



Evidence of a relational spatial strategy in learning the centre of enclosures in human children (*Homo sapiens*)



Luca Tommasi*, Alda Giuliano

University of Chieti, Italy

ARTICLE INFO

Article history:

Received 8 April 2014

Received in revised form 9 June 2014

Accepted 12 June 2014

Available online 19 June 2014

Keywords:

Place learning

Centre

Children

Geometry

Spatial strategies

Spatial cognition

ABSTRACT

Three- to five-year-old children were trained to localize a sensor hidden underneath the floor, in the centre of a square-shaped enclosure (1.5 m × 1.5 m). Walking over the sensor caused a pleasant music to be played in the environment, thus engaging children in a playful spatial search. Children easily learned to find the centre of the training environment starting from random positions. After training, children were tested in enclosures of different size and/or shape: a larger square-shaped enclosure (3 m × 3 m), a rectangle-shaped enclosure (1.5 m × 3 m), an equilateral triangle-shaped enclosure (side 3 m) and an isosceles triangle-shaped enclosure (base 1.5 m; sides 3 m). Children searched in the central region of the enclosures, their precision varying as a function of the similarity of the testing enclosure's shape to the shape of the training enclosure. This suggests that a relational spatial strategy was used, and that it depended on the encoding of geometrical shape. This result highlights a distinctive role of the geometric centre of enclosed spaces in place learning in children, as already observed in nonhuman species.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Remembering the location of objects and places in the environment is an ability that allows animals to move around in meaningful ways, sometimes heading to relevant places that are directly perceived as beacons (as are figures in a figure–ground relationship), other times locating places that do not stand out against their surroundings but that have to be reached by reference to one or more distant landmarks, to the surrounding spatial frame of reference, or to a combination of these two aspects.

Many species have been tested in a variety of place learning tasks involving reference to (i) individual or multiple landmarks, (ii) extended surfaces surrounding the goal region, or (iii) a combination of landmarks and surfaces (see Tommasi et al., 2012; Tommasi and Laeng, 2012, for recent reviews). In many cases, empirically evaluating the presence and the precision of such abilities has been accompanied by assessing changes in spatial behaviour following transformations of an environment. There are many examples in which the global arrangement of an array of landmarks was shown to be exploited as a spatial reference to localize a goal (see Collett et al., 1986, for seminal studies carried out in the gerbil). In this

respect, experiments that played on transformations of the landmark arrays (contractions, expansions, etc.) have proven crucial in revealing which type of information is used by animals orienting to a goal (the ‘transformational approach’; Cheng and Spetch, 2001).

If an animal has been trained to find the central position between two landmarks, tests carried out following increases (or decreases) of the inter-landmark distance can tell us whether the animal relies upon vector-like information from either landmark or upon a relational strategy, such as the acquisition of a ‘middle’ rule (gerbil: Collett et al., 1986; Clark’s nutcracker: Kamil and Jones, 1997). An array of landmarks arranged in a given geometric shape (e.g. the four vertices of a square) offers exactly the same opportunity: if an animal is trained to find the centre of the array, tests in expanded or contracted arrays (leaving the square shape unchanged) can provide researchers with very useful information on what information is stored and retrieved to accomplish the task (e.g. the exact distance and direction from one isolated landmark or equidistance from all of the landmarks). Removing one or more landmarks while leaving the others in place would be another interesting test of those alternative mechanisms (gerbil: Collett et al., 1986; pigeon: Spetch et al., 1997). Finally, if the position to be localized is at the centre of a square-shaped enclosure made of continuous walls, a test in a larger (or in a smaller) replica of the enclosure can provide interesting results about the use of the global spatial framework represented by the walls of the enclosure in determining the position of the goal. Again, a transformation of the shape of

* Corresponding author at: Department of Psychological Science, Humanities and Territory, University of Chieti, BLOCCO A, Via dei Vestini, 29, I-66013 Chieti, Italy. Tel.: +39 0871 3554210; fax: +39 0871 3554163.

E-mail address: luca.tommasi@unich.it (L. Tommasi).

the enclosure could also provide useful results (see [Thinus-Blanc et al., 2010](#) for examples).

A number of species, including humans at various stages of development, have been tested insofar in place learning paradigms involving searching in the middle or the centre of a space. Comparing the data obtained in humans with those of other mammalian and non-mammalian species, in place learning paradigms exploiting the three types of arrangement described above (landmark pairs, landmark arrays, enclosures), is important to understand the generality of strategies (vector-based, configural, rule-based, etc.) exploited by living organisms in spatial search.

[Yerkes \(1934\)](#) was probably the first to empirically investigate the possibility that animals can manage a spatial task involving the concept of 'middle', rewarding chimpanzees when they entered the door of the middle box in a row of three boxes. The same problem was proposed to the chimpanzees with rows of five, seven and nine boxes, in a protocol of increasing difficulty. Yerkes had to give up because all chimpanzees failed to master the task, a problem that [Spence \(1939\)](#) attributed to imperfections in methodology. Using a simpler technique in which a tray was topped with a row of metal boxes and the chimpanzee had to select the middle one, Spence showed that chimpanzees could successfully select the middle box, but he did not attempt with more than five boxes in a row. Extending Spence's study, [Rohles and Devine \(1966, 1967\)](#) tested whether a female chimpanzee possessed a concept of 'middleness'. After a training phase in which baited food could be found in the middle of a row of three identical wells on a tray, the chimpanzee was tested on sequential trials in which the number of wells in a row increased up to seventeen. The chimpanzee mastered the task without showing signs of decreased performance as the number of wells increased.

In the last two decades, evidence has accumulated at a faster pace on place learning involving searching in the middle, and studies using landmark arrays in particular have focused more on nonhuman primates and children. [Sutton et al. \(2000\)](#), for instance, investigated squirrel monkeys using a protocol involving a pair of landmarks or a square-shaped array. Results showed that in expansion tests the monkeys searched neither in the middle of the enlarged configurations, nor at a fixed distance from any individual landmark. Similarly, [Potì et al. \(2005\)](#) tested capuchin monkeys in expansion tests both with a square-shaped array and with a pair of landmarks. The capuchins searched in the vicinity of two landmarks in the case of the expanded square array, or at the same distance from landmark to centre as that experienced during training in the case of the expanded pair of landmarks, although they did not show any form of relational or rule-like strategy (see also [Potì et al., 2010](#) for similar results in bonobos).

In a study directly comparing humans and nonhuman primates, [MacDonald et al. \(2004\)](#) tested human adults, children and marmoset monkeys in a square array expansion task. This experiment, similarly to those by [Sutton et al. \(2000\)](#) and [Potì et al. \(2005\)](#), was carried out over a discrete search space, involving a grid of holes. Following training in which the goal (one of the holes covered by a cup) was found in the middle of four adjacent landmarks (differently coloured cups), human adults searched consistently in the middle of the array when it was expanded, but neither marmosets nor human children (aged 5–9 years) showed any evidence of relational encoding. Interestingly, whereas the children searched equidistantly around the landmarks in any direction, the marmosets searched more in the correct direction towards the goal. In a second experiment carried out only on 3- to 5-year-old children, however, [MacDonald et al. \(2004\)](#) modified the task so as to involve training and testing over a continuous space, using a box filled with confetti. In this experiment, some of the children followed either a middle rule or a rule based on absolute distance and direction from landmarks.

Confirming that the nature of the search space (discrete versus continuous) plays a role in encoding the central position in children, [Uttal et al. \(2006\)](#) showed that 4- and 5-year-old children used a middle rule when they were asked to find a hidden toy in expansion tests involving two landmarks in an open space. [Simms and Gentner \(2008\)](#), testing children in a landmark pair midpoint task using a box filled with Styrofoam peanuts, showed (i) that children could rely upon a middle rule and, confirming a more informal observation by [MacDonald et al. \(2004\)](#) and (ii) that knowledge of the relevant spatial terms was a good predictor of children's spatial precision (see [Ankowski et al., 2012](#), for similar results).

[Marsh et al. \(2011\)](#) carried out a study comparing human children and Sumatran orangutans in expansion tests involving square arrays of landmarks on a vertical grid-like surface (a touch-screen divided into cells). Whereas children (4–10 year olds) searched both using a middle rule and a vector strategy, orangutans did not adopt a middle rule but appeared to rely upon landmarks as beacons or as anchors for a vector-like strategy. In a similar experiment, in which the search space was a continuous surface, the results were comparable.

These results suggest that human adults master "middle rule" tasks while, depending on the experimental conditions, nonhuman primates can rely on vector information with reference to individual landmarks. Children fall somewhat in between: despite some variability in the results as regards age effects, hints of a relational or rule-like strategy were observed alongside vector-like and beaconing strategies, also depending on the type of task space. Tasks taking place over a discrete space appear more difficult, whereas tasks taking place over a continuous surface or in an open space, seem to be mastered more easily. Such a difference is accompanied by a correlation between the knowledge of relevant spatial words by children and their precision.

Based on previous work carried out by [Hartley et al. \(2004\)](#), [Batty et al. \(2010\)](#) devised a task that involved learning the position of an object hidden in a square-shaped 2D search space (on a computer screen). Tests were carried out in both an unmodified and an expanded search space. Adults and children were tested, and in both cases the accuracy of search was shown to depend on the proximity of the object to the boundary of the square, suggesting that encoding of absolute distance could best explain performance when the object was close to the edge, and that relational encoding could explain trials in which the object was in the centre of the square. For positions falling in between edge and centre, the performance could be explained by the adoption of a mixture of these two strategies.

In the studies reviewed above, the middle position was defined with reference to pairs of landmarks, to square arrays of landmarks, or to a square 2D search space. However, central place training and transformation tests can be carried out also in empty environments surrounded by walls (arenas, rooms, etc.). There is growing empirical evidence that orientation by extended surfaces is easier and more accurate than orientation based on arrays of distinctive landmarks, both in human infants and in animals ([Gouteux and Spelke, 2001](#); [Vallortigara, 2009](#); [Pecchia and Vallortigara, 2012](#); [Lee et al., 2012, 2013](#)). It has been argued that this primacy might depend on the fact that surfaces provide for higher spatial stability and durability than landmarks ([Gallistel, 1990](#)), and that the properties of wholeness and connectedness make the geometry of extended surfaces more affordable than landmarks, whose geometrical pattern must be extracted ([Lee and Spelke, 2008](#)). Data available for avian species (domestic chicks: [Tommasi et al., 1997](#); [Tommasi and Vallortigara, 2000](#); pigeons: [Gray et al., 2004](#); [Wilzeck et al., 2009](#)), and rodents (rats: [Tommasi and Thinus-Blanc, 2004](#); mice: [Inoue and Watanabe, 2012](#)), show that the adoption of a relational encoding strategy can be mastered when the centre has to be localized in spaces defined by extended walls. Tests carried out after changes

Download English Version:

<https://daneshyari.com/en/article/2426675>

Download Persian Version:

<https://daneshyari.com/article/2426675>

[Daneshyari.com](https://daneshyari.com)