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Domestic hens have declarative representations

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Abstract It is generally considered that information can be stored either as a procedural or as a declarative representation. A devaluation technique was used to determine whether hens have declarative representations. Individual hens (*Gallus gallus domesticus*) were fed in an enclosure with two containers, each with a new food type. One of the food types was devalued by pre-feeding with that food, after which the hens were tested with empty food containers. The pre-feeding should only affect the choice of the hens if they have learned where a particular food type was (declarative representation) rather than "go left when coming into the enclosure" (procedural representation). A significant proportion of the hens went to the location previously occupied by the non-devalued food (seven out of eight). This supports the hypothesis that domestic hens can form declarative representations.

Key words Cognition · Chicken · Hen · Declarative representation

Introduction

There are two ways in which learned information can be stored, as a procedural representation or as a declarative representation (Bolles 1972; Dickinson 1980; Dickinson and Balleine 1994). Procedural representations can be likened to a set of instructions that are initiated by a given stimulus. The animal simply reacts to a stimulus without knowing anything about the consequences of that reaction. Behavior governed by procedural representations can therefore not be said to involve a goal-representation (McFarland 1989). Declarative representations on the other hand contain more general information about the relationships between events in the animal's world which is not directly linked to any given situation. This general information can be used to take a decision. When an animal is using a declarative representation it can change the response to a given stimulus in a flexible way compared to when it is using a procedural representation. Indeed, using a flexible representation, it is possible to take functional decisions under completely new circumstances which the animal has never experienced before.

Studies of declarative representations have mainly been done on rats (e.g. Holland and Straub 1979; Adams and Dickinson 1981; Colwill and Rescorla 1985). Despite a general agreement that information about the cognitive capabilities of farm animals is important (Fraser and Broom 1990; Toates 1986) little is known about the cognitive powers of farm animals in general and the domestic hen in particular (Rogers 1995; but see Regolin et al. 1995; Regolin and Vallortigara 1995).

Knowledge about the cognitive abilities of farm animals influences how we handle their welfare for three reasons. Firstly, it is possible to imagine situations that an animal will interpret in different ways depending on its cognitive ability, i.e. situations in which some animals may suffer while others do not. Secondly, many of the tests used to determine the preferences of animals depend on their cognitive ability (Toates 1986). Thirdly, the public's perception of which animals deserve most to be protected depends at least partly on the perceived level of cognition of that species (e.g. Singer 1976).

In this study a devaluation technique based on specific hungers was used to determine whether hens are capable of forming declarative representations. Individual hens were fed in an enclosure that had two food containers, each with a new food type. Before the test, the hens were pre-fed in cages (placed in a third room) with one of the two food types. The pre-feeding should satiate their hunger for that food type and thus devalue that food type (Balleine and Dickinson 1998). The hens were then tested

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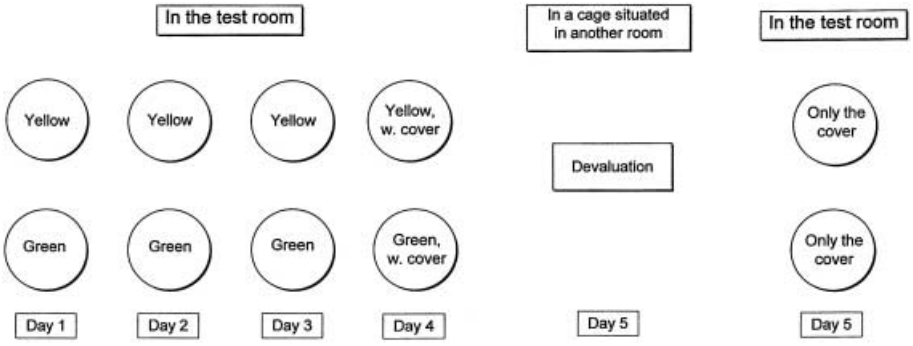

Fig. 1 The experimental protocol. The first 3 days are training days with food available in the dishes. On day 4 the food was partly covered with strips of paper. On the test day, day 5, the birds were first food-deprived, then given one of the two food types to eat for 30 min, after which they were given access to the test enclosure. The food sources did not contain any food but were completely covered with paper strips

in the enclosure in which the two empty food-sources had been covered by paper towels.

The pre-feeding should only affect the choice of the hens if they have learned the location of a particular food type (a declarative representation) rather than "go left when coming into the enclosure" (because in the past it has led to more pleasurable consequences when they have gone left instead of right; procedural representation).

Methods

Ten adult domestic hens (*Gallus gallus domesticus*) were used. The animals were habituated to the experimental set up for 3 days, each hen being put into the experimental enclosure (1 × 2 m) for 30 min per day. During the habituation period the enclosure contained only sawdust.

During the training phase of the experiment the animals were put individually into the enclosure for 15 min per day for 4 days. The enclosure now contained two identical food dishes, one at each end of the enclosure. In each food dish there was one of two types of food, both of which were completely new to the animals at the start of the experiment. Each type of food was always in the same location for the same hen, but balanced between hens (Fig. 1). The hens were placed facing away from the food at the third point of an isosceles triangle between the two food sources.

The two types of food used were green rice flavored with almond essence and yellow rice flavored with banana essence (both colors and flavors from Sainsbury's Supercook range, approximately 10 ml of color and 5 ml of flavor to 100 cl dry rice). Boiling water was mixed with the color and flavor, it was then poured over the rice, which was allowed to stand for 3 h which allowed the rice to become soft without being sticky.

On the test day the approach to and pecking at the food dishes was to be registered. To prolong the time spent investigating the food dishes they were to be presented empty but covered with paper strips. To accustom the birds to the paper strips, the food dishes containing rice were partially covered with paper strips on the last day of the training (Fig. 1).

On the test day, the first day after the training phase, the hens were first food-deprived for 4 h and then pre-fed. The pre-feeding took place in cages which had been placed in a new room, separate from both the experimental room and their home pen. The pre-feeding was done to devalue one of the food types (Kushner and Mook 1984; Balleine and Dickinson 1998). For five birds the green rice was devalued and for five birds the yellow rice. The rice to be devalued for each bird was chosen so as to minimize the difference in mean intake between the two rice types. The mean intake during training was 23.2 g (SE 7.9) for the food they were to be pre-fed with, i.e. the food they were expected to avoid after the devaluation. The consumption of the other food type was 16.8 g (SE 4.9). This difference was not significant ($P = 0.56$, Student's *t*-test).

The hens were then taken to the test enclosure in which the two empty food dishes (that had previously contained the two types of rice) had been completely covered by paper strips. The approach (head less than 10 cm from either food dish) and pecks directed at the different food dishes was noted. The test session lasted for 5 min.

Results

During the test two hens escaped repeatedly from the enclosure, without ever having approached any of the food locations. These have therefore been excluded from the results.

The mean intake of the food the hens were later to be pre-fed with, i.e. the food they were expected to avoid after the devaluation, was 23.2 g (SE ± 7.9). The corresponding amount eaten of the other food type was 16.8 g (SE 4.9).

Seven of the eight hens approached the place where the food with which they had not been pre-fed had been previously placed (binomial test: $n = 8$, $P = 0.035$, one-tailed). Six of the hens pecked at the paper towels, five of these did so at the place that had contained the non-pre-feeding, i.e. non-devalued food (binomial test: $n = 6$, $P = 0.11$, one-tailed). This supports the hypothesis that domestic hens can have declarative representations.

Discussion

The results show that the hens know where each type of food is in the experimental enclosure, i.e. they have a declarative representation, a cognitive map, of the enclosure with its content. Declarative representations have only been demonstrated in a small number of species and have never before been shown in the domestic hen. They have however been previously observed in the scrub jay (Clayton and Dickinson 1998).

A similar phenomenon, object permanence, has previously been shown in chicks (Regolin and Vallortigara 1995; Vallortigara et al. 1998) and in a number of species of parrots (Pepperberg and Funk 1990). In studies of object permanence the animal or child is presented with the problem of finding a given object that might be partially or totally hidden, visibly or invisibly displaced. The

chicks studied by Regolin and Vallortigara did show object permanence of stage 4 (Piaget 1955), that is, they were able to find an object that was hidden from view. For full object permanence to be shown however, an animal has to solve stage 6 problems, which involve invisible displacement.

Object permanence experiments show whether animals can remember where something is, even when it is not visible, and it is considered to be a prerequisite for anticipatory or insightful behaviour (Etienne 1984). These studies do not show that the animals know what that something is, however, only that it is something desirable. Devaluation studies differ from studies of object permanence in that devaluation studies set out to specifically test whether a given "object" is encoded as an object or as a hedonic value.

The finding that declarative representations exist in galliform birds offers the possibility that they exist in many other species as well.

The present study has implications for the considerations of welfare for domestic poultry. Many scientists (e.g. Duncan and Petherick 1991) have maintained that the welfare of animals is based on the subjective experiences of the animal. That is, if the animal feels that its welfare is compromised then so it is, irrespective of any "objective measurement". Understanding the ways in which the animal can represent its environment will therefore be of prime importance.

Dawkins (1980) went even further, stating that "What is much more clear cut, however, is the connection between conscious awareness and the ability to suffer. To say that an animal suffers implies that it is aware of its suffering..." (Dawkins 1980, p. 24). McFarland (1989) has argued in a similar way that on evolutionary grounds that it is not probable for an animal to have the capacity to suffer unless it has the ability to form declarative representations. "...suffering is not a concept that is necessary for explaining the behaviour, because in each particular case the animal has a ready and automatic response, or is able to quickly learn an appropriate response. The animal responds on the basis of procedural rules which are either innate or acquired by simple conditioning." (McFarland 1989, p. 39).

In conclusion, the present experiment shows that domestic fowl can form declarative representations, mental representations that can be used to direct behaviour based on predictions of the outcome of a behaviour rather than on the consequences of the behaviour in the past.

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