Staying oriented in wayfinding: a comparison of orientation information between english and mandarin speakers

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Abstract Verbal descriptions are commonly used in daily lives for giving directions for wayfinding. They are valuable sources to understand underlying components that can contribute to spatial orientation, which is degrading with the growing use of routing services in navigation systems. Previous studies deconstruct and categorize all information embedded in spatial descriptions as a framework to investigate their roles in spatial orientation. Researchers look into the spatial descriptions given in different languages for their characteristics and suggest that characteristics vary in descriptions given in different languages. Adapting the same framework of categorizing information in spatial descriptions, this study compared directions given by English and Mandarin speakers. Results showed that the usage of orientation information is prominent in both languages. This type of information is not commonly included in routing services. Furthermore, comparisons between both languages revealed that English speakers provide detailed information to support orientation in wayfinding, which is different from some earlier suggestions derived from comparison between English and Japanese. This study also points out topics which are necessary for studies in the future.

Keywords Orientation · Spatial knowledge · Awareness · Spatial descriptions · Wayfinding

Introduction

Asking for directions is the most common form of acquiring spatial knowledge in wayfinding, a task that people carry out in their daily lives planning or getting from one place to another. Either asking someone for directions in person directly or questing information on an online routing service, persons receive the verbal descriptions in oral or written forms to support their wayfinding tasks. As a major means of acquiring spatial knowledge in addition to using maps, directions given in verbal forms have been the focus of many studies. For example, some researchers are interested in spatial descriptions as a type of important sources to help understand the underlying cognitive processing, planning, perspectives in cognitive mapping and acquisition of spatial knowledge (Denis et al. 1999; Giudice et al. 2006; Taylor and Tversky 1992). Other researchers investigate the quality of verbal descriptions for forming effective directions for someone to follow in wayfinding tasks (Allen 2000;

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Lovelace et al. 1999). Other aspects of verbal descriptions which studies address include the characteristics of formed mental representations (Tversky and Taylor 1998), the effectiveness of verbal description on wayfinding success (Hölscher et al. 2011), the types of verbal descriptions given for wayfinding (Schwering et al. 2013, 2017) and the cognitive disclosure in given descriptions (Tenbrink 2015).

Of particular interest, this study investigate the differences among directions given in various languages. For example, a study of wayfinding directions given in English and Japanese guidebooks shows that more verbal descriptions are used in English guidebook but more pictorial information is used in Japanese guidebook (Suzuki and Wakabayashi 2005). This researcher later carries out a wayfinding tasks on university campus between English and Japanese speakers and suggests that English speakers have higher preference to verbal directions than Japanese speakers, who are not familiar to only verbal forms of directions (Suzuki 2013). These two studies focus on the directions given to wayfinders, but not entirely on the information provided by these speakers. On the contrary, a study examines the directions given by both English and Japanese speakers using recorded directions through phone instead of written directions (Barney 2015) at hotel reception desks in major cities. It suggests that English directions are precise and simply in a linear style but Japanese directions are leaning towards configuration with intention to orient wayfinders. This is indicating that contrasting suggestions about English and Japanese instructions are given. It is also uncertain if English directions support spatial orientation as well, without the same type of descriptions in Japanese.

In consequence, this study investigates the verbal directions given in both English and Mandarin, the language widely spoken in China that many Japanese characters derived from. The focus is on the orientation information given in both languages and the comparison between them in supporting orientation. This study tests two hypotheses. The first hypothesis is that verbal directions given in both languages provide different means to support orientation, which is normally excluded in instructions given in routing services. The second hypothesis is that Mandarin speakers provide verbal directions similar to Japanese speakers, which is fewer than English speakers. In particular, the characteristics in Mandarin

directions tends to embed different types of information to support spatial orientation than English directions.

Related work

Directions serve a very important role in wayfinding and learning about a new environment. It hence motivates researchers to investigate which particular information embedded in verbal descriptions contribute to spatial orientation and their differences in the two languages. The related work first introduces the current research on spatial descriptions for wayfinding. It then reviews the literature on the important role of orientation information in descriptions and its gradual disappearance nowadays. This section then reviews a framework of categorization spatial descriptions to investigate orientation information for understanding their association with spatial orientation, which is the framework adapted in this study.

Spatial descriptions

Spatial descriptions are verbal forms of directions provided by a person to assist others in wayfinding. Researchers make efforts to reduce the amount of descriptions provided in directions aiming to support the easiness of wayfinding. For example, researchers (e.g. Denis 1997; Tom and Denis 2004) investigate verbal descriptions by breaking them into minimum segments, each of which represents a piece of meaningful information for executing a wayfinding task. Out of all minimum segments, the authors select the least number of meaningful segments, including turning and essential information to support the completion of wayfinding and term it skeletal descriptions. The structure of skeletal descriptions is very similar to that given in routing services such as navigation systems or online maps.

Using such a structure with only essential information can lead to disadvantage for orientation and spatial awareness. The minimum structure with only distance and street names in routing services nowadays is the most common way that persons can acquire direction for wayfinding. Many researchers point out that the use of such directions leads to several problems including the degradation of spatial

knowledge about surroundings (Parush et al. 2007; Münzer et al. 2006), the lack of spatial awareness (Speake and Axon 2012), and poor spatial orientation (Ishikawa 2018). That is to say, with only metric information and street names, users can not form a mental representation easily to support orientation. Researchers hence suggest the necessity of investigating orientation information embedded in verbal descriptions, but excluded in routing services, as they may contribute to spatial learning and orientation of users.

Orientation information

Spatial orientation is an essential skill when a person learns about an environment (Golledge and Stimson 1997). Especially when this person needs to become familiar with the surroundings for decision making, it is particularly important to use spatial orientation to establish the relationship between the person and the environment (Montello and Sas 2006). To help establish the relationship between the person and the environment, using an object's location and relating it to a person's location is considered the most effective way (Sholl 1996). The object in the environment is often referred as a landmark. Researchers suggest that using landmark information in spatial descriptions is more effective than using street names for supporting wayfinding (e.g. Tom and Denis 2004; Steck and Mallot 2000; Raubal and Winter 2012; Schroder et al. 2011). The use of landmarks in wayfinding is an application of the anchor point theory (Golledge and Stimson 1997). This theory suggests that acquired landmark knowledge can form anchor points in one's mental representations which contribute to spatial orientation. Some researchers focus on those landmarks located at direction-changing points (e.g. Denis 1997). As a person who uses the spatial descriptions needs to change heading in order to reach a destination, these locations are considered essential in spatial descriptions and commonly used in routing services.

Other researchers argue that landmarks in spatial descriptions which does not indicate changing directions are also important. In reality, before a person makes a turn at a decision-making position, he or she needs to pass many locations where changing direction is not necessary. These locations where wrong turns can occur cause anxiety to a person in wayfinding. These researchers emphasize the importance of

those potential decision-making locations where a person needs to maintain the direction of movement. One concern is that the inclusion of this information will increase the amount of information. Lovelace et al. (1999) suggest that, however, the amount of information included in spatial descriptions is not associated with their quality for wayfinding. In this study, we adapt the theory and consider all possible locations that landmarks can locate in the environment, which can contribute to spatial orientation.

Categorization of spatial descriptions

In the process of creating skeletal descriptions, spatial descriptions are minimized to only keep the landmarks at turning locations and their associated actions. The process is conducted through compiling spatial descriptions provided by humans. All descriptions are first divided into minimum segments and then classified into essential and non-essential descriptions. As introduced earlier, the skeletal descriptions with essential information are minimum in size and meaningful in contents.

As the essential descriptions mostly contain landmarks and turning information at decision-making locations, the information at potential decision-making locations is then missing. But the process of breaking up spatial descriptions into minimum segments provides great resource to investigate all spatial descriptions given by humans. Studies adapt the same framework but then keep all segments of spatial descriptions for investigating orientation information. These segments are categorized based on their functions, locations of landmarks, and paths (Anacta et al. 2017).

These segments, developed and refined in those studies, form a comprehensive set of categories to represent different characteristics of spatial descriptions. It extends the only three categories in skeletal descriptions to thirteen categories that could exist in all spatial descriptions. Table 1 presents the complete framework of categorizing spatial descriptions and their explanations. These categories first consider the actions with or without landmarks. If landmarks are associated, the location of landmarks further separates actions with landmarks into specific categories. The original category of describing landmarks is further extended to two different types reflecting the surroundings or specific landmarks along a route. This

Table 1 Types of categorized spatial descriptions and explanations, adapted from (Anacta et al. 2017)

Type of spatial descriptions	Explanation
TA	Turning action without a landmark
TADP	Turning action with a landmark at decision point
TAGL	Turning action with a global landmark
NTAAR	Non-turning action with a landmark along a route
NTAGL	Non-turning action with reference to a global landmark
NTA	Non-turning action without a landmark
OAR	Orientation with a landmarks along a route
ODP	Orientation with a landmark at decision points
OGL	Orientation with a global landmark (not part of a route)
O	Orientation without a landmark
DL	Describing a landmark
DE/DS	Describing environment/Describing space
C	Comments

framework uses the notion of global landmark, a type of landmark that is not along a wayfinding route but in the surrounding. Human spatial descriptions refer to landmarks in the environment that are not associated with a particular route for wayfinding, but humans use them to support global spatial orientation. This type of landmarks and its usage is not available in generated descriptions in routing services, as they only use local information along a calculated route. This study adapts this framework for categorizing spatial descriptions in both languages.

Methods

This study chose two campuses to carry out this experiment: one on an author's university campus in upstate New York and one on the other author's institute campus in a major city in southwest China. The principle was to use controllable and similar setup in both environments. For example, the length between the starting and ending points on each campus shall be similar in order to collect comparable spatial descriptions from participants. The following sections report the details of design and execution of this experiment.

Participants

In total 53 students took part in this experiment, in which 26 students were on the U.S. campus and 27 students were on the Chinese campus. Participants

were native speakers of the corresponding language in a country. For controlling familiarity with that campus, all participants on both campuses have studied there for more than one semester. They were new to geospatial concepts with very limited prior training in geography-related courses. On the U.S. campus, all participants were enrolled in a 100-level course of geographic information, which was an introductory course for students to start learning geospatial technologies. On the Chinese campus, all participants were majored in Fine Arts but enrolled in a summer class to learn introductory level of geospatial technologies. Participants completed this experiment to earn course credits. Those who could not participate were given alternative equal opportunities for the same credit. In design of the experiment, this study did not collect personal or identifiable information such as age, name, or gender. The experiment only collected spatial descriptions that participants would give in their daily lives.

Materials

A pair of locations were selected on each campus to serve as the starting and ending locations for participants to provide spatial descriptions for wayfinding. The selection of these locations were based on the same principles. It was inevitable that the form of environment can play a role in shaping one's spatial descriptions. This was one reason that this study selected an open area on each campus so a person has flexibility to walk around, in order to minimize the

influence. In addition, this study considered the following criteria to select locations for testing. First, these points should be places that students visit on a regular basis. Second, the distance from the starting location to the ending location should be similar in length and form. Third, the starting location was at the edge of the campus where a visitor would enter a campus. Fourth, multiple routing options were available from the starting location to the ending location, so each participant was flexible to suggest possible route to reach the ending location. Fifth, considering the type of locomotion is walking, the distance should be within the acceptable threshold. We selected a 1 km search radius from the most common entrance on each campus and searched for possible destinations that were close to the end of the search radius. If there were multiple locations available within this search radius, we then chose the location that was most popular to students. Figure 1 below shows the selected locations on each campus. On the left, the selected starting point on the U.S. campus is the bus stop where most students or guests would arrive on campus. The ending point is the University Arena where most indoor sports and speaker series take place. The average distance from the starting location to the ending location, based on all possible routes, is 1.2 km. On the right, the selected starting point on the Chinese campus is the West Gate of the institute. As a new satellite campus of this institute, most students and guests would come to this campus

through the light rail. The West Gate is the most adjacent entrance to the campus from the light rail station. The selected ending location on the campus is the Design Academy Complex where most lectures take place.

Procedure

Participants gave their spatial descriptions in their native languages on each campus in a large and quiet classroom. The main task of this experiment was asking each participant to provide spatial descriptions for walking from the starting location to the ending location on the campus. This study introduced the scenario that a participant's friend was coming to visit this campus which this friend has never been too. He or she would take public transportation and arrive on campus at the starting location. The friend's goal was to meet the participant at the ending location where individual participant was waiting for this friend. Participants were asked to type down the descriptions on the lab computer or their own laptop in a classroom where the experiment took place. Participants then uploaded their spatial descriptions onto an online drop box at the end of the session.

The English descriptions were directly categorized into minimum segments using the adapted framework of categorization by one experimenter. The same experimenter directly applied the categorization framework to categories the Mandarin descriptions
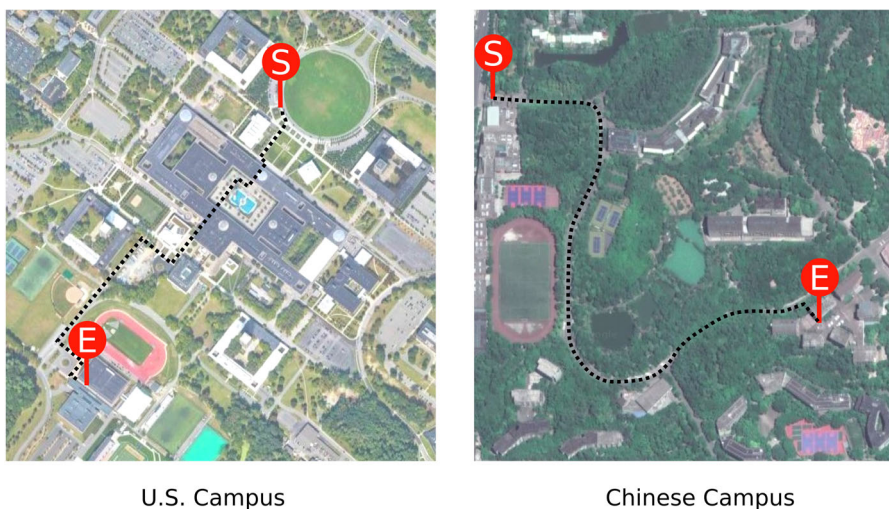

Fig. 1 Starting location (S) and ending location (E) selected for each campus. Dotted lines represent the most frequently described route (Satellite images edited from the Earth Explorer of United States Geological Survey)

and then translated them to English. This approach was adapted from a previous study using the framework of categorizing direction given in German (Anacta et al. 2017).

Results

The results of the study present two major parts. The first part reports the descriptive statistics of spatial descriptions in both English and Mandarin. The second part reports the comparison of spatial descriptions given by English and Mandarin speakers. Because the adapted framework categorizes spatial descriptions provided by all participants, the statistics of each individual category covers all various types of descriptions given by participants. The categorized descriptions represent the directions given as an individual language group.

Descriptive statistics

Spatial descriptions in both languages cover only a portion of university campus. All spatial descriptions provided by all American participants form 429 meaningful minimum segments. Spatial descriptions provided by Chinese participants form 300 meaningful segments. Likely due to the small environment covered in the experiment, spatial descriptions with reference to global landmarks, which are objects located not along a potential route as defined in Table 1, are not frequent in both languages. Table 2 presents the statistics of each category in both languages. As the table shows, no participant provides descriptions with turning action with reference to global landmarks (TAGL) nor non-turning action with reference to global marks (NTAGL) in both languages. In addition, no English speakers mention orientation at decision point (ODP) and orientation with reference to global landmarks (O). The frequencies of using ODP and O in Mandarin speakers are also very low. Besides those categories not mentioned, the most frequently mentioned category is non-turning actions with landmarks along a route (NTAAR) in both languages. Furthermore, the category of orientation along the route (OAR) in both languages is mentioned with the similar frequency (28.67%). This category is the second most frequently used categories in both languages.

Turning action (TA) and Turning at a decision point (TADP) represent the commonly used descriptions used in routing services. Results show that the spatial descriptions associated with turning actions consist of only less than 15% of all segments in English (TA: 7.46%, TADP: 6.76%). Descriptions associated with turning actions are less than 10% (TA: 3%, TADP: 7.33%) in Mandarin. Most categories given by participants are related to supporting spatial orientation using non-turning actions and direct orientation with landmarks (English: 77.86%, Mandarin: 84.33%).

Typical examples of non-turning actions with landmarks along the route (NTAAR) are "walk towards the Campus Center", "pass a volleyball court", or "walk to the entrance of the Design Academy" (translated) in both languages. Examples of actions in the category of orientation along the route (OAR) are "you will see a road fork" (translated), "you will see a stone arch on your right hand side" (translated), or "a big circle full of grass is in front of you". The third most frequently used category is non-turning action without landmarks (NTA) in both languages. Examples include "keep walking forward", "cross it", and "walk straight" (translated). Table 3 below presents the sample statements frequently mentioned in both languages.

Between-group comparison

It is important to note first that no single participant uses all categories in their spatial descriptions. In addition, all participants' descriptions do not cover all categories in the defined framework of categorization in both languages. Table 4 presents the number of participants using a specific category of descriptions.

Mann–Whitney U Test is conducted to examine the difference on use of specific category between two language groups. The frequency of participant's each used type of descriptions is a test variable with the language being the grouping variable. Only two categories of spatial descriptions show significant differences between languages. Both categories were non-turning action with a landmark along a route (NTAAR) and orientation with a landmark along a route (OAR). In the category of NTAAR, the mean rank was higher in English speakers ($Mean = 31.69$) than in Mandarin speakers ($Mean = 22.48$), $U = 229$, $p < 0.05$. In the category of OAR, the mean rank was also higher in English speakers ($Mean = 29.46$) than

Table 2 Categorization of spatial descriptions in all defined categories in English and Mandarin

Category	English	%	Mandarin	%
Turning action without a landmark (TA)	32	7.46	9	3
Turning action with a landmark at decision point (TADP)	29	6.76	22	7.33
Turning action with a global landmark (TAGL)	–	–	–	–
Non-turning action with a landmark along a route (NTAAR)	161	37.53	123	41
Non-turning action with reference to a global landmark (NTAGL)	–	–	–	–
Non-turning action without a landmark (NTA)	45	10.49	40	13.33
Orientation with a landmarks along a route (OAR)	123	28.67	86	28.67
Orientation with a landmark at decision points (ODP)	–	–	2	0.67
Orientation with a global landmark (OGL)	–	–	1	0.33
Orientation without a landmark (O)	5	1.17	1	0.33
Describing a landmark (DL)	14	3.26	9	3
Describing environment/Describing space (DE/DS)	3	0.70	2	0.67
Comments (C)	17	3.96	5	1.67
Total	429		300	

Table 3 Examples of directions given by participants in mentioned categories

	English	Mandarin (translated)
TA	Go all the way right	Walk to the right
	Turn to the right	Turn left
	Walk left	
TADP	Turn right at the Starbucks	Turn right at the road fork
	Make a left at the smaller fountain	Turn right at the entrance
NTAAR	Walk through the Dutch Quad	Walk through the corridor
	Walk towards the Campus Center	Walk through the stone arch
	Walk straight towards the podium	Pass the cafeteria
NTA	Keep walking in straight line	Keep walking straight
	Continue walking south	Walk for about 200 m
	Go straight forward	Walk along
OAR	You will see a large parking lot on your left	There is a road fork
	Heading against the circle	The building is on your right hand side
	You will see a big white bubble	You can see a small plaza in front of you
O	Face the north first	Look right
DL	It is a giant tower	The staircase is very narrow
	It is a steep grass section on which you can walk	It is an arch with a sculpture
	That fountain is small	The building has a letter B on this wall
DE/DS	At the corner one can turn right or go straight	There is a main entrance to the Complex
C	This is the only place to enter	I am waiting for you right there
		I will look for you

Table 4 The number of participants using specific types of directions in both languages

	English (Maximum 26)	Mandarin (Maximum 27)
Turning action without a landmark (TA)	14	7
Turning action with a landmark at decision point (TADP)	16	16
Non-turning action with a landmark along a route (NTAAR)	26	27
Non-turning action without a landmark (NTA)	19	20
Orientation with a landmarks along a route (OAR)	24	24
Orientation without a landmark (O)	2	1
Describing a landmark (DL)	8	7
Describing environment/Describing space (DE/DS)	3	2
Comments (C)	9	5

in Mandarin speakers ($Mean = 19.54$), $U = 169$, $p < 0.05$. Considering both NTAAR and OAR were two of the three most frequently used categories, the other category of descriptions did not differ between these two language for Non-turning action without a landmark (NTA), English $Mean = 20.58$, Mandarin $Mean = 19.45$. This indicates that both English and Mandarin speakers tend to use descriptions in verbal descriptions to support spatial orientation, although the specific categories of descriptions differ.

Discussion

Orientation information in both languages

Results in this study clearly show that the mostly frequently used spatial descriptions are associated with supporting spatial orientation in an environment, which strongly support the first hypothesis. The most frequently used categories of spatial descriptions such as NTAAR, OAR, and NTA consist of over three quarters of given instructions to maintain wayfinder's orientation by not changing direction or directly orienting them. This spatial reference established between spatial objects and the person by using NTAAR and OAR reflects the perspective structure of object-to-self relation in the cognitive mapping process that is essential to maintain spatial orientation (Sholl 1996). Since those referred spatial objects are distinctive and recognizable in the environment, they are often used as landmarks. There is slightly different finding from the previous studies carried out in

German cities (Anacta et al. 2017) that participants use global landmarks frequently. This is likely due to the use of only a portion of campus for describing veal directions. When applying this study to a city, future experiments can compare the frequency of using global landmarks in relation to the size of an environment.

It is important to point out that this study does not argue that routing services in existing devices are ineffective. They are effective in limited aspects such as using a minimum set of directions consisting of only turning actions, which can support a person to reach the quested destination with least amount of information. Their effectiveness on spatial orientation, however, is not part of their original design. Because of the lack of descriptions that support spatial orientation, a person using this type of descriptions are prone to develop insufficient spatial knowledge and awareness of the surroundings. Therefore, using the identified categories such as NTAAR, OAR and NTA in wayfinding directions has the potential to facilitate spatial orientation.

Differences between languages

In this study, English speakers give more directions than Mandarin speakers. This is in support of the earlier finding between English and Japanese directions that English speakers prefer to have detailed and longer verbal descriptions (see Suzuki 2013). It supports the second hypothesis of this study. This finding, however, is very different from another report on the comparison between English and Japanese (see

Barney 2015) that Japanese directions are more orientation specific and detailed than English directions. In the comparison between English and Japanese directions, this study suggested the English directions are precise and simply. In current study, statistics of the number of minimum segments shows that English speakers also give detailed and orientation-specific directions. There are likely two reasons, both of which are related to the methodology for data collection. In the study of English and Japanese directions, the researcher collects the data by calling hotel reception desks of various hotels in U.S. and Japan cities. Each city, even in the same country, can vary in its environment form and distance from a traffic station to hotel. This study controls the distance and environment used in each country. The second reason is related to the participants in both studies. In the study of English and Japanese directions, the time sufficiency at each hotel reception desk can vary at times. If one is very busy with customers on site, the responses to provide the direction can be very brief. In this study, each participant completes the task with sufficient time that no one is rushed to complete and submit. It is then important to have a more controlled study to compare the differences between English and Japanese directions for verification.

English and Mandarin speakers in this study show differences in using specific categories for orientation. The distinctive categories include NTAAR and OAR. NTAAR is a type of descriptions to keep a wayfinder not to change heading with the reference to a landmark. OAR is providing direct orientation information with the reference to a landmark on the route. It seems that English speakers in this study prefer to use both NTAAR and OAR more than Mandarin speakers. In other words, they tend to use more landmarks on a route to orient a wayfinder. Interestingly, these two categories are the two most frequently used in each language. This shows that English speaker prefer to use these types repeatedly when giving directions. All English speakers do not use four categories involving global landmarks (TAGL, NTAGL, ODP, and OGL) and orientation at decision point (ODP). Mandarin speakers use more diverse categories without the use of TAGL and NTAGL only.

Limitation and future work

The study's main focus in on the differences between two language groups, some results imply the existence of individual difference within a language group, which is the limitation in this study. One observation is that not every participant uses all possible types of spatial descriptions. Among all categories of spatial descriptions, it is unlikely that effective spatial descriptions should include all of them as the framework of categorization is a comprehensive set of all possible spatial descriptions given by humans. Results show that not all categories are necessary to reach a destination with orientation information. While finding the differences among individual difference in particular categories, there are many factors associated with these differences. For example, a person's spatial ability, sex, and sense of direction all can contribute to the different spatial learning. The spatial descriptions given by a person can also be very related to one's habit of exploring an environment, the familiarity, the preference to metric or landmark information. In future studies, it is necessary to investigate the roles of a set of individual factors in giving spatial descriptions.

This study supports the suggestion that orientation information facilitates one's spatial learning and awareness in wayfinding. It is then crucial to investigate the effectiveness of using such information in actual wayfinding and spatial orientation. One consideration, suggested in some previous studies (e.g. Raubal et al. 2012, Schwering et al. 2017), is to keep orientation-supporting descriptions in directions. There are many aspects, however, to consider. First, what is an ideal amount of information to be added into spatial descriptions? Second, once these descriptions are added into spatial descriptions, would understanding these spatial descriptions significantly increase the cognitive load of a wayfinder? It is our next goal to investigate the amount of landmark information in directions for supporting spatial orientation without significantly impact the effectiveness and convenience of wayfinding.

Conclusion

Asking someone for direction is the most common way of communicating and acquiring spatial

knowledge. Supporting spatial orientation through spatial descriptions is a regarded topic in many studies. Based on previous suggestion of categorizing spatial descriptions, this study carries out a comparison of descriptions between English and Mandarin. Results show that in both languages, the usage of spatial descriptions to support orientation is among the most frequently categories. Actions such as non-turning actions and direct orientation are used to help a person be aware of the surroundings by establishing the relation between the person and objects in the environment. These categories of descriptions are commonly used in both English and Mandarin. The results also show that specific language has its preference to certain categories of descriptions for keeping a wayfinder oriented. English speakers, in this study, seem to provide more spatial descriptions for supporting spatial orientation than Mandarin speakers. Since this study only addressed the information in spatial descriptions, more studies are needed to investigate the roles of particular category of spatial descriptions in spatial orientation as well as wayfinding performance.

Compliance with ethical standards

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