TECHNICAL COMMENT

EVOLUTIONARY COGNITION

Comment on "Ducklings imprint on the relational concept of 'same or different'"

Jan Langbein[1]* and Birger Puppe[1,2]

Martinho and Kacelnik (Reports, 15 July 2016, p. 286) reported that newly hatched ducklings imprinted on relational concepts. We argue that reanalyzing the data at the individual level shows that this conclusion cannot be applied for all sets of stimuli presented and that the ability to grasp relational concepts is limited to the stimulus category that is most beneficial for survival.

Martinho and Kacelnik (*1*) presented a set of learning experiments in newly hatched mallard ducklings using the imprinting phenomenon and concluded that ducklings are able to learn and transfer the relational concepts "same" and "different" using three-dimensional (3D) objects identical or different in shape or color. While acknowledging the innovative elegance of their applied procedure, we nevertheless criticize the determination of preferences in the test at the individual level, which might lead to overestimation of the strength of the conclusions regarding the generalization and/or interpretation of the ducklings' assumed cognitive abilities.

The study of higher-learning problems in ducklings, in addition to previous investigations of relational concept learning in different primate and bird species, is appropriate for a variety of reasons. A large part of the fundamental work on imprinting has been conducted in ducks. For comparative reasons, it is of interest to investigate learning and cognitive abilities not only in "show species" of cognitive science (e.g., primates, crows, and dogs) but also in other species, including domesticated animals, which, in contrast to earlier belief, have recently been shown to possess developed cognitive abilities (*2*–*5*). Martinho and Kacelnik exposed newly hatched ducklings in the imprinting phase to a circularly moving pair of 3D objects either identical in shape and color or different in one of these features. Later in the test, each duckling was confronted with two pairs of novel stimuli, either identical or different in one dimension—shape or color—to the originally trained set. The results presented for approach behavior indicated that, independent of whether the ducklings imprinted on identical or different sets of shape or color, they preferred the related set of novel stimuli in the test. The authors concluded that because the accuracy of the ducklings was equally or even better than that of primates or birds in complex discrimination tasks on relational learning, using the imprinting paradigm demonstrates that ducklings are able "to pick up abstract relational properties between elements of their sensory input and those elements' characteristics."

However, a serious problem in the study is the determination of the preference on the individual level in the test. Martinho and Kacelnik noted that the study considered "ducklings exhibiting more than 50% of approaches to one stimulus scored as having preferred that stimulus" [p. 5 of supplementary materials for (*1*)]. Hence, they scored a duckling that approached one set of stimuli four times and the other three times in the test period as showing a preference for the first set [further examples of preference determination: 44 versus 43; 38 versus 37; 4 versus 2; see supplementary materials for (*1*)]. We consider this to be incorrect. In fact, for many ducklings, the distribution of approach behavior is simply random and provides no information about real preferences. To demonstrate that single ducklings have a preference for one set over another, individual approach behavior must be tested using the binomial (sign) test (*6*, *7*).

We have recalculated the approach behavior for all individuals in both experiments (shapes and colors) and both experimental groups (same and different) using the binomial test. The results are given in Fig. 1. The number of ducklings showing a significant preference is much lower in the shapes condition (N = 32) (Fig. 1A) and the colors condition (N = 50) (Fig. 1B) compared with the numbers given by Martinho and Kacelnik (N = 47 and N = 66), because a large number of animals with ambiguous preference were excluded in our analysis. However, in the shapes condition, 23 ducklings preferred the pair of stimuli bearing their imprinted shape relation (two-tailed binomial test, P = 0.020), thus mirroring the results in Martinho and Kacelnik. However, in the colors condition, only 30 ducklings preferred the set of stimuli related to the imprinted one, which is no longer significant at the group level (P = 0.203). Thus, based on the recalculated data, the authors' conclusion is valid only for the shapes condition.

Thus far, domestic fowl have been shown to have tetrachromatic color vision (*8*), with color discrimination abilities comparable to those of humans (*9*). Railton *et al.* (*10*) demonstrated that adult hens are able to learn a color discrimination task quickly but had difficulty in a shape discrimination task. These results suggest that adult chickens rely more on color than shape to discriminate stimuli in the natural world. However, the situation in mallard ducklings might be different from that in adult chickens. Mallard ducks are diurnal and nocturnal, whereas chickens are diurnal (*11*). In the retina, cones for brightness and color vision and rods for noncolored mesopic vision are both abundant, indicating good night

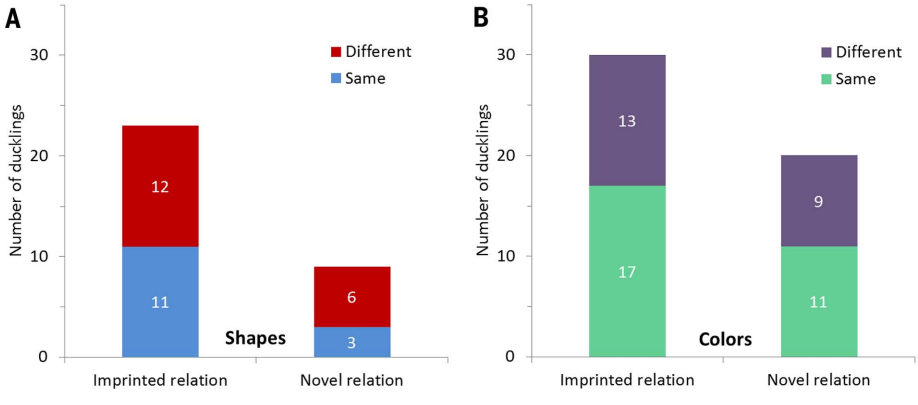

Fig. 1. Ducklings' preference for imprinted relational concepts. (**A** and **B**) Recalculation of the data of Martinho and Kacelnik shows that the relational hypothesis is more strongly supported in relation to shape (A) than color (B). The numbers in the bars give the number of ducklings showing a significant preference for that set of stimuli in the different experiments (shapes or colors) and experimental groups (same or different).

[1]Institute of Behavioural Physiology, Leibniz Institute for Farm Animal Biology, D-18196 Dummerstorf, Germany. [2]Behavioural Sciences, Faculty of Agricultural and Environmental Sciences, University of Rostock, Germany.
*Corresponding author. Email: langbein@fbn-dummerstorf.de

vision (*12*). Ducklings hatch at any time of day and night, with a maximum between 9:00 a.m. and 3:00 p.m. (*13*). One can conclude that imprinting not only occurs during daytime but also when brightness is low, and that color is not a salient stimulus for learning about the mother and siblings. Thus, it might make biological sense that shape has a higher evolved valence than color as the critical stimulus dimension for imprinting under natural conditions. For young precocial birds, the reliable identification of varying shapes as mother and siblings under difficult environmental conditions seems to have priority over the different sensory inputs perceived. Hence, we argue that the ability of newly hatched ducklings to understand relational properties is limited to the stimulus category that is most beneficial for survival.

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