

## Object and spatial representations in detour problems by chicks

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**Abstract.** Two-day-old chicks, *Gallus gallus domesticus*, were tested in a detour situation requiring them to abandon a clear view of a desired goal (a small red object on which they had been imprinted) in order to achieve that goal. The chicks were placed in a closed corridor, at one end of which was a barrier with a small window through which the goal was visible. Two symmetrical apertures placed midline to the corridor allowed the chicks to adopt routes passing around the barrier. After entering the aperture, chicks showed searching behaviour for the goal and appeared able to localize it, turning either right or left depending on their previous direction of turn. Thus, in the absence of any local orienting cues emanating from the goal, chicks were aware of the existence of an object that was no longer visible and could represent its spatial localization in egocentric coordinates.

The ability to solve detour problems has been demonstrated in several species of mammals (review in Chapuis 1987). Detour abilities of birds, however, have not been extensively investigated (see however Krushinskii 1970). Koehler (1925) presented experimental evidence that little, if any, detour behaviour can be obtained in chickens, *Gallus gallus domesticus*. More recent studies, however, have shown that this species can show detour learning if not detour behaviour. Etienne (1973) presented 6-day-old chicks with a mealworm that disappeared behind one of two screens. At the first trial, chicks did not necessarily choose the screen behind which the mealworm had disappeared; with repeated testing, however, some chicks learned to orient their delayed response directly to the correct side (see also Scholes 1965; Scholes & Wheaton 1966).

The distinction between detour behaviour and detour learning thus appears to be crucial. It may be that chicks learn the correct route to the goal after repeated trials, but the difficulty they exhibit when faced with the problem for the first time may reflect a lack of 'object permanence' (Piaget 1936) and/or a reduced ability for spatial representation of the goal. Detour learning itself is open to a purely behaviouristic interpretation: with repeated experience, chicks may learn that certain motor

responses associated with particular environmental stimuli are reinforced. The problem, therefore, is to establish whether the chicks' difficulty when faced with a detour situation for the first time really reflects a cognitive difficulty.

We have recently investigated possible causes of the chicks' difficulty when faced with a detour problem for the first time (Regolin et al. 1994). Cagemates were used as goals and placed behind U-shaped barriers that concealed them to various degrees. We found that both perceptual factors (related to the perceived 'barred character' of the obstacle, see Koehler 1925; Tolman 1932) and motivational factors (related to the degree of visibility of the goal) strongly affected the chicks' performance. Once these factors were properly manipulated (e.g. using highly occlusive barriers with the goal placed far away), chicks successfully mastered the detour problem.

Nevertheless, our data still did not unequivocally demonstrate that chicks solve a detour problem in much the same way as, say, a primate does since cagemates used as the goal provided both visual and acoustic stimuli. The performance of the chicks might therefore be accounted for in terms of a sensory guidance system, with chick spatial behaviour under the control of local sensory cues from the goal (the same objection could be applied to the Scholes' (1965) study). It may be that the chicks, after several frustrated attempts

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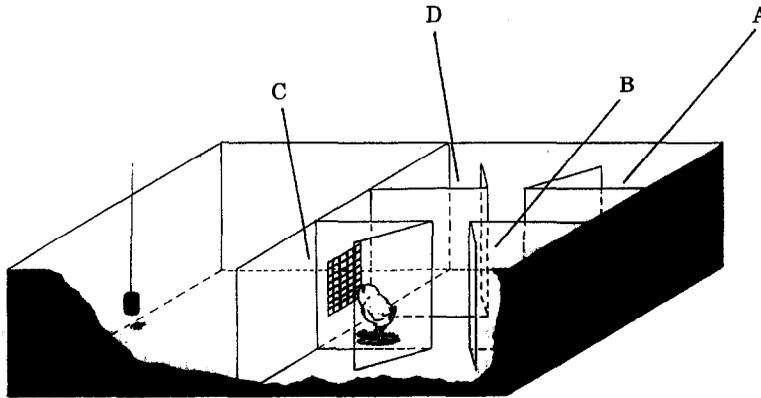


Fig. 1. Schematic representation of the experimental apparatus. 'A', 'B' are incorrect compartments; 'C', 'D' are correct compartments.

through the obstacle, moved around randomly and, in so doing, reached the end of the aped barrier. When they went outside the aped barrier, and lost sight of the goal, olfactory and olfactory stimuli from cages (perhaps asymmetries of the test arena such as closed and open ends) allowed them to orient directly towards the goal. Ambiguous perceptual information could thus contribute to the difficulty of the task but, none the less, chicks might lack the ability to represent the goal and its spatial location in the absence of locally orienting cues. This issue could be addressed by looking at the behaviour of the chick after the goal disappears at the first trial, in the absence of both sensory cues orient towards the goal and previous experiences that might have resulted in the formation of a goal. If chicks move randomly when the goal is no longer directly perceptible, then no straightforward conclusion can be drawn because chicks may possess the notion of object permanence but lack the ability to discover the object's position. If, on the other hand, chicks orient towards the disappearing goal, then some sort of mental representation of the goal can be ascribed to the animals. Here we present for the first time evidence that 7-day-old chicks are able to solve a detour problem at the first trial, and that they have a representation of the permanence and location of the goal in the absence of locally orienting cues.

### EXPERIMENT 1

In this experiment we used artificial social partners, small red objects, as goals, thus eliminating

the possibility that chicks could orient towards the goal using auditory or olfactory cues.

### Methods

#### *Subjects*

The subjects were 13 male and 12 female Hybro (White Leghorn) chicks obtained from a commercial hatchery when they were a few hours old. Chicks were reared singly in cages (22.5 × 40 × 30 cm; lit from above by fluorescent lamps) containing a red plastic cylinder (50 × 33 mm) suspended by a fine thread at about head height. Chicks were maintained at a controlled temperature (30–35°C) with food and water ad libitum.

#### *Apparatus and procedure*

The apparatus (Fig. 1) consisted of a uniformly white rectangular cage (120 × 35 × 60 cm) with sawdust (3 cm deep) on the floor, containing a corridor made of two grey walls (27 cm in length, 18 cm in height, spaced 10 cm apart). The end of the corridor facing the goal had a square aperture (4.5 × 5 cm) with a small grid (vertical and horizontal bars 0.3 cm in diameter and spaced 1.2 cm apart) through which a cylinder identical to that used during rearing could be seen. The cylinder/goal was placed 50 cm away from the barrier. Midline along the corridor were two symmetrical apertures (9 cm in size), allowing the chick to go outside the corridor. Diagonal partitions were placed outside the corridor offering the chicks a choice between two compartments for each aperture (incorrect compartments: A and B;

correct compartments: C and D). Diagonal partitions prevented the chick from being faced immediately with closed walls after going outside the corridor. Chicks were tested on day 2. The test chick was placed in the corridor, close to the barrier, and the time taken to reach one of the four compartments was recorded. A choice was considered to have been made when the chick's entire body entered one of the four compartments. The chick was allowed to remain in the apparatus for a maximum of 600 s.

The rearing cages and the test apparatus were in separate rooms so that the subjects were acoustically isolated from conspecifics. Sawdust substrate was moved or changed after each trial in order to remove any faeces or 'tracks' which might have been made by previously tested chicks. A unidirectional screen placed over the testing arena allowed the experimenter to observe the animals without being seen.

## Results and Discussion

Five (all males) of the 25 chicks failed to go outside the corridor within 600 s. Of the remaining 20 animals, 18 chose the correct compartments C-D ( $\chi^2=12.80$ ,  $df=1$ ,  $P<0.001$ ; males 8 versus 0,  $\chi^2=8.00$ ,  $df=1$ ,  $P=0.005$ ; females 10 versus 2,  $\chi^2=5.33$ ,  $df=1$ ,  $P=0.02$ ). There was no significant difference between choices for C and D (12 versus 6,  $P>0.10$ ) and A and B (2 versus 0,  $P>0.10$ ). Thus chicks were able to turn correctly towards the goal in the absence of any locally orienting cues.

Times needed to solve the problem were significantly lower in females than in males ( $\bar{X} \pm SE$  were: females  $261 \pm 52$  s; males  $423 \pm 47$  s, two-tailed Mann-Whitney  $U$ -test:  $U=20.5$ ,  $N_1=8$ ,  $N_2=12$ ,  $P<0.05$ ).

## EXPERIMENT 2

Studies on detour learning seem implicitly to assume that the reduction in the time needed to solve the problem after repeated trials reflects spatial learning of the correct route (e.g. Scholes 1965). Our results, however, suggest that chicks may have little to learn about the spatial localization of the goal, since they can turn correctly in the absence of previous experience of the correct route. Thus, time reduction in detour learning

may be better accounted for in terms of reduced emotional responses to the novel environment and an appreciation of the futility of following the straight route because of the 'barred character' (Koehler 1925) of the obstacle. Because the procedure we adopted in experiment 1 differed in several respects from that used by previous investigators (e.g. Scholes 1965; Etienne 1973, 1974) we performed a repeated-trials experiment to check whether a reduction in the times needed to reach the goal could be observed with our paradigm.

## Methods

### Subjects

We used six male and seven female Hybr chicks. Rearing conditions were the same as in the previous experiment.

### Apparatus and procedure

The apparatus was the same as that used in the previous experiment. This time, however, a small opening (5 cm) was made in compartments C and D, near the external walls of the corridor, allowing the chick to go outside these compartments and to reach the goal. The opening was not visible until the chick put its head into the compartment. The procedure was similar to that of experiment 1. After the chick had reached the cylinder/goal, it was allowed to stay there for 15 s (reinforcement time) and then was returned to the corridor in front of the barrier. The procedure was repeated six times, and the series of visits to the various compartments as well as the time needed to reach the goal in each of the six trials were recorded.

## Results and Discussion

Three animals (two males and one female) failed to go outside the corridor within 600 s in the first trial. Figure 2 shows the times needed to reach the goal in the various trials for the remaining animals (four males and six females). Analysis of variance revealed a significant main effect of Trials ( $F_{5,40}=5.776$ ,  $P<0.001$ ) and a significant Sex\*Trials interaction ( $F_{5,40}=3.983$ ,  $P=0.005$ ). The main effect of Sex was not significant ( $F_{1,8}=0.209$ ). In the first two trials females took less time to solve the task than males ( $F_{1,8}=5.97$ ,  $P=0.039$ ), whereas in the last four trials mal

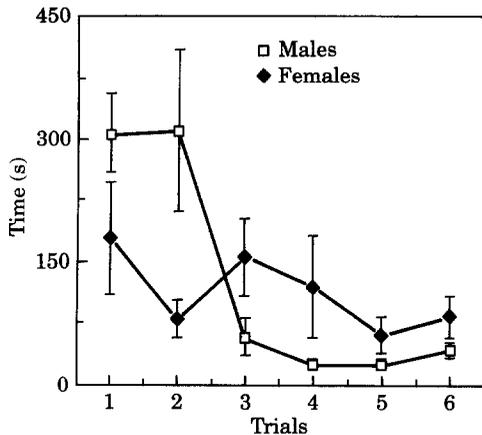


Figure 2. Mean  $\pm$  SE times needed to reach the goal during six successive trials.

took less time than females ( $F_{1,8}=8.789$ ,  $P=0.017$ ).

Results from the first trial confirmed those of experiment 1 (nine out of 10 animals chose the correct compartments;  $\chi^2=6.40$ ,  $df=1$ ,  $P=0.011$ ). Overall, errors (i.e. visits to A–B compartments) during the six trials were rare (eight out of 60 visits). Some birds made consistent choices, always turning right (or left) in all six trials. However, the majority of birds varied their correct choices, that is, sometimes they chose C and sometimes D, turning right or left depending on their right or left direction of turn when they went outside the corridor.

Four birds (three females and one male) were given another two trials after an interval of 2 h; they all chose the correct compartments (C–D) on both trials. Mean ( $\pm$  SE) times needed to reach the goal were  $53.2 \pm 12.2$  s in the first (seventh) trial, and  $28.0 \pm 8.71$  s in the second (eighth) trial.

## GENERAL DISCUSSION

Experiment 1 showed that chicks are able to orient correctly towards the goal in the absence of any local sensory cues emanating from it. This achievement requires an ability to maintain a representation of the goal at least for some time after its perceptual disappearance, a time during which the chick engaged in an active and non-random search for it.

Since in experiment 1 chicks had no previous opportunity to explore the environment, the

spatial localization of the goal was likely to be based on an egocentred frame of reference. Chicks could have used a motor algorithm with instructions such as 'if you turned right (left) before the goal disappeared, then turn right (left) to find it again'. Dead reckoning (see Gallistel 1990) could be a possibility: chicks may be able continuously to update their position with respect to the goal in a represented space moment by moment.

Whatever the orienting mechanism used, what is relevant in the present context is that it seems to imply some form of the idea that a goal has not gone 'out of existence' when it can no longer be seen. Experiment 2 confirmed these results. It additionally showed that at least some of the chicks did not learn a fixed response (i.e. turn right or left) but rather a position in space in egocentric coordinates (i.e. turn either right or left depending on the previous direction of turn). Experiment 2 also suggested that the long times needed to solve the detour problem in the first trial were probably due to the emotional reactions induced in the animal by being placed in a novel environment.

Gender effects were apparent in both experiments. Females performed better in the first trials, whereas males took less time to reach the goal after a certain number of trials. It is known that females are more active and vocal than males when placed in a novel environment (Jones 1977), and it has been suggested that this may be because females have stronger social reinstatement motivation than males (Vallortigara 1992). Stronger social motivation should make the detour task more difficult for females than for males. However, the task requirements were quite different at first presentations and in successive trials. When faced with the problem for the first time, chicks exhibited emotional responses to the novel environment, and freezing is known to be more frequent in males (Jones 1977). The probability of finding the apertures in the corridor largely depended on moving about in a novel environment, and females are more likely to do this than males (Vallortigara & Zanforlin 1988). Thus, females could be expected to take less time than males during the first trials. In subsequent trials, on the other hand, chicks had learnt the correct route to the goal, and had also learnt that reinforcement occurred for following that route. At this stage, stronger social motivation in females could compete with correct execution of the

spatial task (i.e. females are more attracted than males towards the direct route), thus producing better performances in males.

The notion that objects are separate entities that continue to exist when they are no longer available to direct perception has recently become a focus of interest in comparative cognitive research (for reviews see Etienne 1977; Doré & Dumas 1987). Observation of the behaviour of several avian species in seminatural conditions and in the wild provides evidence of abilities that seem to require a concept of object permanence (e.g. Sherry 1982; Shettleworth & Krebs 1982). Psittacine birds perform very well in standardized object-permanence tasks (Pepperberg & Funk 1990).

Textbooks have considered previous studies on detour behaviour in chicks as indicating poor abilities to form cognitive maps in this species (e.g. Pearce 1987, page 224). However, recent evidence clearly shows that chicks are capable of topographical learning (Vallortigara & Zanforlin 1986; Rashid & Andrew 1989; Vallortigara et al. 1990). In our previous study (Regolin et al. 1994) we showed that most of the difficulties exhibited by young chicks when faced with a detour problem for the first time could be attributed to the emotional overtones and perceptual ambiguities of the test situation. In the present study, we have demonstrated that young chicks as early as day 2 of age do possess the cognitive abilities for performing detour behaviour, thus suggesting that at least in this precocial species the concept of object permanence may be already acquired (and possibly inborn).

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