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What constitutes effective wayfinding directions: The interactive role of descriptive cues and memory demands

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ABSTRACT

The main goal was to understand the interactive role that descriptive cues and memory demands play in wayfinding effectiveness. Participants followed directions containing route or survey cues from memory or read them piecemeal during wayfinding in a complex indoor environment. They also provided effectiveness ratings for the directions before and after wayfinding. Route cues resulted in higher effectiveness ratings and faster wayfinding with fewer errors than did survey cues. Interestingly, using piecemeal directions resulted in higher effectiveness ratings and fewer errors, but relying on memorized directions resulted in faster wayfinding. As expected, cues and memory demands interacted such that wayfinding was faster when using route cues than when using survey cues only when reading directions piecemeal. Moreover, women were faster during wayfinding when using route cues relative to survey cues, but men showed no difference in wayfinding time. Together, these findings provide important details about wayfinding processes.

Finding our way through the environment is necessary every day. Often, people rely on directions from others to facilitate wayfinding. These directions may contain route cues, such as left-right turns and landmarks, and survey cues, such as cardinal directions and distances (Galea & Kimura, 1993; Lawton, 1994; Prestopnik & Roskos-Ewoldsen, 2000; Taylor & Tversky, 1996). A growing number of studies suggest that route cues are most effective in terms of preference ratings and success in finding a destination (Daniel, Tom, Manghi, & Denis, 2003; Denis, Pazzaglia, Cornoldi, & Bertolo, 1999; Hund & Padgitt, 2010; Padgitt & Hund, 2012); however, the effectiveness of cues may depend upon the situation in which they are used (Chai & Jacobs, 2009). In fact, some studies suggest that survey cues facilitate efficient wayfinding through indoor environments and model towns despite ratings indicating preferences for route cues (Hund & Minarik, 2006; Hund & Nazarczuk, 2009). It is possible that these contradictory findings depend, in part, on the complex interaction of memory demands, such as differences in cue efficiency when finding a destination using a written set of directions or relying only on memory. The goal of the present study was to specify what constitutes effective wayfinding directions. In particular, we sought to specify the interactive role that wayfinding cues and memory demands play in determining direction effectiveness measured using ratings and wayfinding indices. Another goal was to investigate how individual differences in spatial skills relate to effectiveness, possibly adding clarity regarding conflicting patterns of results.

Wayfinding involves two strategies derived from perspective (Taylor & Tversky, 1996). The first strategy, a route strategy, involves adopting an intrinsic perspective such that the point-of-view originates from the wayfinder. Typically, locations are described using descriptors such as left, right, front, or back (e.g., "To get to the café, take a left at the gas station and go straight. The café will be on the right."). So, in this example, after turning left at the gas station, the café is on the right from the point-of-view of the wayfinder. The route strategy unfolds segment by segment, adopting the traveler's viewpoint that is updated with each turn. The second strategy, a survey strategy, involves adopting a fixed reference frame using the surrounding environment (e.g., a bird's-eye point-of-view; Allen, 2000; Taylor & Tversky, 1996). Typically, locations are described in terms of cardinal descriptions such as north, south, east, or west and distances (e.g., "To get to the café, turn west at the gas station. Travel west 25 m; the café is on the north side of the road.").

One question is whether wayfinding directions containing route or survey cues are more effective. How do we determine the

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effectiveness of wayfinding directions? Lovelace, Hegarty, and Montello (1999) outlined two possibilities. First, researchers can utilize effectiveness ratings, asking participants how effective a route would be in facilitating wayfinding to a destination. Overall, directions containing landmarks often receive higher effectiveness ratings (Denis et al., 1999; Lovelace et al., 1999). For example, Padgitt and Hund (2012) asked participants to rate a set of directions that included route and survey cues. As expected, directions containing route descriptors (i.e., left/right and landmarks) received higher ratings than did directions containing survey descriptors (i.e., cardinal directions and distances).

A second way to determine the effectiveness of wayfinding directions is to measure behavioral indices of wayfinding (Lovelace et al., 1999). For example, researchers often record the duration of a wayfinding experience and the number of errors incurred as a wayfinder locates a destination using a particular set of directions. Adopting this approach, Allen (2000) found that adults committed fewer errors when using directions containing route descriptors relative to survey descriptors. Similarly, Denis et al. (1999) found that people who followed directions containing more route cues committed fewer errors than did people who followed directions containing fewer of these cues while walking to destinations in Venice. Additionally, when asked about their preferences, participants often indicate that route cues such as landmarks are one of the most helpful features of effective wayfinding directions (Hölscher, Tenbrink, & Wiener, 2011; Hund & Padgitt, 2010; Padgitt & Hund, 2012; Ward, Newcombe, & Overton, 1986). Although these findings indicate that using route cues is more effective, other results suggest that survey cues are more effective, leading to discrepancies in the literature. For example, Chai and Jacobs (2009) found that using a survey strategy correlated with better wayfinding performance during a directional wayfinding task. Hund and Minarik (2006) found that survey descriptors led to more efficient wayfinding (e.g., faster times and fewer errors) through a model town than did route descriptors. Additionally, Hund, Haney, and Seanor (2008) found that participants found a destination faster in a model town following directions that contained a large proportion of survey cues, despite rating these directions as less effective.

It is possible that these discrepancies may be due, at least in part, to the nature of the wayfinding task at hand, especially with regard to working memory demands. For example, Denis et al. (1999) asked participants to study a set of directions for 2 min and then find a destination within Venice based on memory. In this task, route cues led to more effective wayfinding. Alternatively, other studies have asked participants to follow written directions piece by piece in a building or a scale model of a building or town (Hund et al., 2008; Hund & Padgitt, 2010; Padgitt & Hund, 2012). It is possible that differences in memory demands led to different patterns of results with regard to cue effectiveness. Clearly, following directions from memory differs in many important ways from following directions piece by piece, including differences in memory demands. Recently, Meilinger, Knauff, and Bülthoff (2008) examined the role of working memory in wayfinding using a dual task paradigm. Participants learned two routes through a virtual environment of a city while completing visual, spatial, or verbal secondary tasks or no secondary task. At test, participants were asked to retrace the routes to find goal locations. Performance was hindered with verbal and spatial secondary tasks, but not with the visual secondary task, indicating that verbal and spatial working memory are required for wayfinding (see also Garden, Cornoldi, & Logie, 2002; Wen, Ishikawa, & Sato, 2011). These findings suggest that it is important to examine how the memory demands involved in following wayfinding directions from memory or in piecemeal fashion influence performance.

In addition to probing the interactive influence of descriptive cues and memory demands, another aim of this study was to determine the relation between individual differences in spatial skills and effectiveness (see also Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006; Malinowski & Gillespie, 2001). Confidence in one's ability to keep track of one's location within an environment is known as sense of direction (Kozlowski & Bryant, 1977). Past studies have measured sense of direction via self-report measures and behavioral indices related to the accuracy of pointing to unseen locations (e.g., Hund & Nazarczuk, 2009). In general, sense of direction is related to wayfinding effectiveness, such that as sense of direction increases, so does performance during wayfinding (i.e., decreases in time and number of errors; Hund & Nazarczuk, 2009; Kato & Takeuchi, 2003). Kato and Takeuchi (2003) found that people with a good sense of direction adopt an optimal strategy for a given situation, whereas people with poor sense of direction have more difficulties. Given there are myriad wayfinding contexts, however, Kato and Takeuchi suggested that more work was needed to discern which strategies work best and under which conditions strategies might flourish.

Another factor that may be related to wayfinding effectiveness is mental rotation—the ability to process spatial details by mentally rotating objects or environmental features. The Mental Rotation Test (MRT; Vandenberg & Kuse, 1978) is a well-established measure in which participants indicate which rotated three-dimensional objects match a target object. De Beni, Pazzaglia, and Gardini (2006) showed that mental rotation ability was related to map learning, such that individuals who scored higher on the MRT were better able to learn maps. Additionally, Padgitt and Hund (2012) found that mental rotation ability was inversely related to wayfinding errors when participants used survey cues during wayfinding. These findings appear to link mental rotation ability with survey strategies and wayfinding ability. Other findings demonstrate that greater feelings of spatial anxiety relate to poorer spatial abilities. For example, spatial anxiety is negatively related to survey strategy preference and positively related to route strategy preference (Hund & Padgitt, 2010; Lawton, 1994). Additionally, people who reported greater spatial anxiety made more errors during a wayfinding task, suggesting that spatial anxiety may play a role in wayfinding effectiveness (Hund & Minarik, 2006).

The main goal of this study was to understand the interactive role that descriptive cues and memory demands play in wayfinding effectiveness. Specifically, we examined the difference between experiencing directions containing route or survey cues in a piecemeal fashion vs. relying on memory for the directions. We measured effectiveness ratings and behavioral indices of wayfinding (i.e., time and errors) using the same sets of directions. We expected higher effectiveness ratings for route cues than for survey cues given previous illustrations of preference for route cues (Allen, 2000; Hund & Padgitt, 2010; Hölscher et al., 2011; Padgitt & Hund, 2012). Although previous evidence is mixed regarding the influence of route and survey cues on wayfinding time and errors (Allen, 2000; Hund & Minarik, 2006; Padgitt & Hund, 2012), we expected route cues to lead to faster and more accurate wayfinding, though it is possible that this effect would interact with memory demands. Another goal was to understand the relation between individual differences in spatial skills and wayfinding effectiveness. We expected tight links between survey strategy preference, mental rotation, sense of direction, and effective wayfinding performance and also between route strategy preference and spatial anxiety. In addition, we expected survey and route strategy preferences to mediate the relation between individual differences (i.e., mental rotation, sense of direction performance, and spatial anxiety) and wayfinding time and errors.