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Orientational manoeuvres in the dark: dissociating allocentric and egocentric influences on spatial memory

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Abstract

Subjects in a darkroom saw an array of five phosphorescent objects on a circular table and, after a short delay, indicated which object had been moved. During the delay the subject, the table or a phosphorescent landmark external to the array was moved (a rotation about the centre of the table) either alone or together. The subject then had to indicate which one of the five objects had been moved. A fully factorial design was used to detect the use of three types of representations of object location: (i) visual snapshots; (ii) egocentric representations updated by self-motion; and (iii) representations relative to the external cue. Improved performance was seen whenever the test array was oriented consistently with any of these stored representations. The influence of representations (i) and (ii) replicates previous work. The influence of representation (iii) is a novel finding which implies that allocentric representations play a role in spatial memory, even over short distances and times. The effect of the external cue was greater when initially experienced as stable. Females out-performed males except when the array was consistent with self-motion but not visual snapshots. These results enable a simple egocentric model of spatial memory to be extended to address large-scale navigation, including the effects of allocentric knowledge, landmark stability and gender.

Keywords: Spatial updating; Visual snapshot; Viewpoint; Frame of reference; Ideothetic; Landmark

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1. Introduction

How do we remember the locations of objects in the world? Previous experiments using the spatial updating paradigm (Simons & Wang, 1998; Wang & Simons, 1999) have illustrated the presence of two types of representation in memory for the locations of objects in an array. One acts like a visual snapshot of the array[1] that can best be used when the array is in the same configuration relative to the viewer as it was at presentation. The second is an egocentric representation of locations that can be internally updated to accommodate self-motion. Wang and Spelke (2002) have recently argued that these two types of representation, together with a process by which disoriented subjects can re-orient themselves (see Hermer & Spelke, 1994), are sufficient to provide the cognitive basis for human spatial memory and navigation. This model also appears consistent with evidence for automatic updating of locations to accommodate self-motion (Farrell & Robertson, 1998; Farrell & Thomson, 1998; Presson & Montello, 1994; Rieser, 1989) as well as results indicating a cumulative updating process in tasks where the subject's memory is tested from a different viewpoint than that presented (Diwadkar & McNamara, 1997; Easton & Sholl, 1995; Wraga, Creem, & Proffitt, 2000). It is a simple and clear example of the theoretical position that memory for the locations of objects depends solely on egocentric representations (Roskos-Ewoldsen, McNamara, Shelton, & Carr, 1998; Scholkopf & Mallot, 1995; Wang & Spelke, 2000).

In a classic spatial updating experiment (Wang & Simons, 1999), following Rieser (1989), subjects view an array of objects on a circular table and, after a brief delay, indicate which one has been moved. Between presentation and test the table or the subject can be moved to provide four conditions: *no change*, *subject* rotation, *table* rotation, *subject & table* rotation in the same direction. Although not presented in this way, the experiment can be thought of as a 2×2 factorial design in terms of the consistency of the test array with visual snapshots or egocentric representations that are internally updatable by self-motion. The test array is consistent with visual snapshot representations in conditions *no change* and *subject&table* because subjects see the same view of it at presentation and test, and consistent with updatable egocentric representations in conditions *no change* and *subject* because the array maintains its position relative to an inertial frame of reference. Performance in condition *table* (inconsistent with both types of representation) can be considered as a baseline above which performance is raised by the effects of consistency with visual snapshot or updatable egocentric representations, assuming that the more appropriate of the two representations will be used where they conflict (as in, e.g. the selection of sensory or motoric representations of path Lambrey, Viaud-Delmon, & Berthoz, 2002). Improved performance was found when the test array would be consistent with updatable egocentric representations or with visual snapshots, and the effect was greater for the former type of representation. See Fig. 1.

However, there is evidence that spatial behaviour in larger-scale environments can be influenced by external landmarks (Acredolo, Pick, & Olsen, 1975; Herman & Siegel, 1978; Jacobs, Thomas, Laurance, & Nadel, 1998; Mallot & Gillner, 2000; Presson, 1987;

[1] This type of representation is also referred to as the 'retinal projection' of the array (Simons & Wang, 1998; Wang & Simons, 1999). We prefer 'visual snapshot' because of the lack of visual fixation.