How Spinning in Circles Informs Spatial Cognition

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In our daily lives, we are always on the move. Successful navigation requires two components (when a GPS unit isn't at hand), a map-like representation, and some knowledge of your current position on the map. From time to time, perhaps after travelling underground in the subway, or by being distracted by a phone conversation, we lose track of the "I am here" sticker on our mental map. Before we are able to carry on with our travels, we must first update our current position on our mental map. Thus, the processing of reorientation, or updating the current spatial position, can be viewed as the first step in the navigation process. This is the process that we will be discussing in this Showcase.

We can investigate the reorientation process in the lab. First, participants are introduced to a controlled environment, where we can manipulate the types of cues that are available to participants. Then participants are shown a goal location, and asked to remember where it is. To induce the state of disorientation (mimicking the subway travel scenario), participants are asked to spin in a circle with their eyes closed. Once they have stopped spinning, then they are allowed to open their eyes, and are asked to return to the goal location. Based on the types of information that we provide to participants, we can investigate how people are able to reorient.

One type of information that is often displayed is a feature cue, such as a uniquely colored landmark. Young children, even toddlers, have been shown to use feature cues for reorientation (Learmonth, Nadel, & Newcombe, 2002). However, it is debated how these feature cues are used by the reorientation system. Lee, Shusterman, and Spelke (2006) have argued that when young children are using feature cues, they do so in an associative manner, to beacon towards a goal location. This is an important point, because from this position, it is argued that the young children are able to partially navigate, without recovering a sense of where they are in the environment. To test this hypothesis, four year old children were introduced to a circular enclosure with an equilateral array of hiding locations. In this array, one of the hiding locations was a red cylinder, while the other two points of the triangle were identical blue rectangular boxes. Thus, the red cylinder could serve as a landmark for reorientation. If this is true, then the four year old children should be successful finding the sticker in any of the locations after disorientation. However, if children are depending on a beaconing strategy, and cannot use features at all for reorientation, then children should succeed when the sticker is at the unique red location, and randomly divide search at the two identical blue containers. Perhaps surprisingly, the second situation was found by Lee et al (2006). Children were able to retrieve the sticker about 80-90% of the time at the unique container, and were only 50% successful at the blue containers. These finding were taken as support of a two-step account of reorientation. In the first step of the reorientation system, participants are hypothesized to reorient based on the available geometry of the environment. In a second step, people can associatively beacon to a target location based on the non-geometric (i.e. feature) properties of the environment. This view of spatial cognition is modular in nature, and leaves little room for the role of experience, malleability, or training.

The alternative position to modularity is adaptive combination. From this theoretical position, the mind is able to use potentially any available cue that may aid the reorientation system. Saliencies, initial tendencies, as well as a past history of success or failure will bias a participant to use one particular type of cue over another when a decision is required. From this framework, there is an alternative explanation of the Lee et al (2006) finding. We believe that since the feature cue was small, portable, and part of the array, it would be a poor landmark choice to determine one's position in the environment. When we are determining heading, cues that are large, stable, and more distal to the task would be better cues for reorientation.

Therefore, in this set of experiments, we ask if four year old children are able to use features for true reorientation (rather than just as beacons to a target location) when the feature cue is mounted on a wall, rather than as part of the array. In the first portion of the experiment, children were asked to search within an equilateral triangle search array, with identical shaped and colored goal locations. The feature cue was mounted on the circular boundary.

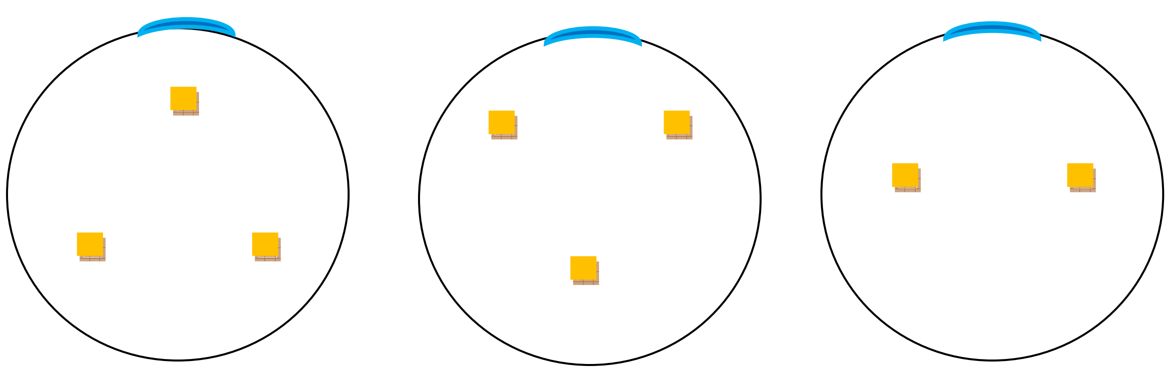

Figure 1. *Search array for the reorientation experiment. Within the circular search space, discrete hiding locations were placed in relation to the animal blanket*

affixed to the white fabric. The hiding locations form a 2 meter equilateral triangle, either with each other as in the first two conditions or with the center of the blanket as in the last condition. The experimenter and the child were always positioned in the center of the array for disorientation.

In contrast to Lee et al, children were able to retrieve the goal at all three positions at above chance levels. However, it is possible that the children were able to infer geometry between the three hiding locations and the feature curtain hanging on the circular wall. To rule out this possibility, the feature served as one point of the equilateral triangle, and then children we asked to search between two containers (composing the rest of the triangle) equidistant from the feature wall. The two-step associative account predicts that children should search equally often at each of the hiding locations. In contrast, four-year-old children in our experiment were able to focus search on the correct hiding location. Therefore, we provide evidence that young children can use features as more than just beacons, as landmarks in the reorientation system.

In summary, we have provided one piece of evidence that bolsters the case the adaptive combination approach to spatial cognition. One point to note is that although children performed at above chance levels, their performance was not impressively high, and therefore it seems that the reorientation system is developing beyond four years of age. As points of future research, it would be interesting to determine the developmental trajectories of each type of reorientation cue, as well as to understand how children resolve situations of conflicting or ambiguous information. Additionally, it would be noteworthy to tie the cognitive data to the neural level. Specifically, it would be interesting to think about how developing neural systems, such as place cells, head direction cells, and boundary vector cells may support or be influenced by spatial development. Lastly, it would also be of interest to think about how this reorientation system relates to the other aspects of cognition and individual differences. Perhaps we might expect reorientation ability to correlate quite well with oriented navigation, and less well with other spatial tasks such as mental rotation. All of these points are open questions, and would be potentially fruitful avenues of future research.

Acknowledgments

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References

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