

Is the Development of Environmental Knowledge in Human Wayfinding Sequential or Simultaneous?

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Abstract

The purpose of this study is to understand the steps of human wayfinder develop environmental knowledge and associating factors. Understanding how humans acquire environmental knowledge contributes to designing and improving navigational aids. The knowledge we use to solve wayfinding problems—environmental knowledge—is classified into landmark-, route-, and survey-based categories. Different from the traditional and dominant framework which suggests the acquisition of these types of knowledge takes place sequentially, growing efforts have been made to investigate an alternative framework that argues the simultaneous acquisition of environmental knowledge. After being trained in an unfamiliar environment through active exploration on an indoor route, participants in this experiment performed spatial tasks including wayfinding in one of three different navigational landmark scenarios (landmarks with directions, landmarks without direction, and no landmarks). Results support the hypothesis that knowledge acquisition does not follow the dominant framework but the alternative framework. Furthermore, landmarks served promisingly for recognition of locations but weakly for the development of survey knowledge. Furthermore, sense of direction had a positive effect on development of survey knowledge in the scenario where landmarks were unavailable.

Background and Relevance

Wayfinding in large-scale unfamiliar spaces requires the development of a mental representation to support spatial decision making (Golledge, 1999). Research on human wayfinding behavior contributes to our understanding of environmental acquisition and related applications, such as navigational systems and mapping services. Environmental knowledge has been studied extensively; one outcome of this research is a traditional classification framework for that knowledge. The accepted and traditional framework consists of three categories: landmark-, route- and survey-knowledge (Siegel & White, 1975). However, the strict sequencing of the three categories (landmark, then route, then survey) and the transition of the knowledge from non-metric to metric has intrigued researchers who search for a clearer understanding of how we acquire knowledge from the environment and correspondingly the navigation strategies for which this knowledge is used. In contrast to the traditional framework, an alternative framework proposes that knowledge at all levels is acquired simultaneously and refined quantitatively through experience (Montello, 1998). Therefore, the primary goal of this study is to investigate whether metric survey knowledge is developed during the earliest stages of acquisition. If so, the next consideration is how the characteristics of an environment, especially landmarks, contribute to the development of environmental knowledge.

Methods and Data

An experimental route was planned on the first floor of a campus building at the University of Saskatchewan. Except one group which consisted of 9 male and 11 female students, 31 female and 29 male students were randomly divided into three groups with equal number of males and females. None of them had previous experience in this building before the experiment.

All of the experimental sessions were carried out on a one-on-one basis in the following order: route training, directional estimation, route retracing, and directional estimation. Each participant was in one of three unique conditions:

1. Learning and retracing with navigational landmarks indicating right and left turns at decision points;
2. Landmarks indicating left and right were present during training but replaced with generic landmarks during retracing;
3. Landmarks indicating left and right were present during learning but completely removed before retracing started.

Directional estimation consistent with a validated procedure (Bell & Saucier, 2004) was conducted at the arrival of both destination and origin. Each participant's estimations were compared to the actual angle; hence the resulting absolute errors were recorded in the range between 0° and 180° .

Results

The absolute pointing errors are compared in two different ways. First comparison is between the two directional estimations by the same group. Group 3 ($F(1,19)=2.742$, $p=0.008$) showed significant pointing improvement on accuracy in the estimation, while there was no improvement in pointing accuracy in groups 1 ($F(1,19)=-0.198$, $p=0.845$) and 2 ($F(1,19)=-0.766$, $p=0.448$). This was followed by the comparison between groups on the first pointing task. Since each participant learned the route in the same way, there were no difference among the groups in the first pointing task ($F(2, 57) = 0.087$, $p = 0.916$). In addition, all angular estimations were better than chance performance (90°).

The main purpose of the second comparison was to examine the contribution of different environmental characteristics to the development of survey knowledge. Among all three pairs there was a significant difference between group 2 and 3 ($F(1,38)=4.634$, $p=0.038$). No significant difference was found between group 1 and 2 ($F(1,38)=0.001$, $p=0.978$) but a marginal significance was found between group 1 and 3 ($F(1,38)=3.361$, $p=0.075$). The presence or absence of landmarks appears to be important to the development of survey knowledge.

First of all, the initial knowledge people obtain when they travel into a new environment is not limited to landmark knowledge as suggested in traditional framework. Instead,

the process of acquiring metric and non-metric environmental knowledge starts simultaneously at the earliest stages. In particular, survey knowledge is acquired along with more primitive forms of spatial and non-spatial knowledge, although its improvement depends on the experiences with the environment.

Conclusions

The alternative framework is supported by these experimental results. Even though different levels of knowledge develop simultaneously at a wayfinder's initial exposure to an unknown environment, the refinement of environmental knowledge is influenced by the nature of the environment in which learning occurs as well as the type of navigational assistance available in that environment. Additionally, the contribution of landmarks to the improvement of survey knowledge is very weak. Based on the experimental results it actually inhibits the development of some survey knowledge.

It was suggested that the sequence we acquire environment knowledge appeared to be the same order that we utilize the acquired knowledge (Lawton, 1996). The assessment of the alternative framework establishes the basis for further examination on utilization of wayfinding strategies and their sequence of use.

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