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Research report

Selective scene perception deficits in a case of topographical disorientation

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ABSTRACT

Topographical disorientation (TD) is a neuropsychological condition characterized by an inability to find one's way, even in familiar environments. One common contributing cause of TD is landmark agnosia, a visual recognition impairment specific to scenes and landmarks. Although many cases of TD with landmark agnosia have been documented, little is known about the perceptual mechanisms which lead to selective deficits in recognizing scenes. In the present study, we test LH, a man who exhibits TD and landmark agnosia, on measures of scene perception that require selectively attending to either the configural or surface properties of a scene. Compared to healthy controls, LH demonstrates perceptual impairments when attending to the configuration of a scene, but not when attending to its surface properties, such as the pattern of the walls or whether the ground is sand or grass. In contrast, when focusing on objects instead of scenes, LH demonstrates intact perception of both geometric and surface properties. This study demonstrates that in a case of TD and landmark agnosia, the perceptual impairments are selective to the layout of scenes, providing insight into the mechanism of landmark agnosia and scene-selective perceptual processes.

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1. Introduction

Topographical disorientation (TD) refers to a condition in which individuals are not able to find their way, often even in familiar environments. This condition can be caused by deficits relating to differing sub-processes involved in navigation, such as the ability to orient oneself in an environment, the ability to form and remember spatial maps, and the ability to recognize and identify landmarks (Aguirre & D'Esposito, 1999; Barrash, 1998; Landis & Cummings, 1986). The latter is a common feature of TD, referred to as landmark agnosia, usually caused by lesions in the right or bilateral ventral occipitotemporal cortex, including the posterior

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parahippocampal cortex and anterior lingual gyrus (Aguirre & D'Esposito, 1999; Incisa della Rocchetta, Cipolotti, & Warrington, 1996; McCarthy, Evans, & Hodges, 1996; Mendez & Cherrier, 2003; Rainville et al., 2005; Takahashi & Kawamura, 2002).

In individuals with TD relating to landmark agnosia, basic perceptual abilities often are reported to be intact, but a profound deficit in the ability to recognize even very familiar environmental features is reported, resulting in way-finding deficits. It has been proposed that landmark agnosia, while not representing a global perceptual impairment, may stem from subtle perceptual deficits, which lead to specific difficulties in recognition and memory of landmarks (Aguirre & D'Esposito, 1999). Individuals with TD characterized by landmark agnosia often retain semantic knowledge of landmarks and map-based spatial memory. TD can also relate to other features than landmark agnosia, such as heading disorientation, in which individuals cannot derive directional information from landmarks but can still recognize them (Aguirre & D'Esposito, 1999; Hashimoto, Tanaka, & Nakano, 2010). Heading disorientation is accompanied by lesions in the retrosplenial cortex (Aguirre & D'Esposito, 1999; Hashimoto et al., 2010).

Landmark agnosia is distinct from other visual agnosias, such as form agnosia, caused by lesions in the lateral occipital cortex, in which individuals cannot visually recognize objects, but can still identify scenes (Steeves et al., 2004). In fact, in many cases of landmark agnosia, patients are reported to rely on their preserved object recognition abilities in order to compensate for deficits in scene recognition, often focusing on specific details such as windows or doorways in order to identify a particular scene (Aguirre & D'Esposito, 1999; Incisa della Rocchetta et al., 1996). Although many case studies of TD characterized by landmark agnosia have been reported, the underlying mechanism of this selective impairment is still not well understood. It is unknown what stage or what features of landmark recognition are impaired, rendering familiar scenes unrecognizable and hindering navigation abilities. Aguirre and D'Esposito (1999) proposed that individuals with TD and landmark agnosia may be specifically impaired at using high salience environmental features, and in arranging stimuli into scenes. Thus, it is possible that TD relating to landmark agnosia is caused by specific deficits to scene perception. Since basic visual skills and other forms of object and space perception are often intact in such cases, identifying what aspects of scene perception are impaired in cases of landmark agnosia and TD will provide insight into which perceptual processes are unique to the ability to perceive and recognize scenes, which is crucial for navigation.

One possibility is that the geometric or configural processing involved in scene perception is selectively impaired in cases of landmark agnosia and TD, though this has not previously been tested (Mendez & Cherrier, 2003; Rainville et al., 2005). This configural hypothesis is consistent with theories of the function of the parahippocampal place area (PPA), an area that is often damaged in cases of landmark agnosia. It has been proposed that this area is specialized for processing scenes based on features of their spatial layout (Epstein & Kanwisher, 1998). For example, early studies found that the PPA was more active when participants viewed scenes; this was true even if the components of the scene were fractured as long an intact layout configuration of scenes was maintained (Epstein & Kanwisher, 1998). When, however, the fractured components of the scene were rearranged, disrupting the layout, the activity in the PPA was reduced. The authors theorized that the role of the PPA, therefore, was to selectively encode the spatial layout of scenes (Epstein, 2008; Epstein & Kanwisher, 1998; Epstein, Higgins, Jablonski, & Feiler, 2007), and thus, damage to this area would be consistent with selective deficits in recognizing scenes due to an inability to process configural information.

Recent research, however, has highlighted other possible roles of the PPA in perceiving scenes, including a sensitivity to the texture or material properties of scenes and even objects (Cant & Goodale, 2007, 2011; Lowe, Gallivan, Ferber, & Cant, 2016). In two studies, objects of different surface and material properties (e.g., wood, marble, tinfoil) were presented and a region in the collateral sulcus (CoS), typically included in the PPA, was selectively active when participants attended to changes in the texture of the objects as opposed to their forms (Cant & Goodale, 2007; 2011). A more recent study utilizing scenes found robust activity in the PPA when participants attended to both layout and texture, though with increased activity to layout in manufactured scenes, where texture cues were thought to be less informative about the nature of the scene (Lowe et al., 2016). Thus, an alternative to the configural hypothesis is that TD with landmark agnosia may be derived from deficits in processing geometric properties of scenes, such as layout, as well as non-geometric properties including texture, since both are encoded by the PPA (Cant & Goodale, 2007, 2011; Epstein & Vass, 2014; Lowe et al., 2016).

In the present study, we tested LH, a man who developed topographical disorientation with landmark agnosia following bilateral posterior infarcts causing bilateral medial occipitotemporal damage. We tested LH's ability to discriminate perceptual changes pertaining to either the spatial layout or the surface texture of real-world scenes. We compared his performance to an object recognition task, where the shape and surface texture of the objects were varied. Thus, the present study examines whether the perceptual deficits associated with a case of landmark agnosia and TD are specific to either the configural properties or the surface properties of scenes, or both, and if they extend to similar properties in non-scene stimuli. These findings contribute to our understanding of the mechanisms underlying landmark agnosia and our certainty about which visual features are used to recognize scenes and navigate in everyday life.

2. Materials and methods

2.1. *Participants*

LH is male, with 21 years of education, and was 69 years old at the time of testing. Four years prior to testing (February 2011), LH developed topographical disorientation following a brain injury sustained during an automobile accident. Immediately following the injury, LH was reported to have bilateral posterior circulation infarcts and multiple foci of parenchymal and intracranial hemorrhage secondary to the trauma. He

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