Boundaries and Prototypes in Categorizing Direction

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Abstract. Projective terms such as left, right, front, back are conceptually interesting due to their flexibility of contextual usage and their central relevance to human spatial cognition. Their default acceptability areas are well known, with prototypical axes representing their most central usage and decreasing acceptability away from the axes. Previous research has shown these axes to be boundaries in certain non-linguistic tasks, indicating an inverse relationship between linguistic and non-linguistic direction concepts under specific circumstances. Given this striking mismatch, our study asks how such inverse non-linguistic concepts are represented in language, as well as how people describe their categorization. Our findings highlight two distinct grouping strategies reminiscent of theories of human categorization: prototype based or boundary based. These lead to different linguistic as well as non-linguistic patterns.

1 Introduction

Imagine you want to divide a circle into four segments, on a piece of paper. A natural solution would be to cut it into quadrants using a vertical and a horizontal stroke of the pen. This segmentation is easy to do and to think about, but surprisingly hard to put into words. Simple direction concepts such as left and right just do not fit very well. However, other ways of categorizing space—for example, based on these simple direction concepts—may serve as natural solutions in other contexts. In this paper, we ask how people categorize direction and how they verbalize these categories, relevant to long-standing debates about human categorization and the relationship between language and thought.

Categorization has been a topic of central interest in psychology and linguistics for many decades (e.g., Smith and Medin, 1981; Taylor, 1989). In the 1970ies, a major paradigm shift led away from previous assumptions that humans distinguish members from non-members of a category by means of essential features.
(boundary-based categorization). Categories are now typically seen as characterized by an idealization of what a perfect member would be, with membership depending on overall perceived similarity to this prototype (Mervis and Rosch, 1981).

In much of the earlier research on categorization, linguistic expressions and non-linguistic concepts were not distinguished very clearly. However, in a different strand of research, the linguistic relativism debate initiated by Whorf (1956) is aimed at determining the extent and directionality of correspondences between language and thought (Bierwisch and Schreuder, 1992; Levinson et al., 2002; Li and Gleitman, 2002). With respect to spatial directions, this relationship has been subject to debate, as we will outline next.

2 Spatial Relations and Their Categorization

It is uncontroversial that the use of projective terms such as left, front, above relies heavily on prototypical axes: turning right invokes a prototypical 90° angle from a view direction just as well as reference to an object on your right does (Tenbrink, 2011), with various linguistic effects when the relevant direction departs from the prototypical axis (Gapp, 1995; Logan and Sadler, 1996; Tenbrink, 2007; Zimmer et al., 1998). While systematic differences emerge depending on the task setting (Vorwerg and Tenbrink, 2007), in particular between dynamic and static uses of projective terms (Herzog, 1995; Hickmann and Hendriks, 2006), existing research shows a stable prototype effect amongst a broad range of tasks.

Regarding the relation to non-linguistic categories, however, the picture is less clear. While Hayward and Tarr (1995) claim that both verbal and non-verbal categories have the same prototype structure, there is compelling evidence that linguistic prototypes for horizontal and vertical directions can correspond to boundaries in non-linguistic categorization (Crawford et al., 2000; Huttenlocher et al., 1991; Klippel and Montello, 2007). This may be due to differences in the specific task and analysis procedures. Hayward and Tarr (1995) showed participants images with configurations of schematic objects. Participants replicated the position of the locatum on a sheet of paper showing only the relatum, or judged the similarity of two consecutively shown configurations. In both tasks, accuracy was greatest when the locatum was on a perpendicular axis. From this, Hayward and Tarr (1995) conclude that verbal and non-verbal categories have the same prototype structure. In contrast, Crawford et al. (2000) and Huttenlocher et al. (1991) presented experiments addressing estimation bias effects in memory tasks. Studies in a large range of domains have demonstrated that humans show an estimation bias away from category boundaries towards prototypes in memory reproduction tasks (Crawford et al., 2000), a fact which can be exploited for analyzing the conceptual structure of human categories. When reproducing the position of a dot in a circle (Huttenlocher et al., 1991), or of a dot in relation to a schematic image of a television (Crawford et al., 2000), participants showed an angular bias of the reproduction towards the center of quadrants, away from the perpendicular axes. Linguistic ratings on the same stimuli, however, show the typical prototype effect. Thus, Crawford et al. (2000)