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Chicks' use of geometrical and nongeometrical information in environments of different sizes

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Spatial reorientation refers to the strategies involved in finding one's bearing after disorientation. To remember a spatial location there are two basic systems: an externally referenced system, that associates a location to the characteristics of the external environment using distance and directions from landmarks, and a self-referenced system, such as path integration, that associates a location to the position of the self, compensating for self movements by encoding the distance and angular variation (direction) of that movement. When the two systems are not in agreement, for instance as a result of movement not controlled by the animal itself and in the absence of orienting visual cues, the externally referenced system is usually used to correct the self-referenced system. This reorientation ability has been extensively investigated in these last years, both in comparative and developmental perspective. It has been shown that there are two main sources of information that an animal can take into account in order to reorient, namely the metric arrangement of the surfaces defining an enclosure (geometric information) and the discrete elements or landmarks located inside or outside such space (nongeometric information).

In the basic paradigm originally introduced by Cheng (1986), rats (Rattus norvegicus) are shown a goal-object hidden in one corner of a rectangular enclosure with several visual and olfactory cues. Then they are removed from the enclosure and spatially disoriented. When reintroduced in the enclosure in the absence of featural information, subjects rely on the shape of the enclosure to locate the goal, searching equally at the location of the goal and at the geometrically equivalent location at the opposite side of the rectangular room (i.e., in the corner located at a 180° rotation from the goal to the centre). When reintroduced in the enclosure in the presence of featural (nongeometric) information, such as a coloured wall, results vary somewhat depending on species, developmental level and procedural details. In rats, for instance, combined use of geometric (the shape of the enclosure) and nongeometric (the coloured wall) information cannot be observed (Cheng 1986). In human infants, it seems that the conjoining of geometric and nongeometric information is not observed until 5–6 years of age. Other species, in contrast (fish: redtail splitfins (*Xenotoca eiseni*): Sovrano et al. 2002, 2003; goldfish (*Carassius auratus*): Vargas et al. 2004; birds: domestic chicks (*Gallus gallus*): Vallortigara et al. 1990; pigeons (*Columba livia*): Kelly et al. 1998; mammals: rhesus monkeys (*Macaca mulatta*): Gouteux et al. 2001; tamarins (*Saguinus Oedipus*): Deipolyi et al. 2001) have been observed to be able to conjoin geometric and nongeometric information to reorient themselves (review in Cheng and Newcombe 2005).

More recently, it has been shown that also human infants could use geometric information in combination with nongeometric (landmark) information when tested in large experimental spaces (Learmonth et al. 2002). Chicks, in contrast, appear to be able to conjoin geometric and nongeometric information in both large and small spaces and also when displaced from a large to a small arena and vice versa. Yet, when tested with an affine transformation that alters the geometric relations between the local cues and the overall metric properties of the environment, they make more geometric errors in a small than in a large environment (Vallortigara et al. 2005).

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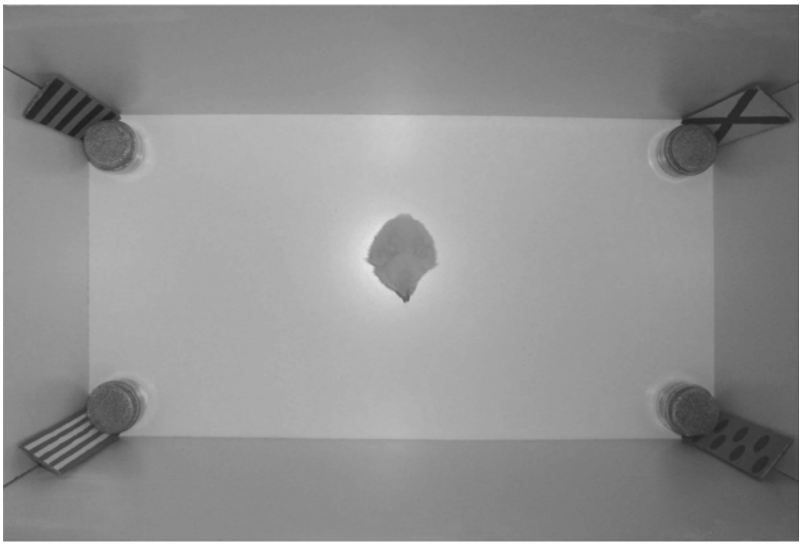

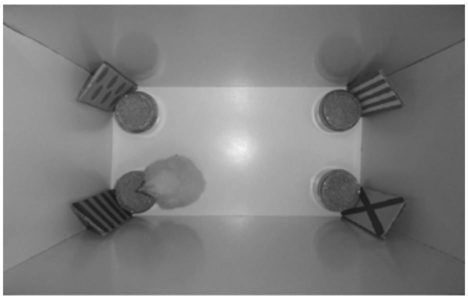

Fig. 1 The large and the small rectangular enclosures with the panels available at the corners

We addressed the importance of the experimental space's size in three different experiments. In all experiments, chicks were trained in a small (35 cm deep x 40 cm high x 17.5 cm wide) or in a large (70 cm deep x 40 cm high x 35 cm wide) white-coloured wooden rectangular enclosure with four different cardboard panels (20 x 4.5 cm) placed on each corner (as shown in Fig. 1). In experiment 1, chicks were tested in a large or in a small enclosure respectively with the panels displaced according to an affine transformation so as to provide contradictory geometric and nongeometric information.

In experiment 2 chicks were trained in a small or in a large rectangular arena with different panels at each corner and tested in the same enclosure but in absence of all the panels. In experiment 3 the shape of the arena was changed from rectangular (during training) to square-shaped (at test) in order to disentangle the specific role of the geometrical vs. nongeometrical cues.

In experiment 1 it could have been anticipated that chicks would encode the target cue together with the nearest panel along the short wall in order to correctly reorient after the displacement of the landmarks; however, results showed that chicks did not process the distant cue but chose the reinforced panel even when located in the wrong position. Moreover, the selective removal of either one of the two sources of information revealed that encoding of both types of information certainly occurred in both enclosures: i.e. after removal of features chicks still searched at the two geometrically correct locations and after removal of geometry chicks still searched at the location identified by the correct landmark. However when tested in the presence of the only geometrical information (experiment 2) chicks made stronger use of geometry in the small than in the large experimental space; moreover, when the arena was changed in shape (experiment 3) chicks resorted to landmark use much more in the large than in the small enclosure.

These findings suggest that chicks do encode both geometric and nongeometric information whatever the size of the environment, but that they tend to use the more reliable cue in relation to the size of the experimental space. In small environments, when metric information from close walls is fully available, they rely mainly on geometric information, whereas in large environments, when metric information would require motion or extensive visual scanning of the surfaces of the environment, they rely on local cues available at the corners.

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