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The Relationship Between Object-Based Judgments and Judgments of Relative Direction as Measures of Spatial Memory

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The Relationship Between Object-Based Judgments and Judgments of Relative Direction as Measures of Spatial Memory

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Introduction

Directional pointing has been a major technique for measuring a person's knowledge of the spatial layout of objects in an environment. Typically, people answer queries using a direction circle, as shown in Figure 1. There has typically been two types of queries used to measure spatial layout knowledge: judgements of relative direction, JRDs (e.g., 4) and object-based judgments, OBJs (e.g., 1). Both judgments assess how we retrieve spatial knowledge we may have learned and stored in memory. JRD queries refer to three different objects (a standingAt object, a facing object, and a target object). An OBJ query refers to just two objects, a base object, which participants imagine standing directly in front of and squarely facing, and a target object. OBJs assume that participants store relevant information about landmark objects, such as fronts, that can be used as a surface referent. Therefore, the source of error in an OBJ is related to whether a participant can remember the spatial relation between the imagined base object and the imagined target object. JRDs, however, have two different potential sources of spatial error. One potential source of error is related to whether a participant can remember the spatial relation between the imagined standingAt object and the imagined facing object. The other potential source of error is related to whether a participant can remember the spatial relation between the imagined facing object and the imagined target object. Figure 2 shows these relationships on a hypothetical remembered layout map. JRDs have potential error in remembering the facing object, OBJs do not have a separate facing object.

If OBJs and JRDs both are judgments that use the same underlying spatial memory processes, then they should be related to each other. As Figures 1 and 2 describe, a JRD angle on a direction circle should be equal to the difference between two OBJ queries, one between the base object that is the JRD's standingAt object and the JRD's facing object, and the other between the same base object and the JRD's target object. To assess this relationship, the DualOBJ task was created. Participants made two OBJ judgments successively, one from a base object to a facing object, and the second one from the base object to a target object. Experiment 1 manipulated both the task (JRD, DualOBJ) and the location of the JRD's facing object (near, far). The OBJ and JRD queries always had the same locations for the base (standingAt) and target objects in the virtual environment. The near and far facing objects were placed in the virtual environment so that the near facing object queries had the same angles as the far facing object queries. Near facing objects were in the same room as the base (standingAt) and target objects, and far facing objects were always in a different room

Method

Construction of and Navigation in the Virtual Environment

Participants experienced a virtual 3D environment from a first-person perspective of four rooms in a building with the rooms connected by a hallway. Figure 3 shows the square layout of the rooms and objects in each room, along with the hallways wrapping around the rooms. Each room had four objects (16 total), and they were grouped categorically (vending machines, arcade games, furniture, and appliances). There were 16 pairs of within-room and 16 pairs of between-room queries with the same angular relationship. These angles were balanced so that between-room queries in each room were used equally often. Also, vertically, horizontal , and diagonally orientated angles were balanced across the four rooms. Objects and object orientations (fronts) were irregularly placed but were placed so that near and far facing angles were equal, as shown in Figure 3. Participants were given a scenario in which they were assigned the task of inventorying each object, which the navigation took them up to and they stood squarely in front of. They visited each object in the environment only once. Following this learning experience, they were tested on one of the pointing tasks from memory.

Spatial Memory Measurement: Pointing Tasks

JRD: Imagine yourself standing at the sofa facing the dresser, point to the stove.
Dual-OBJ: On the same directions circle, mark query (1) then mark query (2)
(1) Imagine yourself standing in front of and squarely facing the sofa from about an arm's length away, point to the dresser.
(2) Imagine yourself standing in front of and squarely facing the sofa from about an arm's length away, point to the stove.

Experimental Design

The design was a 2 x 2 mixed factorial design with a between-subject factor of judgment type (DualOBJ, JRD) and a repeated-measure factor of facing location (near, far).

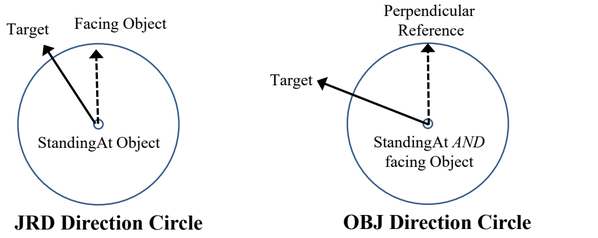
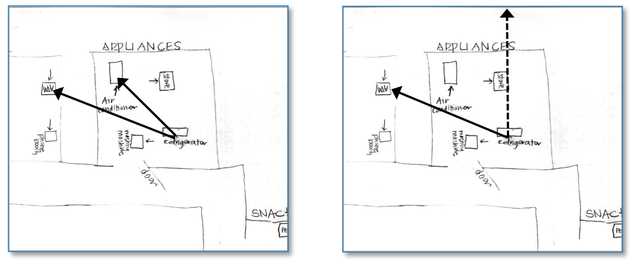


Figure 1. The JRD direction circle is on the left and the OBJ direction circle is on the right. The small circle in the center represented a participant's head with the eyes facing towards the top. The top would be the hidden facing object for a JRD, but it would be the perpendicular to the standing-at object's front for an OBJ. Participants would only mark the circle where the solid arrow points. Figure 2 explains how these judgments relate to a layout.



Map - *JRD* Map - *OBJ*

Figure 2. The left diagram shows how an imagined JRD is related to a hypothetical remembered map. The participant imagines being at one location, and the facing and the target objects being at two different locations. The right diagram shows how an imagined OBJ is related to the same environment. The participant imagines being at the same object's location but is now right next to it facing its front (the perpendicular line) and only the target object is at a different location.

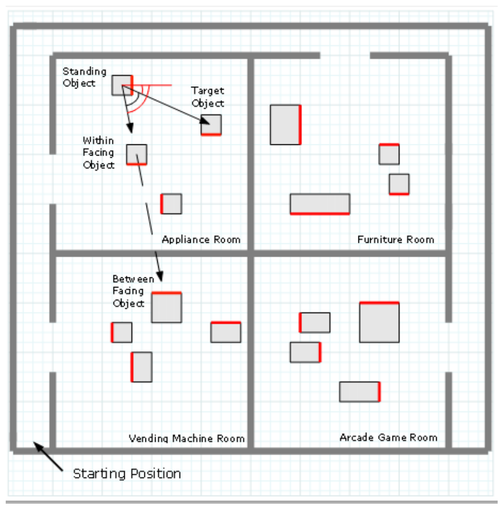


Figure 3 on the left is the layout of the virtual environment used in Experiment 1. The bolded red lines indicate fronts of objects. The black arrows represent an example of a JRD query, with the between-room facing object represented by a dashed arrow. The red line indicates the perpendicular reference created by an OBJ. The black arc is the JRD angle. The Two red arcs show the two DualOBJ angles. Note that the angular relationship between an OBJ and JRD can be seen as the difference between two OBJs in the DualOBJ task.

Results and Discussion

Figure 4 below shows two important results. First, when the facing object was not in the same room as the standing-at and the facing objects, then absolute angular error was substantially increased, the main effect of facing location was statistically significant, $F(1,27) = 34.85$, $p < .0001$. This result reflects a phenomenon called the room effect, which was discovered for OBJ judgments (1, 2). It appears in the JRD judgment indirectly, because the near and far facing object are in different rooms. The results are also consistent with this interpretation, because the estimate of the JRD angle obtained from the two OBJ angles in the DualOBJ task produced the same near versus far difference, the room effect, because of the OBJ facing object. Neither the main effect of judgment nor the judgment x facing location interaction were statistically significant, $F(1, 27) = 0.82$, $p = .37$, and $F(1,27) = 0.08$, $p = .78$, respectively. The implication is that angles from the JRD directional pointing task can be predicted from the OBJ directional pointing task, a result that is consistent with the assumption that both tasks measure the same underlying spatial memory processes.

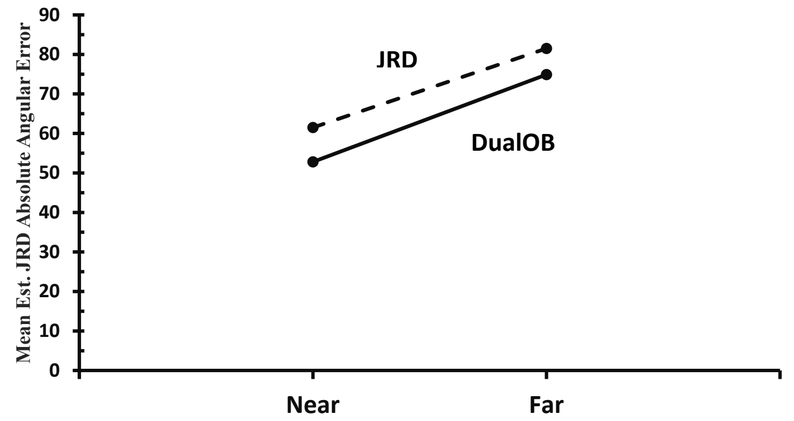


Figure 4. Absolute angular error for JRD angles obtained directly from a JRD directional pointing task and estimated from the DualOBJ directional pointing task, for both near and far facing angles.

Ongoing Experiment 2

Experiment 2 is an additional ongoing test of the relationship between near versus far facing objects. All the objects remained in the same locations and the entire environment and procedure was identical, except for the hallways and the navigation pathway. The doorways to the hallways were removed and doorways were created so that participants could move directly from room to room. Except for the change in initial starting position, within room navigation was the same as in Experiment 1. Direct room to room navigation has been found to reduce or eliminate the difference in angular error for near and far judgments (e.g., 2, 4). Therefore, if the room effect phenomenon produced the JRD increase in absolute angular error for far facing objects compared with near facing objects, then the difference in JRDs for near and far facing locations should be reduced considerably or eliminated in Experiment 2, although the near and far facing angles remain the same and with object in their original rooms.

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