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Object categorization by wild ranging birds—Winter feeder experiments

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A B S T R A C T

The object categorization is only scarcely studied using untrained wild ranging animals and relevant stimuli. We tested the importance of the spatial position of features salient for categorization of a predator using wild ranging birds (titmice) visiting a winter feeder. As a relevant stimulus we used a dummy of a raptor, the European sparrowhawk (*Accipiter nisus*), placed at the feeding location. This dummy was designed to be dismantled into three parts and rearranged with the head in the correct position, in the middle or at the bottom of the dummy. When the birds had the option of visiting an alternative feeder with a dummy pigeon, they preferred this option to visiting the feeder with the dummy sparrowhawk with the head in any of the three positions. When the birds had the option of visiting an alternative feeder with an un-rearranged dummy sparrowhawk, they visited both feeders equally often, and very scarcely. This suggests that the titmice considered all of the sparrowhawk modifications as being dangerous, and equally dangerous as the un-rearranged sparrowhawk. The position of the head was not the most important cue for categorization. The presence of the key features was probably sufficient for categorization, and their mutual spatial position was of lower importance.

1. Introduction

The study of the process of object recognition and categorization (based primarily on experiments using operant conditioning) differs in the understanding of the importance of the correct spatial constellation of particular components of the visual stimulus. Theory formulated by Biederman et al. (1987) presupposes that every object is composed of simple components, called geons, and that these components form the whole shape. Simultaneously, different arrangements of the same components can produce different objects (Biederman et al., 1987). This suggests that the correct mutual spatial orientation of geons is essential for successful categorization.

At the same times, Cerella (1986) proposed that birds (in the experiments, pigeons (*Columba livia*)) categorize objects by the perception of particular details of the object. This theory suggests that there are several simple features that birds recognize and use them in the categorization of all objects. The results of Cerella's experiment showed, that categorization performed by pigeons is based on the presence of simple features and that their mutual spatial orientation has only a low impact on the correct categorization. This theory was further confirmed in other Cerella's experiments (1977, 1979, 1980) and later updated in a study with humans, showing that there are informative fragments of intermediate complexity in the image/object that are necessary and sufficient for object categorization (Ullman et al., 2002).

Nevertheless, more studies using the object categorization in trained (using operant conditioning) pigeons show that a successful categorization of the visual stimuli demanded not only the presence of the most important features of the object, but also the concurrent presentation of such features in the correct position (Kirkpatrick-Steger et al., 1996, 1998; Matsukawa et al., 2004; Van Hamme et al., 1992; Wassermann et al., 1993).

All the above mentioned studies used simple visual stimuli (mostly contour drawings), which were supposed to be of no relevance to the tested pigeons (abstract stimuli). Another study attempting to asses the importance of the spatial position of the components of visual stimulus in categorization using more complex stimuli (Watanabe 2001) showed that the position of the characteristic features of the object is more important when a very complex visual stimulus (photograph) is present. The authors suggest that the tested pigeons were able to identify the real objects (people, pigeons) on the photographs, and, therefore, were more sensitive to the accurate spatial arrangement of such objects.

Moreover, the methods used may also affect the importance of the spatial position, as the motivation of tested animals may differ. Cerella (1979, 1980) used go/no go procedure, which rewards only the correct response to the positive category while the correct response to the negative category – non-pecking – is not rewarded. This can lead pigeons to respond to the novel stimuli as if they were positive, because there is at least a chance of some reward. Wasserman et al. (1993), and other studies proving the importance of the position of the salient features (Kirkpatrick-Steger et al., 1996, 1998; Van Hamme et al., 1992) used a

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4-alternative forced-choice procedure which provides four clearly defined categories with shared sign stimuli which are rewarded equally. This arrangement forces the tested pigeons to respond more precisely and we can consider the results of this approach to be more robust (Bhatt et al., 1988).

The results of the Watanabe study suggest that in the wild, where birds are confronted with real, usually familiar objects with certain relevance to them (food, mates, and predators), the spatial orientation of particular object components should be of high importance. Nevertheless, the first studies using untrained birds suggested rather the opposite. Classical ethological school recognized a term sign stimulus (Tinbergen 1948) describing a single, important feature of each relevant object that releases the behavioural response (also known as a "releaser" – Lorenz 1937). Examples of such features can be a characteristic colouration causing males to fight (Lack 1943) or engage in courtship (Tinbergen 1948) and chicks to beg for food (Tinbergen 1951), or a characteristic shape of the flight silhouette causing birds to flee to a shelter (Goethe 1937, 1940; Krätzig 1940; Lorenz 1939). The object carrying this feature can be significantly changed and still release the proper response provided the feature is present (Lack, 1937). Therefore, the simple presence of such a salient feature is sufficient for a proper categorization.

Nevertheless, more recent behavioural studies have shown that such features do not work universally. Curio (1975) showed that predators may be categorized based on the presence of a typical element of colouration; nevertheless, when this element is moved to an improbable position the predator is no longer categorized. Similarly, more recent studies testing the effect of the characteristic colouration of the underparts of the predator (European sparrowhawk – *Accipiter nisus*) or a nest parasite (European cuckoo – *Cuculus canorus*) on the categorization of them by their avian prey/hosts suggested that its presence improves the ability of categorization; nevertheless, this feature is expendable to some degree (Trnka and Prokop 2012; Trnka et al., 2012; Welbergen and Davies, 2008, 2011).

We decided to follow the study using the operant conditioning protocol and transfer its methods (used stimuli) to the research of behavioural ecology. Already two decades before, behavioural ecology was predicted to be one of the future directions of the research of animal cognition (Balda et al., 1998). Though, experimental studies using untrained birds are still very scarce and usually following the skinner-box procedure (Shimizu 1998; Patton et al., 2010). We decided to repeat the experiment of Cerella (1979), who presented to pigeons a line drawing stimulus, the cartoon character of Charlie Brown, horizontally split into three parts and scrambled. To be able to obtain measurable responses from untrained birds, we followed the experimental protocol of Tvardíková and Fuchs (2011) presenting predators (relevant stimuli) to birds visiting a winter feeder.

The stimulus used was a dummy of a European sparrowhawk, split into three parts and scrambled (Fig. 1). This dummy was presented at the feeder, and the number of birds visiting this feeder was used as a measure of the level of fear caused by such a predator. To be able to measure the threat represented by the modified stimulus, we used a two feeder arrangement. At the first feeder, there was a scrambled sparrowhawk, and at the other (within the view of present birds) an unchanged sparrowhawk or a control pigeon dummy were placed.

We tested the hypothesis that a sparrowhawk with scrambled body parts is not categorized as threatening. This hypothesis predicts that the numbers of birds visiting the feeder with the sparrowhawk having its head in an incorrect position and the numbers of birds visiting the feeder with the pigeon would not differ. And further, the number of birds visiting the feeder with the scrambled sparrowhawk having its head in an incorrect position would be higher than the number of birds visiting the feeder with an unmodified sparrowhawk.

Fig. 1. Dummies presented at the prime feeder, scrambled sparrowhawk. TOP – scrambled sparrowhawk dummy with the head part on the top (correct position), MIDDLE – scrambled sparrowhawk dummy with the head part in the middle, BOTTOM – scrambled sparrowhawk dummy with the head part on the bottom.

2. Material and methods

2.1. Experimental site and species

The experiment was conducted during the winter 2013/2014 in mixed forest near the town of Strunkovice nad Blanicí, South Bohemia, Czech Republic (N 49°4'14.451", E14°3'24.297", 458 m above sea level). There was one pair of feeders, at which all experiments were conducted. The two feeders were placed on the edge of forest consisting of spruce (*Picea abies*) with a smaller proportion of pine (*Pinus sylvestris* L.), beech (*Fagus sylvatica*), and oak (*Quercus petraea*). They were situated at the edge of a big thicket of blackthorn (*Prunus spinosa*) in which the birds rested. We used two identical feeders in our experiment. Feeders were made from a wooden frame with dimensions of 50 × 50 centimetres and were placed at least two metres from the thicket and approximately 20 m apart. Apart from during the experiments, the feeders were supplied with sunflower seeds. During the experiments all the sunflower seeds were removed and mashed walnuts were introduced to force the birds to collect small samples of food and spend more time at the feeder, which reinforces their vigilance and fear levels (Tvardíková and Fuchs, 2011).

Despite the fact that numerous species of birds visited the feeder, arrival data from only the four most abundant species were used: the great tit (*Parus major*), blue tit (*Cyanistes caeruleus*), and "Poecile spp" tit, which was represented by the willow tit (*Poecile montanus*) and marsh tit (*Poecile palustris*) – as these two species are indistinguishable on video (as each visit was too short and no recorded voices were available), they were lumped together.

2.2. Dummies

Three types of dummies were used in the experiment. The first dummy was the European sparrowhawk divided horizontally in three parts (head/breast, belly/shoulders, and tail/legs). The scrambled sparrowhawk dummy was presented in three positions: one with the head in the correct position, one with the head in the middle of the dummy, and one with the head at the bottom of the body (Fig. 1). These combinations were selected (out of the six possible) to focus on the importance of the position of head, carrying the most conspicuous features (beak, eyes). The other two parts (belly and tail) were always attached together in a correct mutual position.

Besides this dummy, there was a threatening control (a complete dummy of a sparrowhawk) and a non-threatening control (an intact