Journal of Memory and Language 104 (2019) 1–24

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Social and configural effects on the cognitive dynamics of perspective-taking

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ARTICLE INFO

Keywords:
Perspective-taking
Audience design
Spatial instructions
Spatial cognition
Mouse-tracking
Cognitive dynamics

ABSTRACT

How do environmental cues and social perspectives influence perspective selection? Listeners responded to instructions (e.g., "Give me the folder on the right") from a simulated partner, selecting from two objects consistently aligned with themselves (ego-aligned; Experiment 1a) or the speaker (other-aligned; Experiment1b). In Experiment 2, listeners selected from triangular 3-object configurations whose orientation varied (ego-, other-, or neither-aligned). When the configural cue was other-aligned (consistently or inconsistently: Experiments 1b and 2), listeners were more likely to be other-centric. Other-centric responders stabilized their strategy more quickly when the cue was other-aligned, but their mouse trajectories did not exhibit facilitation (Experiment 1b vs. 1a). In Experiment 2, other-centric responders showed sensitivity to the configural cue, making longer and more complex trajectories on neither-aligned configurations. That cue also influenced how listeners interpreted the *front-back* terms. Our findings suggest that configural cues can promote an other-centric strategy and its stabilization, influence response dynamics selectively, and impact the interpretation of spatial language.

Introduction

During various tasks, from navigation to social interaction, humans may consider different perspectives. A perspective that bears on the self, known as the *egocentric perspective* ("left" = "my left"), coincides in most tasks with one's sensorimotor perspective—the perspective capturing self-to-object relations in the immediate environment. But humans can also accommodate a task partner, and take that partner's perspective ("left = "their left"). This is sometimes referred to as the *other-centric perspective*. In this paper, our goal to uncover how different cues shape the cognitive processes involved in perspective-taking. To do so, we adapt a perspective-taking task that tracks computer-mouse movements during perspective choice. By tracking the *dynamics* of perspective choice, in the streaming x, y coordinates of computer-mouse movements during the task, we aim to refine our understanding of how cue integration works.

Many critical cues about perspective reside in the environment. Humans, like all navigating animals, use environmental cues to orient themselves and act in the world. Such configural cues include global features concerning the environment's geometry and symmetry (Shelton and McNamara, 2001; Tversky, 1981), its salient axes (e.g., those formed by prominent streets, Werner & Schmidt, 1999), and the slope of its terrain (Nardi, Newcombe, & Shipley, 2011; Weisberg & Newcombe, 2014), among many more. Beyond such global configural cues, relevant information about how to interact with the world also comes from more local configural cues, such as the direction and orientation of objects in the environment (e.g., Burigo & Sacchi, 2013), the internal elongated axes of the objects (Quinlan & Humphreys, 1993; Sekuler & Swimmer, 2000), and the affordances of those objects (Gibson, 1979; Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010).

Importantly, as social animals, we also use cues about the location and orientation of others in space to guide our language use and actions (e.g., Galati, Michael, Mello, Greenauer, & Avraamides, 2013; Özyürek, 2002). In countless everyday scenarios, the alignment of social perspectives with configural features can provide useful information about others' likely intentions, given the function and affordances of objects, and even cultural convention. For example, when sharing a meal with others, we may take into account the perspective of a dinner guest and place a serving spoon in a location appropriate for their taking a turn with a food item: with the spoon's handle turned toward our guest and the implement's "head" located near or in the food item in question. As this example suggests, we routinely take into account the orientation of others and the orientation of objects in space. However, the way in

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https://doi.org/10.1016/j.jml.2018.08.007
Received 6 November 2017; Received in revised form 21 August 2018

which we do so remains underexplored.

In the current research, we examine the potential interaction of configural and social cues on perspective selection in a task where the linguistic descriptions of space are ambiguous. In our experiments, participants receive verbal instructions from a social partner (albeit simulated) to select one of two or three candidate objects in a common visual space. In target trials, it is ambiguous whether the target object should be selected based on the partner's perspective ("other-centric) or from the participant's perspective ("ego-centric"). Processing ambiguous spatial descriptions in everyday language use is not uncommon, given the multiplicity of options for how spatial terms can be mapped onto space, including the availability of relative/person-centered and absolute/geocentric terms (e.g., Levinson, 2003). Moreover, given constraints of our task, where participants cannot explicitly ask about intended perspective, participants must make a spontaneous choice. What we are most interested in is how this perspective choice, as well as the accompanying cognitive difficulty in making the choice—reflected in the participants' mouse movements—is influenced by subtle changes in the configural organization of the objects. Specifically, we investigate the effects of the convergence between configural (directional or geometric) features of the scene and the participant's vs. the task partner's perspective.

In what follows, we first review evidence concerning the influence of configural cues on spatial reasoning and spatial language use. We then consider how the extant literature addresses the potential integration of such configural cues with social cues about the task partner. As we will point out, with the exception of a few studies using mouse-tracking and eye-tracking methods, little is known about the cognitive dynamics of that integration process. One of the persisting questions is whether configural cues that are spatially aligned with the task partner's perspective facilitate responses from that perspective, as indicated by increased preference for that perspective and more efficient processing. The current study, which we describe in more detail at the end of the Introduction, addresses precisely these questions in a mouse-tracking paradigm.

The role of configural cues on spatial reasoning

There is evidence that configural properties contribute to perspective selection when reasoning about previously experienced scenes. In the domain of spatial memory, configural cues—such as the environment's geometry and geometric properties of objects in the environment—have been shown to influence the ease with which people reason from imagined perspectives about spatial relationships in that environment. In the absence of configural cues, people are typically fastest and most accurate to make spatial judgments from their initially experienced, egocentric viewpoint (Shelton & McNamara, 2001). But in the presence of salient configural cues, the egocentric preference can be overridden, with non-egocentric perspectives exhibiting facilitation instead. For example, people are fastest or most accurate to reason from non-egocentric perspectives when those perspectives are reinforced by the axis of the environment's geometry (Shelton & McNamara, 2001), by the orientation the configuration's constituent objects that have intrinsic axes (i.e., the objects having an intrinsic *front-back*, Marchette & Shelton, 2010), and by the intrinsic axis of the spatial configuration arising from its symmetry (i.e., the symmetrical shape formed by the objects, Mou & McNamara, 2002; Li, Carlson, Mou, Williams, & Miller, 2011) or from its orthogonality (i.e., the number of right angles in that array, Richard & Waller, 2013).

Beyond the domain of memory, the contribution of configural cues to spatial reasoning has also been examined in the domain of "reference frame" selection during spatial language interpretation and production (e.g., Carlson, 1999). A reference frame, in its broadest characterization, is thought to be a representation of a coordinate system for organizing spatial relations, consisting of a set of axes that define space and including parameters such as an origin, scale, direction, and orientation (Logan & Sadler, 1996). A confluence of evidence suggests that geometric properties of objects that are part of spatial configurations play an important role in how people use and interpret spatial descriptions (Burigo & Sacchi, 2013; Burigo, Coventry, Cangelosi & Lynott, 2016; Carlson & Van Deman, 2008; Carlson-Radvansky & Irwin, 1994; Carlson-Radvansky & Logan, 1997). For instance, when objects are presented in non-canonical vs. canonical orientations (e.g., an "upside-down" pumpkin), language users take longer to formulate descriptions of those scenes or to respond to instructions (e.g., "the pumpkin is above the strawberry") by placing objects at the correct location (Burigo & Sacchi, 2013). Recent computational modeling work (Schultheis & Carlson, 2017) further underscores the contribution of contextual information in the environment to reference frame selection, including configural cues about the axes of symmetry and the geometric properties of objects (e.g., about their direction and orientation).

Attributional cues and integration with configural cues

Despite the evidence presented so far that configural cues individually contribute to perspective selection, little is known about how configural cues might interact with other cues, including social ones. Social cues—such as the partner's viewpoint or social attributions about the partner's ability to contribute to the task—have also been shown individually to influence people's memory for spatial arrays (Galati et al., 2013; Shelton & McNamara, 2004), their interpretation of spatial expressions (Duran, Dale, & Kreuz, 2011; Mainwaring, Tversky, Ohgishi, & Schiano, 2003) and their production of spatial expressions (Schober, 1993, 1995, 2009).

For example, social attributions about the task partner serve as a contextual cue that modulates the listeners' perspective strategy. Duran et al. (2011) demonstrated that listeners who responded to spatial instructions (e.g., "Give me the folder on the left") that were ambiguous in some visual contexts, were more likely to interpret these instructions from the partner's perspective when they believed that the partner did not know their viewpoint, whereas they were more likely to interpret these instructions egocentrically when they believed their partner was real (vs. simulated) and thus had the capacity to adopt a perspective other than their own.

This is compatible with findings that speakers adapt their spatial descriptions, by including more spatial details or by being more likely to adopt their partner's perspective, when they perceive the partner to be limited in terms of their ability to contribute to the task (e.g., when the partner is unfamiliar with the environment, Hölscher, Tenbrink, & Wiener, 2011; not able to interact contingently, Schober, 1993; or has worse spatial abilities than they do, Schober, 2009). Collectively, these findings suggest that social cues can provide pragmatic motivation for language users to override the egocentric perspective, despite the presumed associated cognitive cost of adopting the partner's perspective (e.g., Clark & Wilkes-Gibbs, 1986).

Beyond demonstrations that configural cues and social cues individually influence perspective selection, to our knowledge, only recent work by Galati and Avraamides (2015) has systematically parameterized both types of cues to assess their joint contribution to perspective selection. In that study, speakers had to describe a configuration with an axis of symmetry to a partner. Critically, that axis of symmetry was aligned with the speaker's viewpoint, their partner's viewpoint, or neither viewpoint. The speaker's linguistic choices during the description of the configuration, as well as their memory performance (prior to descriptions) were examined. The findings revealed that the speakers' spatial judgments about the previously studied configuration were influenced by the convergence of social and configural cues. When the configuration's axis was aligned with the egocentric perspective, that perspective exhibited facilitation during spatial judgments. When the configuration's axis was aligned with the partner's perspective and this was known in advance, the partner's perspective showed facilitation relative to other headings. Similar patterns were