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Describing spatial locations from perception and memory: The influence of intrinsic axes on reference object selection

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ABSTRACT

A target object's location within a configuration of objects can be described by spatially relating it to a reference object that is selected from among its neighbors, with a preference for reference objects that are spatially close and aligned with the target. In the spatial memory literature, these properties of alignment and proximity are defined with respect to a set of intrinsic axes that organizes the configuration of objects. The current study assesses whether the intrinsic axes used to encode a display influences reference object selection in a spatial description task. In Experiments 1–4, participants selected reference objects from displays that were perceptually available or retrieved from memory. There was a significant bias to select reference objects consistent with the intrinsic axes used to organize the displays. In Experiment 5, participants learned the display from one viewpoint, but described it from another viewpoint. Both viewpoints influenced reference object selection. Across experiments, these results suggest that the spatial features underlying reference object selection are the intrinsic axes used to encode the displays.

Introduction

When people describe the location of an object, they often spatially relate it to one of the many surrounding objects in the environment. For example, imagine that your spouse is looking for his or her sunglasses, and you know that they are on the kitchen counter. How would you describe their location? Kitchen counters often contain many objects, and therefore there are many candidate reference objects. You could use the spatial description "Your sunglasses are in front of the microwave," with the sunglasses as the located object and the microwave as the reference object. Alternatively, you could describe their location with respect to other reference objects, such as "by the coffee pot" or "next to the phone." It is typically assumed that a reference object is selected on the basis of properties such as perceptual, conceptual and/or spatial features that make it salient relative to other surrounding objects, and therefore easy to find (e.g., De Vega, Rodrigo, Ato, Dehn, & Barquero, 2002; Miller & Johnson-Laird, 1976; Talmy, 1983). In the sunglasses example, the microwave may be considered perceptually salient because of its large size. In contrast, the phone may be considered conceptually salient, because you just hung up from a phone call. Finally, the coffee pot may be considered spatially salient because its position on the counter is vertically or horizontally aligned with the sunglasses in terms of the viewing perspective.

Among these different salience dimensions, previous research has shown that the spatial features between the located object and the candidate reference objects play a central role in reference object selection (Carlson & Hill, 2008; Craton, Elicker, Plumert, & Pick, 1990; Hund & Plumert, 2007; Miller & Carlson, 2011; Miller, Carlson, & Hill, 2011). For example, Hund and Plumert (2007) found an influence of proximity, such that objects that were closer to the located object were preferred as reference objects.

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Carlson and colleagues (Carlson & Hill, 2008; Miller et al., 2011) found a preference for reference objects that were aligned with the located object, occurring in an on-axis placement that was in a vertical or horizontal direction rather than in an off-axis placement that was in a diagonal direction. Moreover, when these dimensions were directly contrasted, the spatial features were prioritized over perceptual features such as color and over conceptual features such as the functional relations between the two objects. To illustrate, Miller et al. (2011) compared the influence of spatial and perceptual features on reference object selection. Participants were shown scenes containing a located object, two candidate reference objects placed around and at the same distance from the located object, and two distractor objects placed farther away. The spatial features of the candidate reference objects were manipulated, such that one was placed vertically aligned with the located object (on-axis, a preferred location, Hayward & Tarr, 1995; Logan & Sadler, 1996), and the other was placed in an diagonal direction (off-axis) with respect to the located object. The perceptual features were also manipulated, such that one candidate reference object was uniquely colored within the display, and the other candidate reference object shared its color with the located object and the distractors. These features (spatial: on-axis/off-axis and color: unique/shared) were crossed across displays. The key finding was a strong preference for aligned on-axis reference objects, with no influence of whether the objects were perceptually unique.

In the current paper, we extend this work on the importance of spatial features in reference object selection in two directions. First, we link these spatial features of proximity and alignment to the concept of a spatial reference direction (Mou & McNamara, 2002), which corresponds to a preferred organization of a configuration of objects according to a set of intrinsic axes. Second, we examine the influence of these intrinsic axes on reference object selection across three conditions: *perceptual*, *memory*, and *changed perspective*. For the perceptual condition, we consider a situation in which a reference object must be selected from a configuration of objects that are currently in view. In the sunglasses example, this would be analogous to indicating the location of the sunglasses to a person standing in the kitchen who is searching for them on the counters in front of them. The prior work on reference object selection has focused on this type of perceptual situation.

However, we often need to select reference objects in other situations, such as recalling the objects from memory or when viewing the objects from different perspectives over time. Accordingly, for the memory condition, we consider the situation in which a configuration of objects is initially learned, and a reference object must be selected from that configuration from memory at a later point in time when the objects are not perceptually available. In the sunglasses example, this would be analogous to standing in the living room in your house, and describing the location of the sunglasses that are on the counter in the kitchen.

Finally, for the changed perspective condition, we consider the situation in which a configuration of objects is learned from a given perspective, and then a reference object must be selected from this configuration when viewed from a different perspective. In the sunglasses example, this would be analogous to describing the location of the sunglasses when standing at the backdoor – a location that offers a different viewpoint from the one in which you noticed the sunglasses while at the counter in the kitchen.

Spatial reference direction and intrinsic axes

The spatial features of proximity and alignment that have been identified in previous work as being important for reference object selection can be interpreted with respect to the concept of a *spatial reference direction* that comes from the spatial memory literature (Mou & McNamara, 2002). A spatial reference direction corresponds to a set of axes that are imposed on an array of objects that can then be used to define their spatial relationships, much like cardinal directions such as north and east can be applied to large scale places to encode geographic knowledge. These axes are referred to as intrinsic axes, because once applied to the configuration, they effectively assign directions to the configuration (much like assigning top, bottom, left and right sides to an object, or applying cardinal directions, such as north side, west side, and so on). Importantly, the intrinsic axes may adopt their orientation from different sources of information, such as the layout of the objects, environmental properties including the shape of the room or the table upon which the objects are located, or the perspective of the viewer. For example, Fig. 1, Panel A shows a display of seven objects with a set of intrinsic axes (in white) imposed on the configuration. The spatial reference direction that corresponds to this orientation of intrinsic axes could be adopted based on the symmetric axis of the layout (Greenauer & Waller, 2010; Mou, Liu, & McNamara, 2009; Mou & McNamara, 2002), the orientations of the individual objects (Marchette & Shelton, 2010), the rectangular dimensions of the table (Mou, Xiao, & McNamara, 2008; Shelton & McNamara, 2001), or the viewing perspective of a person (Greenauer & Waller, 2008; Shelton & McNamara, 2001) standing at the front of the table at the position labeled with 0°. In Panel A, these sources all orient the axes in the same way. Alternatively, the viewing perspective could be changed to the position at 315° as shown in Panel B. In this panel we show a set of intrinsic axes that are based on the spatial reference direction defined by this viewing perspective; note that this is at odds with the orientation of the axes based on the symmetric axis of the layout and the rectangular dimensions of the table, which would both orient the axes as in Panel A. Finally, Fig. 1, Panel C shows a configuration in which the orientation of the objects and the viewpoint at 315° both correspond to a spatial reference direction with the intrinsic axes defined as in Panel B, whereas the rectangular table and the viewpoint at 0° both correspond to a spatial reference direction with the intrinsic axes defined as in Panel A. These three panels illustrate the idea that there may be correspondence and conflict among these different sources of information. Throughout, we will use the term spatial reference direction to refer to the application of a given set of intrinsic axes to the configuration, oriented with respect to a given source of information (e.g., layout, object orientation, environmental features, viewing perspective).