% of them did it successfully). Children with a lower degree of information about individual animals, as well as less mature children usually explained that an animal is not dangerous *because it is good*. A number of children believed that the animal is not dangerous if it is small, and therefore ant, snail, and butterfly were marked as harmless animals. On the other hand, some animals were marked as dangerous if they perceived them to be horrible, as is usually the case with spiders. Some animals were also marked as harmless because the children felt that they were not close to them, and that these animals therefore could not hurt them. Some answers of this kind were: "fish cannot hurt us because it is under water, and we are on the surface", or "a penguin cannot hurt us because it lives far away, at the South Pole". Some children suggested that a bee's sting is dangerous, because it can cause an allergic reaction, and many respondents mentioned possible risks with a frog, recalling the fact that "there are poisonous frogs, and they are dangerous, and others are not". The children mostly had some conception regarding the dangerousness or harmlessness of an animal, but some of the respondents had a problem verbalizing the answer to this question. In such cases they often mentioned that "the animal is not dangerous because it is a pet, it is good, it only crawls, swims, flies..." Note that children's responses revealed that many of them were aware that some animals become dangerous when one touches them, because they defend themselves in that way. Overall, our preschoolers often interpreted the dangerousness or harmlessness of an animal by considering its size, movements, and habitat (e.g. cage, water, other continent). A similar augmentation, thought less diverse, can be found in Kubiatko (2012). In addition, regarding the danger of spiders, snakes, and frogs, the preschoolers were aware that there are certain poisonous specimens that pose a danger, whereas other, often-encountered specimens are harmless, and there is thus no need to fear of them. Gender differences were only found for *spider* (69.6%-boys, 49.1%-girls), which may be a sign that boys had more developed mental representations about spiders, probably because, as Hummel *et al.* (2015) suggested, their attitudes towards spiders were more positive than those of girls.

Implications for Practice

Small children initially name tiny animals, frequently insects, with the word "bugs". Based on their personal experience, they later notice animals' characteristics whereby they can call them bee, ladybird, ant, fly, spider. To develop adequate mental representations about animals, it is first important to name animals correctly. To attain this aim, children's personal experience with animals, gained in a family environment (usually through television, books, and the Internet; see Torkar & Mavrič 2016) should be coupled with didactically modeled activities in kindergartens, such as studying some animals using a magnifying glass, examining enlarged images and photos of animals, and making models of animals by using different materials. Secondly, these mental representations have to capture basic knowledge about the appearance of animals and their feeding habits. To improve children's mental representations and correct possible misconceptions, the didactically modeled activities based upon group discussions should start from individual children's ideas (possibly incomplete or wrong in our view). "It is better if

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teachers have to guess what the children think than vice versa" (Haglund, Jeppsson, & Andersson, 2012; p. 754). Furthermore, for a desired conceptual change, as Allen underlines (2015), some scientific ideas should be seeded at the earliest years of formal education (e.g., during the last year in kindergartens in our case), focusing on the relation between perceptual and conceptual issues, and modeling these issues in practical and formal terms (Gelman, 2004).

A fear of or feelings of disgust and discomfort toward certain animals is another factor that can interfere with developing mental representations about different animals. It is thus important to discover the cause of children's fears. It is necessary to provide the relevant information about the animal, to explain and, if possible, personally demonstrate which behavior towards it is appropriate and which behavior is not. We should bear in mind that children often imitate their peers, and because of that, if we have in a kindergarten group a child who is, for example, afraid and panics when s/he spots a bee, there is big chance that we will soon notice more peers with similar behavior. It is thus necessary to create activities that include closer observations of bees, or other animals perceived in that way. It is appropriate, for example, to make parallels between the organization and group work of bees and these of children in the kindergarten. Modeling bees with play dough and placing them on paper flowers, or making and playing with a honeycomb made of cardboard would reduce child's fear to some extent. Watching a video on how bees gather nectar and pollen allows children to see the life of bees from a safe position. A teacher's explanation of the situations when a bee may sting a child and what should be done if this happens would result in a more adequate relationship with this animal, unburdened by stress and fear. For didactically modeled activities about spiders and other animals, see Tytler, Haslam, and Peterson (2015), for example. Teachers should not forget that when unencumbered by fear, a child has better attention and can recognize more similarities and differences between animals, and the main characteristics of particular species, as well as detect and adopt typical patterns of adequate behavior with animals.

Conclusions

Apart from the very successful naming of animals, the participants' mental representations about different animals with respect to the animals' feeding habits, body coverings, as well as the reasons why animals are dangerous or harmless, were correct to a moderate degree, which is in line with other studies. However, because this research used a larger sample, children's misconceptions and the arguments for animal's dangerousness or harmlessness were more diverse, resulting in some responses that have not, to the author's readings, been reported in the literature so far. For example, dog eats dog food, ant eats soil, and a goat's body is covered with wool. Furthermore, there were responses that described an animal's dangerousness or harmlessness in terms of its size (e.g., "small animals are less dangerous"), movements (e.g., "it only crawls"), and habitat (e.g., "it is under water, we are on the surface"). Although some gender differences were found and their effect size was not small, apart from these for lion (more dangerous for girls than boys), other differences may not be considered as general patterns. Note that significant gender differences were found in just five of ninety 2 x 2 tables considered.

It is true that children have a direct knowledge of some animals (e.g., dog, cat), and an indirect knowledge of other animals (e.g., penguin, lion). Because of that, it may be objected that on the basis of the children's familiarity with them, this research could divide animals examined into two groups and compare the participants' responses. This objection, which indicates a possible limitation of this research, is not relevant, however. As shown on the five figures given in the Results section, familiar and unfamiliar animals are mixed (not grouped as may be expected), which suggests that the distinction familiar/unfamiliar may not be of general nature.

As discussed above, preschoolers' mental representations of animals are important for children's personal development, and they can be developed towards actual scientific models by using a range of didactically modeled activities in kindergartens. Research may thus focus on designing and sequencing these activities. Because possible reasons for children's misconceptions are still largely unknown, research may focus on these reasons, which would, when better known, promote more adequate didactically modeled activities.

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