

# ORIENTATION INFORMATION IN DIFFERENT FORMS OF ROUTE INSTRUCTIONS

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## Abstract

Providing quality and easy-to-follow route instructions has been an ongoing research interest. This exploratory work attempts to determine types of information in route instructions that support orientation and cognitive mapping during wayfinding. This study examined a set of 20 verbal route instructions and 18 sketch maps collected from participants. Verbal instructions are first compared with machine generated instructions. Verbal route instructions are then examined based on the adaption of methodology used in generating skeletal descriptions and our addition of categories that emphasize orientation using landmarks. We also consider global landmarks included in both verbal instructions and sketch maps that are off route but supportive for orientation. Results show that human verbal instructions include landmarks and use them intensively for direction and orientation. Results also show that human instructions include both local and global landmarks while sketch maps use more global landmarks for orientation. Landmark types are further analyzed, which shows that in addition to the instructions of turning direction at decision points, participants use landmarks along the route to maintain orientation or direct non-turning movement.

## 1 Introduction

The goals of cognitive wayfinding instructions research include making route instructions less complex, identifying decision points easier, and computing efficient route [1-3]. We further introduce another important goal: providing wayfinding instructions that facilitate person's orientation and cognitive mapping. We initiate our study by investigating the importance of orientation information in different types of route instructions: verbal descriptions, machine generated descriptions, and sketch maps. Results shed light on the providence of instructions for wayfinding that enhance wayfinders' orientation and cognitive mapping.

## 2 Related work

### 2.1 Cognitive Wayfinding

Research on cognitive wayfinding has focused on three aspects: route instructions, decision points, and route computations. The research of route instructions addresses how to make both visual and verbal route instructions easier to understand. Research explores schematization for visual route instructions as it occurs in both human internal spatial cognition and external sketched maps. It has been applied to map design to emphasize important information while underrepresent less important information [1, 4]. Linguistic expressions are explored in verbal route instructions. Klippel [2] used mental concepts of direction changes to find better expressions to describe turn directions. Additionally, methods like *spatial chunking* [5] or *segmentation* [6] are used to reduce the overall complexity of wayfinding instructions [4].

Decision points are addressed together with landmarks as they serve as very important features in route directions [7]

and orientation [8]. But few researchers further investigate the hierarchical communication of space referring to local and global landmarks (on and off route landmarks) which were considered advantageous for orientation [9]. Moreover, studies mostly focus on point-like landmarks, neglecting regional landmarks that might be useful for hierarchical structuring and abstracting spatial information. We consider both global landmarks and regional landmarks as important concepts in orientation wayfinding in the present study.

Route computation addresses the determination of paths. Algorithms such as simplest path algorithm, least-angle strategy [10], longest leg strategy [11] or algorithms for hierarchical path planning [12, 13] compute cognitively plausible paths. The enhanced simplest path algorithm [1] further considers decision point complexity, references to landmarks, and spatial chunking to reduce the overall path complexity. This improved method, however, uses landmarks to identify the spatial decision points, but not to support overall orientation. This is another aspect we consider in this current study.

In short, related work above has improved route instructions in navigation aids in numerous ways. All these approaches, however, adhere to the principles of traditional turn-by-turn navigation systems: routes are computed and given as a sequence of route instructions which users need to execute step-by-step. Instructions describe the action to be implemented at decision points. In this study, we intend to understand route instructions given by humans that support wayfinding and facilitate orientation. Our research aims at a new way for wayfinding assistance: using orientation information to support orientation and cognitive mapmaking in wayfinding.

## 2.2 Roles of landmarks

Landmarks serve as indicators to identify locations [14, 15] and to gain orientation. Michon and Denis [8] suggested that participants refer to landmarks for reorientation when there is a change of direction or at so-called ‘critical nodes’. The absence of landmarks makes it difficult to follow a route where reorientation is needed or where several choices of directions are possible.

Change of orientation is needed at decision points and can be supported by landmarks [7]. The major role of landmarks not at decision points is to confirm or maintain the orientation along a route. Landmarks off route (global landmarks) support novices for overall guidance by providing global orientation [16]. Consequently, research focused only on local landmarks for providing effective route instructions [17]. In the current study, we investigate also the role of landmarks in distance for providing global orientation.

## 2.3 Skeletal descriptions

Denis [18] developed a method called “skeletal descriptions” to shorten wayfinding instructions to a minimum description governing cognitive aspects and remaining fully informative. Instructions given in natural languages were deconstructed into a set of mega-descriptions. The mega-descriptions were then extracted to produce a minimum set of instructions containing only landmarks and actions. In his skeletal descriptions, most landmarks were mentioned at decision points while few were mentioned along route segments as skeletal descriptions omit landmarks along the straight paths and descriptions of landmarks. This view has also been challenged by Lovelace and colleagues [7] that not only landmarks at decisions points are sufficient to construct quality route directions. We also argue that landmarks along straight paths are also important particularly to maintain orientation. Our goal is not to provide minimum set of route instructions but information that is essential for orientation. Therefore, we only adapted Denis’ framework that he used in the first phase to deconstruct route instructions into mega-descriptions for us to further construct categories that address orientation information.

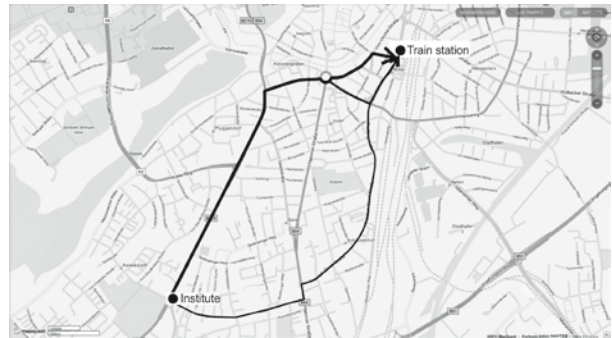
To sum up, landmarks play a central role in human wayfinding. Research differentiate roles of landmarks based on their locations: at decision points, between decision points, and off route [7]. While most research so far concentrated on point-like landmarks, we categorized landmarks into local and global ones. Local landmarks are either at decision points or between decision points. Global landmarks are off routes that are not only point-like but also regional. Regional landmarks (e.g. city center) do not exist in maps for navigation and orientation, but they are well-known in everyday communication and are commonly used as landmarks in navigation.

## 3 Methods

We designed an exploratory study on providing wayfinding instructions to support orientation and cognitive mapping and examining the differences of route instructions given by humans and machine. We selected two locations in an area

that is familiar to students and asked them to provide route instructions between these two locations in the forms of verbal instructions and sketch maps. The first location is the institute building, and the second is the railway station. Distance between these two locations is approximately 2.7 km. The area and the locations of these two locations are shown in figure 1.

Figure 1: Study Area and selected locations. Both locations in dots were used as origins and destinations in experiment.



Source: MapQuest. Routes provided by participants from institute to train station. The width of line indicated the frequency of routes that participants chose.

## 3.1 Participants

Students participated as a course requirement. As two components of this experiment were carried out on separate days, 18 students (Age:  $M = 25.00$ ,  $SD = 2.42$ ; 18 males) participated in the first component, and 20 students (Age:  $M = 25.35$ ,  $SD = 2.76$ ; 19 males and 1 female) participated in the second component. All participants have lived in the city for over half a year.

## 3.2 Procedure

The experiment was conducted on two executive days to complete two components. Students were randomly divided into two groups. On the first day, the first group of students was asked to draw sketch maps for first-time visitors to get from the institute building to the train station while the second group was asked to draw sketch maps for the reverse direction. On the second day, both groups were asked to provide verbal instructions for the same route that they sketched previously. We carried out the experiment in this way is to avoid the possibility that students provide identical information in both forms.

## 4 Results

In data analyses, we adapted part of the framework by Denis [18] that deconstructs route instructions into minimal and informative segments and then integrated it with our categorization of orientation information. Based on collected data, we carried out analyses as follows: 1) comparison between human and machine generated instructions; 2) analysis of verbal instructions based on the introduced

category above; 3) analysis of sketch maps using the same category and comparison with human instructions.

#### 4.1 Human instructions vs. machine instructions

Route instructions generated by MapQuest<sup>1</sup> are used in this comparison. We present the differences regarding the use of spatial features. The machine instructions were given through a turn-by-turn pattern. All spatial features used in those instructions were street names regardless of transportation mode (car, bike, and walk). No landmarks were used in these instructions. Humans did not rely exclusively on street names. In all human route directions, participants mentioned spatial entities 240 times. Out of all spatial entities, only 45 (18.8%) were street names.

Furthermore, we analyse the (hierarchical) structure of human instructions in contrast to turn-by-turn instructions given by machines. Hierarchical instructions provide a coarse description to cover a longer part of route, and then give refined details along it to complete this part. This hierarchy existed in provided human instructions (40%). A typical hierarchy presented in instructions is like: *“Take the Weseler toward the city center. You will see a Netto supermarket on the right side. Keep walking along the street”*.

#### 4.2 Verbal route instructions

We adapted the general framework that Denis [18] used in his first phase of generating skeletal descriptions and extended it to account for orientation using landmarks. Because the framework aims to reduce the verbal instructions, we focused on analyzing what other types of information could support orientation. In addition to his categories prescribing action (PA), introducing landmarks (IL), describing landmarks (DL), and commentaries (C), we introduced three categories orientation using local landmark (OLL), orientation using global landmark (OGL), turning movement using local landmarks (TALL), and non-turning movement using local landmarks (NTALL). The distinction between OLL and NTALL is that orientation does not require locomotion. All participants used either local or/and global landmarks, to maintain either local or global orientation. For example, one participant stated: *‘When you stand in front of the main station and you are looking in the direction of the city center, you have to walk left.’* Although the instructions did not lead into the city center, it is important to orient the wayfinder.

Based on the introduced category above, we derived 289 segments. Table 1 shows the percentage and count of each category. The most used category is NTALL (31.49%), e.g. *“pass the WL Bank and McDonalds”*. The second most used category is OLL (26.99%) intends to orient wayfinders using the reference to a local landmark, e.g. *“There you will see a church at your left side”*. Comparing to turn-by-turn route instructions, verbal instructions show prominent use of

landmarks not only for guiding movements but also for maintaining orientation.

Only 1.73% out of all categorized instructions provides orientation information using reference to global landmarks. In the work of reducing complexity of route instructions, algorithm generating hierarchical path finding [12] is suggested. From a cognitive perspective, we consider global orientation should be an important element in route directions as to reduce the overall complexity of instructions by providing an overview hierarchy. The results, however, show that providing global orientation in verbal instructions is not common. The global orientation will also be addressed in our analysis of sketch maps. In the future, we intend to test the effectiveness of global orientation in verbal instructions and sketch maps.

Table 1: Percentage of participants who mentioned the classes in route instructions:

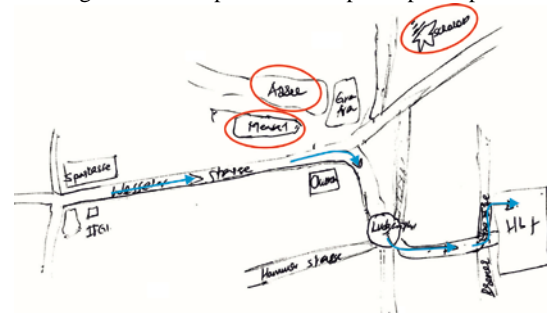
Classes	Percentage	(count)
Prescribing action (PA)	16.95%	(49)
Introducing a landmark (IL)	2.42%	(7)
Describing a landmark (DL)	3.81%	(11)
Commentaries (C)	4.50%	(13)
*Orientation using local landmark (OLL)	26.99%	(78)
*Orientation using global landmark (OGL)	1.73%	(5)
*Turning movement using local landmark (TALL)	12.11%	(35)
*Non-turning movement using local landmark (NTALL)	31.49%	(91)

\*authors’ created categories

#### 4.3 Sketch Maps

We analyzed sketch maps with the reference to the same categories used in examining verbal instructions. We focused on local landmarks drawn along the route, at decision points, and on global landmarks. Figure 2 shows the route with its global landmarks. It gives information in the surrounding areas although they are not directly along one’ route.

Figure 2: A sample sketch map of a participant

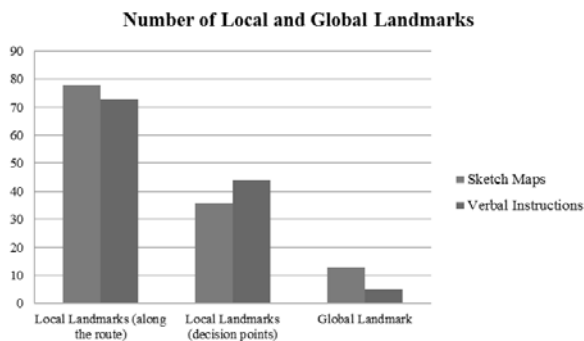


Note: Arrows show the route and the circles show the global landmarks

<sup>1</sup> We compared Google Maps and MapQuest and selected the latter as it provided more transportation modes (walking, car, and bike) and were based on Open Street maps. No matter which service was chosen, all provided information were turn-by-turn instructions.

Participants included more landmarks along the route both in sketch maps and verbal instructions than at decision points (Figure 3), but verbal instructions included more landmarks at decision points than sketch maps. In sketch maps, we found more global landmarks and important spatial features that may provide global orientation.

Figure 3: Landmarks in Verbal instructions and Sketch Maps



## 5 Discussion

### 5.1 Comparing route instructions

This study compares different forms of route instructions: machine generated instructions, human verbal instructions, and their corresponding sketch maps. Not surprisingly the spatial entities used in machine generated instructions are only street names. Many participants also used street names (of main streets), but all participants used landmarks in their verbal instructions more intensively. More importantly, using street names is not as prominent as landmarks in verbal instructions. At decision points, majority of participants preferred landmarks to street names.

Based on Denis' framework [18] for skeletal route instructions, we developed an extended framework including orientation information with landmarks and classified human verbal instructions accordingly for more in-depth examinations. All humans prominently used landmarks in their instructions to maintain orientation or guide a person's non-turning movement.

### 5.2 Hierarchy in verbal instructions

Humans tend to communicate wayfinding instructions at different levels of abstraction and build hierarchies. Humans would first give the general heading direction (often to a certain goal). In this part of route described by hierarchical instructions, they tend to provide information that is important to maintain a person's orientation. This type of structure does not appear in machine generated instructions.

We consider information on different hierarchical levels an important element in route descriptions. Winter [19] developed an approach that classifies global and local landmarks and presents space hierarchically. Although in our study only 1.7 % of the instructions referred to global orientation, we consider this important for route instructions.

We will address the effectiveness of using global orientation in route instructions in our following studies.

## 5.3 Landmarks for orientation

In verbal instructions and sketch maps, local landmarks remain to be the most common type of landmarks. These landmarks are located at decision points where turning actions are required. Human route instructions also include very frequently landmarks along the route (in both sketch maps and verbal instructions). These landmarks provide confirming information about the route that helps maintaining orientation. A previous study revealed the advantage of sketch maps for providing global orientation [20]. Our study confirms that sketch maps conveniently indicate global orientation while verbal instructions easily convey local orientation. Introducing global landmarks is a helpful component in wayfinding instructions which could be used for orientation. Although only few participants mentioned global landmark, its impact on giving a global orientation in an environment is worth exploring.

## 6 Conclusion

In this study, we investigate route instructions provided in different formats: human verbal instructions, sketch maps, and machine instructions. The purpose is to identify the information supporting orientation. The first finding is that humans include landmarks in their provided instructions, while machine generated ones only use street names and distances. We further examine the verbal instructions according to the use of spatial entities to maintain orientation. While machine generated instructions have no orientation information, humans frequently use spatial entities in instructions to provide orientation information. The second finding is that human verbal instructions tend to present a hierarchy in which a very general instruction is given for a large segment of route and followed by detailed information of maintaining orientation and direction change. However, machine generated instructions are turn-by-turn at one level of details. The third finding shows different types of spatial entities (global and local landmarks) and their roles on maintaining orientation. In both forms of verbal instructions and sketch maps, humans provide both global and local landmarks along a route to help maintain orientation. Studies have suggested that landmarks in route instructions would be more effective [17]. We further specify that including landmarks not only at decision points but also along and off route would make route instructions more orientation efficient. We did not find predominant use of global landmarks in verbal instructions, which might be due to the size of our study. However, we intend to formally assess the role of both global and local landmarks in future work.

## 7 References

- [1] Peters, D., Richter, K.F.: Taking off to the third dimension—schematization of virtual environments.

- International Journal of Spatial Data Infrastructures Research* 3, 20-37 (2008)
- [2] Klippel, A., Montello, D.: Linguistic and nonlinguistic turn direction concepts. *Spatial Information Theory* 354-372 (2007)
- [3] Zipf, A.: User-Adaptive Maps for Location-Based Services (LBS) for Tourism *Proceedings of ENTER 2002*. (2002)
- [4] Klippel, A., Richter, K.F., Barkowsky, T., Freksa, C.: The cognitive reality of schematic maps. *Map-based Mobile Services-Theories, Methods and Implementations* 57-74 (2005)
- [5] Klippel, A.: *Wayfinding Choremes: Conceptualizing Wayfinding and Route Direction Elements*. SFB/TR 8 Spatial Cognition (2003)
- [6] Dale, R., Geldof, S., Prost, J.P.: CORAL: Using natural language generation for navigational assistance. *Proceedings of Proceedings of the 26th Australasian computer science conference-Volume 16*, pp. 35-44. Australian Computer Society, Inc., (2003)
- [7] Lovelace, K.L., Hegarty, M., Montello, D.R.: Elements of good route directions in familiar and unfamiliar environments. *Spatial Information Theory: Cognitive and Computational Foundations of Geographic Information Science* 1661, 65-82 (1999)
- [8] Michon, P.E., Denis, M.: When and why are visual landmarks used in giving directions? *Spatial Information Theory, Proceedings of International Conference on Spatial Information Theory* 292-305 (2001)
- [9] Winter, S., Tomko, M., Elias, B., Sester, M.: Landmark hierarchies in context. *Environment and Planning B: Planning and Design* 35, 381-398 (2008)
- [10] Collins, A.M., Loftus, E.F.: A spreading-activation theory of semantic processing. *Psychological review* 82, 407 (1975)
- [11] Hochmair, H., Karlsson, V.: Investigation of preference between the least-angle strategy and the initial segment strategy for route selection in unknown environments. *Spatial Cognition IV. Reasoning, Action, Interaction* 79-97 (2005)
- [12] Wiener, J.M., Mallot, H.A.: 'Fine-to-Coarse'Route Planning and Navigation in Regionalized Environments. *Spatial Cognition and Computation* 3, 331-358 (2003)
- [13] Wiener, J.M., Schnee, A., Mallot, H.A.: Use and interaction of navigation strategies in regionalized environments. *Journal of Environmental Psychology* 24, 475-493 (2004)
- [14] Downs, R.M., Stea, D.: Cognitive maps and spatial behavior: Process and products. In: Downs, R.M., Stea, D. (eds.) *Image and Environment*. Aldine, Chicago (1973)
- [15] Siegel, A.W., White, S.H.: The development of spatial representations of large-scale environments. *Advances in child development and behavior* 10, 9-55 (1975)
- [16] Lynch, K.: *The Image of the City*. MIT Press, Cambridge, MA (1960)
- [17] Raubal, M., Winter, S.: Enriching wayfinding instructions with local landmarks. In: Egenhofer, M.J., Mark, D.M. (eds.) *Geographic Information Science: Second International Conference, GIScience 2002 Boulder, CO, USA, September 25-28, 2002 Proceedings*, vol. LNCS2478, pp. 243-259. Springer, Berlin Heidelberg (2002)
- [18] Denis, M.: The description of routes: A cognitive approach to the production of spatial discourse. *Cahiers de psychologie cognitive* 16, 409-458 (1997)
- [19] Winter, S., Raubal, M., Nothegger, C.: Focalizing measures of salience for wayfinding. *Map-based Mobile Services-Theories, Methods and Implementations* 127-142 (2005)
- [20] Wang, J., Li, R.: A cognitive and computational comparison of sketch maps for wayfinding. *International Journal of Cognitive Informatics and Natural Intelligence* (forthcoming)