



Dissociating contributions of head and torso to spatial reference frames: The misalignment paradigm



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A B S T R A C T

When we represent someone's view of a scene as egocentrically structured, where do we represent the origin of the reference frame? By analysing responses in a spatial perspective-taking task as a function of spatial location with respect to both head and torso, we isolated the respective contribution of each part to spatial judgments. Both the head and the torso contributed to judgements, though with greater contributions from the torso. A second experiment manipulating visual contrast of the torso showed that this does not reflect low-level differences in visual salience between body parts. Our results demonstrate that spatial perspective-taking relies on a weighted combination of reference frames centred on different parts of the body.

1. Introduction

In egocentric frames of reference, coordinate axes are locked to one's body and move along with it. Facing east looking at the Duomo in Milan, the Museo del Novecento is to your right and the Galleria is to your left; facing west from the steps of the Duomo, the opposite is true (Bisiach & Luzzatti, 1978). Egocentric representations are perspectival in this sense. They capture a way the world is experienced from an individual's location, in a manner sensitive to how the individual's body is disposed. Hence, what you see as 'to the left' would be seen as 'to the right' for someone facing you. Consequently, egocentric representations are thought to be essential to the self-specifying nature of spatial perception, presenting the world in relation to oneself (Bermúdez, 1998, 2002; Cassam, 1997; Evans, 1982). Moreover, recent research on self-consciousness is dominated by the idea that the experienced first-person perspective should be identified with the point of origin of an egocentric frame of reference (Blanke & Metzinger, 2009; Foley, Whitwell, & Goodale, 2015; Vogeley & Fink, 2003).

This, however, raises a difficulty: human bodies are not points. Rather, they are composed of articulated parts, which can move independently. Accordingly, changes in relative orientation can dissociate frames of reference anchored to different parts. This might affect the way things appear, as Peacocke describes:

Looking straight ahead at Buckingham Palace is one experience. It is another to look at the palace with one's face still toward it but with one's body turned toward a point on the right. In this second case the palace is experienced as being off to one side from the direction of straight ahead, even if the view remains exactly the same as in the first case.

Peacocke, 1992, p. 62

Fig. 1 shows a schematic depiction of Peacocke's scenario. In the left panel, the observer is facing Buckingham Palace directly,

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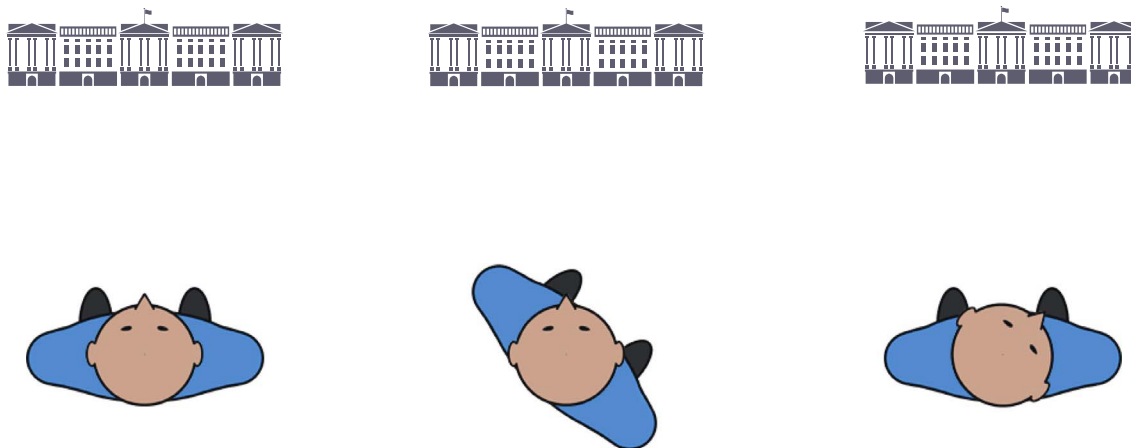


Fig. 1. A schematic depiction of Peacocke's (1992) Buckingham Palace scenario. With both torso and head in alignment, the Palace is directly in front of the observer in both head and torso anchored reference frames (*left panel*). Peacocke asks us to imagine the torso being turned to the right (*centre panel*), expressing the intuition that the Palace would be experienced by the observer as being to the left. This intuition, however, privileges the torso. To fully explore the scenario, the additional case of the head being turned to the right (*right panel*) must also be considered. Would Buckingham Palace also be experienced as to the left in this latter case?

whereas in the centre panel the observer's torso is turned to the right. The intuition here is that the Palace would then be experienced as to the left. Critically, however, this intuition is torso-centric. To probe Peacocke's conclusion, we might adapt the example as shown in the right panel and consider what would happen if the converse were the case: what if one turned one's face to the right while keeping one's body still toward the palace? Would the palace then be experienced as straight-ahead or off to the side? In short, where is the ego in egocentric representation?

As noted above, much of the interest in studying egocentric representation is to learn something about the structure of first-person experience. There are well known difficulties involved in asking subjects to report upon the structure of their own experience (Schwitzgebel, 2011). However, one interpretation of Peacocke's Buckingham Palace scenario above suggests a slightly oblique approach to the problem. When engaging in the thought experiment we are not asked to judge how the world appears from our own perspective, rather we are asked to predict how the world would be experienced from an imagined perspective. This general ability, known as *perspective-taking*, may involve representing any of a large variety of an agent's internal states and their relations to objects and other individuals in their environment (Moll & Meltzoff, 2011). Spatial perspective-taking tasks, in particular, concern spatial relations between an object and an individual (Salatas & Flavell, 1976).

Spatial perspective taking involves a reference frame of a similar kind to an egocentric reference frame, in that both specify how things are presented to an individual viewing a scene from a particular position. But it is not, strictly speaking, egocentric, in that it does not specify how things are presented to the subject herself. Hence, we shall use the term 'alter-egocentric representation' to describe the form of spatial representation employed here (Grush, 2000, 2007) and thus pursue the corresponding question: where is the ego in alter-egocentric representation?

A sense of the range of plausible answers to this question can be gained by considering the complexity of the processes involved in egocentric representation and their connection with the structure of experience. Sensory systems are known to process information in frames of reference anchored to specific body-parts (e.g., Graziano, Yap, & Gross, 1994), as well as hybrid frames involving combinations of these (e.g., Carrozzo & Lacquaniti, 1994), and idiosyncratic frames for transformation between body-part anchored frames (e.g., Chang & Snyder, 2010; Gazzaniga, Ledoux, & Wilson, 1977). Though frames of reference of this kind are often called 'egocentric', some are keen to distinguish this range of body-part anchored coding from the 'egocentric' structure of perceptual experience (Brewer & Pears, 1993; Foley et al., 2015; Levinson, 1996). Indeed, first-person reflection suggests that perceptual experience is unified according to a single perspective (Bayne, 2010; Bermúdez, 1998; Husserl, 1952). To the extent that the perspectival character of experience is due to body-part anchored spatial representation, this would suggest the general hypothesis that information in distinct frames of reference is translated into a single, ultimate frame of reference.

From this general hypothesis, we may draw distinct hypotheses concerning which body-part would anchor an ultimate frame. Research on spatial representation suggests independent motivation for such an ultimate frame being anchored to the head (e.g., Avillac, Denève, Olivier, Pouget, & Duhamel, 2005) or to the torso (e.g., Grubb & Reed, 2002; Karnath, Schenkel, & Fischer, 1991). A key motivation for a head-centric hypothesis is the number and significance of the sensory organs found in the head: the eyes, ears, and the vestibular labyrinth. As Sherrington noted, the latter is a particularly significant source of self-specific information, in that the vestibular system "maintains not merely a limb in flexion or extension, but a posture of the whole animal in regard to gravitation" (Sherrington, 1907, p. 480). But considering morphological structure, the torso is, effectively, the great continent of the body, relative to which other parts are mere peninsulas (Alsmith & Longo, 2014). Accordingly, a key motivation for a torso-centric hypothesis is that the torso is the most stable anchor for the construction of a consistent egocentric representation (Blanck, 2012; Grush, 2000).

8010525741680Both of these hypotheses face a common difficulty, which is that there is a lack of any strong theoretical basis for thinking that there must be such an ultimate frame anchored to a single body part. Correspondingly, there is as yet little exploration

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