



A dissociation between mental rotation and perspective-taking spatial abilities

Mary Hegarty^{a,*}, David Waller^b

^a*Department of Psychology, University of California, Santa Barbara, Santa Barbara, CA 93106-9660, USA*

^b*Miami University, Oxford, OH, USA*

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Abstract

Recent psychometric results [Mem. Cogn. 29 (2001) 745] have supported a distinction between mental abilities that require a spatial transformation of a perceived object (e.g., mental rotation) and those that involve imagining how a scene looks like from different viewpoints (e.g., perspective taking). Two experiments provide further evidence for and generalize this dissociation. Experiment 1 shows that the separability of mental rotation and perspective taking is not dependent on the method by which people are tested. Experiment 2 generalizes the distinction to account for perspective taking within perceived small-scale and imagined large-scale environments. Although dissociable, measures of perspective taking and mental rotation are quite highly correlated. The research suggests some reasons why psychometric studies have not found strong evidence for the separability of the spatial visualization and spatial orientation factors, although a strong dissociation between tasks that are dependent on mental rotation and perspective-taking processes has been found in the experimental cognitive literature.

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1. Introduction

Psychometric studies of spatial ability (e.g., Carroll, 1993; Eliot & Smith, 1983; Lohman, 1979, 1988; McGee, 1979) have identified several different spatial abilities factors. One of these factors, spatial visualization, involves the ability to imagine the movements of objects and spatial forms.

* Corresponding author. Tel.: +1-805-893-3750.

E-mail address: hegarty@psych.ucsb.edu (M. Hegarty).

Typical markers for these factors involve tests of mental rotation,¹ form board tests, and surface development tests (which, for example, test the ability to image the folding and unfolding of pieces of paper). A second spatial factor, spatial orientation, is proposed to measure an ability to imagine the appearance of objects from different orientations (perspectives) of the observer (McGee, 1979). The most commonly used marker for this ability is the Guilford and Zimmerman (1948) Spatial Orientation Test, in which observers are shown two different views of a landscape from the prow of a boat, and have to determine how the boat has changed position from the first to the second view (see Ackerman & Kanfer, 1993; Egan, 1981; Eliot & Smith, 1983 for examples of other, less studied, spatial orientation tests).

As they are conceptualized, tests of spatial visualization and tests of spatial orientation involve different types of mental spatial transformations. These transformations require the viewer to update relations between three different spatial frames of reference; the intrinsic reference frames of objects, the egocentric reference frame (centered on one's body), and the reference frame of the environment (Zacks, Mires, Tversky, & Hazeltine, 2000). The spatial visualization factor has been conceptualized as the ability to make object-based spatial transformations in which the positions of objects are moved with respect to an environmental frame of reference, but one's egocentric reference frame does not change. In contrast, the spatial orientation factor has been interpreted as the ability to make egocentric spatial transformations in which one's egocentric reference frame changes with respect to the environment, but the relation between object-based and environmental frames of reference does not change (Thurstone, 1950).

Although several investigators have supported the existence of a spatial orientation factor that is separable from spatial visualization (Guilford & Zimmerman, 1948; McGee, 1979; Thurstone, 1950), many studies have questioned this distinction. Markers for the two factors are often highly correlated, and sometimes approach the reliabilities of the tests themselves (Borich & Bauman, 1972; Goldberg & Meredith, 1975, Price & Eliot, 1975; Roff, 1952; Vincent & Allmandinger, 1971). In a major meta-analysis of the factor-analytic research, Carroll (1993) failed to find evidence for the separability of spatial orientation from spatial visualization. Although he generally supported the distinction of spatial orientation from spatial visualization, Lohman (1979) also concluded that the Guilford–Zimmerman Spatial Orientation Test and Spatial Visualization Tests do not measure different factors.

In contrast to the psychometric literature, a strong dissociation has been found in the experimental cognitive literature between tasks that depend on object-based spatial transformations and those that depend on egocentric spatial transformations (Amorim & Stucchi, 1997; Huttenlocher & Presson, 1973, 1979; Presson, 1982; Simons & Wang, 1998; Wang & Simons, 1999; Wraga, Creem, & Proffitt, 2000; Zacks et al., 2000). In a typical study, observers are shown an array of objects and are asked questions about the positions of the objects after imagining either a rotation of the array or a rotation of themselves around (or within) the array. Although the outcomes of object rotations and self-rotations are equivalent (e.g., a rotation of an array of objects by 90° clockwise produces the same result as a rotation of oneself around the array by 90° counterclockwise), these two tasks are not equivalent in difficulty. The relative difficulty of object rotation tasks and self-rotation tasks depends on factors such as how the question is asked (Huttenlocher & Presson, 1973, 1979; Presson, 1982), whether a single object or an array of objects is rotated (Wraga et al., 2000), and whether or not people physically move themselves or the

¹ Speeded tests of mental rotation in two dimensions sometimes define a factor known as “spatial relations” or “speeded rotation” that is somewhat separable from spatial visualization (Carroll, 1993; Eliot & Smith, 1983; Lohman, 1988).

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