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Instruction of verbal and spatial strategies for the learning about large-scale spaces

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ABSTRACT

This study examined the effects of instruction on verbal and spatial strategies on the learning about large-scale spaces by people with different levels of sense of direction. 103 participants learned two routes from a video, first without instruction and second with verbalization, spatial operation, or no instruction. For landmark learning, people with a good sense of direction benefited from both verbalization and spatial operation, and people with a poor sense of direction benefited from verbalization only. For survey learning, verbalization had a disruptive effect, and people with a good sense of direction did worse with instruction, either verbal or spatial. By contrast, survey learning by people with a poor sense of direction was not affected by verbalization or spatial operation, indicating their difficulty with survey learning and insensitivity to strategy instruction.

1. Introduction

Learning about new environments is an important ability or skill for our daily lives, but it shows large individual differences: Not all people can remember novel routes or comprehend spatial relations accurately with limited, and even with accumulated, experience (Ishikawa & Montello, 2006). In the literature (e.g., Siegel & White, 1975), knowledge about large-scale spaces has been discussed in terms of three types: landmark knowledge (knowledge of discrete objects or scenes), route knowledge (knowledge of sequences of landmarks and associated actions), and survey knowledge (configurational, map-like knowledge). Importantly for the development of spatial knowledge, the acquisition of survey knowledge requires separately learned landmarks and routes being interrelated with each other in a common frame of reference. People with a good sense of direction can do that after traveling a new route a few times, whereas people with a poor sense of direction cannot (Ishikawa & Montello, 2006). Namely, knowledge by people with a poor sense of direction stays at the levels of landmark and route knowledge after repeated exposures to the route.

Such difficulty with spatial learning points to the theoretical and pedagogical importance of improving its ability, as reflected in the recent recognition of the significance of spatial thinking in various branches of science and engineering and in everyday life (National Research Council, 2006; Newcombe, 2010). Past studies suggested the possibility of improving spatial abilities through instruction (e.g., Wright, Thompson, Ganis, Newcombe, & Kosslyn, 2008), but failed to provide consistent results about the transfer of the trained skills (e.g., Kyllonen, Lohman, & Snow, 1984; Richardson, Powers, & Bousquet, 2011; Vasta, Knott, & Gaze, 1996). Also, small-scale spatial learning has been shown to be related, but not equivalent, to large-scale spatial learning (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006).

To the best of our knowledge, no research has yet examined the possibility of enhancing large-scale spatial learning through instruction of specific types of information processing (cf. the study by Cornell, Heth, and Rowat (1992), which examined effects of strategies on children's and adults' route learning). The present study addresses this question focusing on two types of learning strategies: verbalization (to speak out the things that they notice along a route) and spatial operation (to move and locate small objects on a desk according to movements along the route).

Details of the strategies to be examined in this study are explained in the Method section, but a comment is in order regarding the rationale for the spatial strategy. In the spatial operation, participants were asked to move a model car and a small object on a desk according to movements along a route. It intended to help participants construct "mental maps" by transforming horizontal route views into a vertical perspective. Although differences exist in the types of body movements (arm movements vs. body rotation) and spatial scale (environmental routes vs. figural shapes), past research on the effects of providing kinesthetic information on spatial learning (e.g., Klatzky, Loomis, Beall, Chance, and Golledge (1998), which found facilitation of the learning of spaces, and Yoshimura (1994), which found the enhancement of

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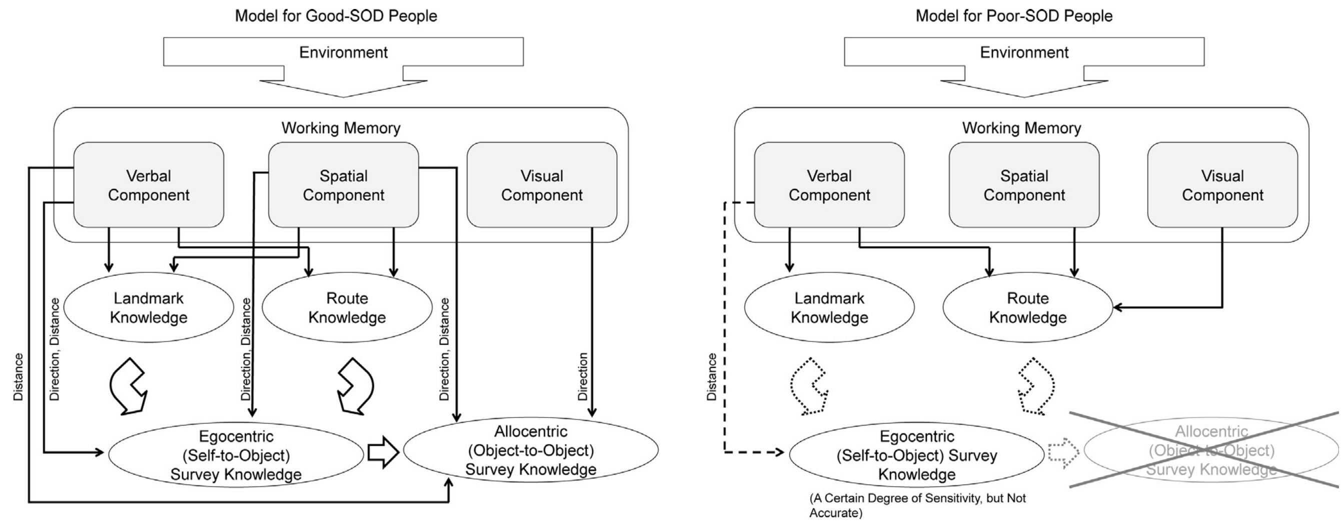

Fig. 1. Model of spatial knowledge acquisition. Black arrows indicate the encoding processes for three types of spatial knowledge; white arrows indicate the integration of landmarks and routes and the transformation from egocentric to allocentric survey knowledge.
From "Individual differences in the encoding processes of egocentric and allocentric survey knowledge," by Wen et al., 2013, *Cognitive Science, 37*, p. 189. Copyright 2012 by the Cognitive Science Society, Inc. Reproduced by permission of the publisher.

the memory for complex figures) provided insights into the development of the spatial operation.[1]

The effects of different types of instruction can be discussed in reference to Wen, Ishikawa, and Sato's (2011, 2013) model for individual differences in the encoding processes of large-scale spatial knowledge. The researchers showed that people with a good sense of direction (SOD) use a rational combination of verbal, visual, and spatial components of working memory, while people with a poor SOD rely mainly on a verbal process (Fig. 1). Based on the results, they proposed a model that posits that people with a good SOD encoded landmarks and routes verbally and spatially, and integrated knowledge about them into survey knowledge with the support of all three components of working memory. In contrast, people with a poor SOD encoded landmarks only verbally and lacked spatial processing, thus failing to acquire accurate survey knowledge.

This model allows us to make hypotheses about possible effects of the verbalization and spatial operation. One possibility is that people would do better when they encode information through the process that they usually use (black arrows in Fig. 1). If so, for landmark knowledge, people with a good SOD would benefit from both verbalization and spatial operation, whereas people with a poor SOD would benefit from verbalization but not from spatial operation. For route knowledge, people with a good and poor SOD would benefit from both verbalization and spatial operation, as both processes are involved in route learning (see Fig. 1).

By contrast, for survey knowledge, there may be some alternative possibilities, due particularly to the elaborate processing required for the transition from landmark-route knowledge to survey knowledge. For people with a good SOD, one possibility is that they would do better with verbalization and spatial operation, as the two processes are both involved in the acquisition of accurate survey knowledge (Fig. 1). A second possibility is that they might do equivalently with or without instruction, because they can acquire accurate survey knowledge from the start. A third possibility is that they might do worse with verbalization because of the "spatial" nature of the processing required for survey understanding. In contrast, for people with a poor SOD, they might do better with verbalization and spatial operation, because these are the processes that good-SOD people use. Or alternatively, poor-SOD people might be insensitive to either instruction, because of the difficulty that they naturally have with survey understanding.

There are some other past studies that are also suggestive. Concerning verbal strategies, researchers found that verbalization facilitated verbal problem solving but hindered spatial problem solving (Gagne & Smith, 1962; Gilhooly, Fioratou, & Henretty, 2010), and that verbalizing non-verbal information impaired recognition memory possibly because of a shift from configural to featural processing (Fiore & Schooler, 2002; Meissner & Brigham, 2001; Schooler, 2002). Concerning spatial strategies, Gyselinck, Meneghetti, De Beni, and Pazzaglia (2009) showed that instruction of an imagery strategy activated visuospatial working memory and improved spatial text processing. Therefore, in the present case, it may be hypothesized that inasmuch as landmark and route knowledge are considered featural rather than configural, the acquisition of these two types of knowledge could be facilitated by verbalization. In contrast, the acquisition of survey knowledge, which requires configurational understanding, could be facilitated by spatial operation.

These possibilities are examined empirically in this study, with the differences in the types of knowledge and level of sense of direction taken into consideration. That is, while the Wen et al. (2011, 2013) studies revealed the differences in the encoding processes by disrupting specific processes in a dual-task approach, the present study seeks to examine the effects of instructing or inducing people to use specific processes on the learning about large-scale spaces.

2. Method

2.1. Participants and design

A total of 103 college students (56 men and 47 women) participated in the experiment in return for monetary compensation. Their mean age was 23.9 years ($SD = 3.5$) and they had no prior experience with the study area. The participants were assigned to one of three instructional conditions: 40 participants (18 men and 22 women) to a verbalization condition, 40 (25 men and 15 women) to a spatial-operation condition, and 23 (13 men and 10 women) to a control condition. The allocation was conducted randomly, with the constraint that we aimed to have as many participants as possible in the two instruction conditions.

[1] Drawing a sketch map on a piece of paper while learning the route may be another possible instructional strategy, but its effects may be interpreted as either visual or spatial, which are not easy to disentangle. Inasmuch as the visual processing was not specifically examined in this study and existing research into the effects of instruction on large-scale spatial learning is scarce, our design of the strategies is exploratory but should provide insights for further research.