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Representing Space: Reference Frames and Multiple Views

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Introduction

When people learn locations of objects in space, memory for those spatial relations appears to involve storing multiple viewpoint dependent representations (Diwadkar & McNamara, in press; Shelton & McNamara, 1997). We conducted three experiments to take a closer look at the role of multiple views and the reference frames used to encode spatial relations. The experiments were designed to determine whether or not three views of a spatial layout would produce a viewpoint independent representation in memory and to assess the relative importance of alternative spatial reference frames (e.g., the viewer's perspective & the permanent environment) in encoding spatial location. In each experiment, subjects learned the locations of seven objects in a room-sized space from two or three perspectives and then made judgments of relative direction using memory (e.g., Imagine you are standing at the shoe, facing the lamp. Point to the clock.) Based on prior research, we hypothesized that judgments oriented with learned perspectives would be faster and more accurate than judgments oriented with novel perspectives. We further expected that the spatial structure of the room itself (e.g., the planes and axes specified by the walls) might facilitate representations of certain views and not others.

Experiment 1

Each of 48 subjects learned a display of objects from two orthogonal viewing positions. For half the subjects the viewing positions were aligned with walls of the enclosing room. For the other half, the viewpoints were misaligned with the walls. Performance in judgments of relative direction suggested that when two aligned views were learned, trials oriented with each of these views were faster and more accurate than trials oriented with novel views. However, when two misaligned views were learned, subjects seemed to show a single preferred view for which they were faster and more accurate.

Experiment 2

Each of 24 subjects learned a display of objects from three viewing positions. Two of the views were orthogonal and aligned with walls of the room. The third view was equidistant from the first two and misaligned with the room walls. Half the subjects began the learning phase at an aligned view. The other half began the learning phase at the

misaligned view. Performance in judgments of relative direction indicated that the two views aligned with the walls of the room were represented in memory, but that the misaligned view was not mentally represented, even when it was the first view experienced.

Experiment 3

Experiment 3 was identical to Experiment 2 except that the objects were located in a cylindrical "room" 3.3 m in diameter. Results from judgments of relative direction indicated that the first view learned was mentally represented, but that the two subsequent views were not. Rather than forming multiple views in memory, subjects seemed to be representing a single view when the structure of the space did not provide a salient frame of reference.

Discussion

While there was evidence for multiple viewpoint dependent representations of the spatial layouts, it was not always the case that every experienced view was equally accessible in memory. The results suggest that people store a subset of the study views, based on both a viewer centered reference frame and on the external reference frame provided by the larger context. When room cues are available, viewing positions aligned with the major axes of the room appear to be represented in memory. When no views are aligned with the major axes or when room cues are eliminated, subjects appear to represent a single view of the space. These findings imply that, rather than positing a single reference frame for spatial memory, models may need to incorporate an interplay of reference frames to determine how many views are represented and which views those will be.

References

- Diwadkar, V. A., & McNamara, T. P. (in press). Viewpoint dependence in scene recognition. *Psychological Science*.
- Shelton, A. L., & McNamara, T. P. (1997). Multiple views of spatial memory. *Psychonomic Bulletin and Review*, 4(1), 102-106.