



MONTCLAIR STATE
UNIVERSITY

Montclair State University
**Montclair State University Digital
Commons**

Theses, Dissertations and Culminating Projects

8-2020

The Role of Presentation Type and Spatial Perspective on Wayfinding

Sejeong Park
Montclair State University

Follow this and additional works at: <https://digitalcommons.montclair.edu/etd>



Part of the [Psychology Commons](#)

Recommended Citation

Park, Sejeong, "The Role of Presentation Type and Spatial Perspective on Wayfinding" (2020). *Theses, Dissertations and Culminating Projects*. 586.
<https://digitalcommons.montclair.edu/etd/586>

This Thesis is brought to you for free and open access by Montclair State University Digital Commons. It has been accepted for inclusion in Theses, Dissertations and Culminating Projects by an authorized administrator of Montclair State University Digital Commons. For more information, please contact digitalcommons@montclair.edu.

Abstract

Wayfinding refers to the process people use to find where to go and how to get there. For that, they need information on the presence and location of landmarks in their environment to be able to navigate through their surroundings. Furthermore, spatial awareness is also crucial in the process. The present study aimed to study how modality, spatial perspective, and language influence (a) wayfinding accuracy, (b) cardinal term, (c) relative term, and (d) landmark usage in directions. The map and text were presented to native and non-native English speakers. They provided directions under route and survey perspective. The results indicated the effects of different modality and spatial perspective and also underscored the differences between natives versus. non-natives: (1) Wayfinding accuracy and use of relative terms were better under map than under text, but use of cardinal terms was more predominant under text. (2) Comparing route and survey perspectives, more cardinal terms were used under the survey perspective than route perspective. However, under the route perspective within the map, wayfinding accuracy and use of relative terms was better than the survey perspective. (3) Also, under the route perspective, more cardinal terms were used with text than with map. (4) Finally, while under the non-native condition relative terms usage was better under map than under text, under the native condition more cardinal terms were used with text than with map.

Keywords: wayfinding, spatial cognition, cognitive processing, spatial description

MONTCLAIR STATE UNIVERSITY

The Role of Presentation Type and Spatial Perspective on Wayfinding

by

Sejeong Park

A Master's Thesis Submitted to the Faculty of

Montclair State University

In Partial Fulfillment of the Requirements For the Degree of

Master of Arts

August 2020

College of Humanities and Social Sciences

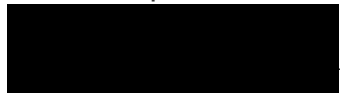
Department of Psychology

Thesis Committee:

 _____

Dr. Jennifer Yingying Yang

Thesis Sponsor

 _____

Dr. Jennifer Pardo

Committee Member

 _____

Dr. Michael Bixter

Committee Member

THE ROLE OF PRESENTATION TYPE AND SPATIAL PERSPECTIVE ON WAYFINDING

A THESIS

Submitted in partial fulfillment of the requirements

For the degree of Master of Arts

by

Sejeong Park

Montclair State University

Montclair, NJ

2020

Copyright c 2020 by *Sejeong Park*. All rights reserved.

Acknowledgments

This thesis could not have been possible without the expertise of Dr. Jennifer Yingying Yang, the thesis adviser. I am grateful for her ideas, insight, and patience. I would also like to thank Dr. Jennifer Pardo and Dr. Michael Bixter for sitting on my committee, taking the time to read my thesis, and giving grateful suggestions. I wish to express my deepest gratitude to Dr. Alan Pehrson for giving me a lot of help and advice. Thank you to the staff at the MSU, especially for Alexis, Dana, Emmett and Justin. I am fully indebted to the research assistants from the lab, Princess and Rebeca. I sincerely appreciate Rebeca's assistance and suggestions throughout this thesis. In addition, a thank you to all my friends and participants. If I did not have any support and encouragement from friends and participants, I could not have gone farther and completed this research study. Last but not least, my thanks and appreciation to my parents and sister, for their endless support, advice and help. I was not sure if I had won the lottery until today because I already have you guys as my family; Without you, none of this would be possible.

Table of Contents

Abstract.....	1
Signature Page.....	2
Title Page.....	3
Copyright Page.....	4
Acknowledgments.....	5
Table of Contents.....	6
List of Tables.....	8
1. Introduction.....	10
a. Cognitive Processing.....	10
b. Spatial Perspective.....	13
c. Language Background.....	17
d. Aim of the Current Study and Hypotheses.....	19
2. Methods.....	21
a. Participants.....	24
b. Materials.....	20
c. Procedure.....	26
d. Data Analysis.....	27
3. Results.....	29
4. Discussion.....	37
a. Implications.....	44
b. Limitations.....	45
c. Future Studies.....	45
5. Conclusion.....	46

6. References.....47

7. Appendices.....54

List of Tables

1. Comparison of Verbal and Visual Instruction (picture)	11
2. Comparison of Route and Survey Directions.....	13
3. Comparison of Route and Survey perspective (picture)	14
4. Summary of The Study & References.....	20
5. Participants' Demographics Descriptive Statistics	22
6. Visual Map.....	25
7. Flow Chart of the Procedure.....	29
8. Main Effect of Modality in Accuracy.....	31
9. 2-way Interaction Between Modality-Perspective in Accuracy	31
10. Main Effect of Modality in Cardinal Term Usage.....	33
11. Main Effect of Spatial Perspective in Cardinal Term Usage.....	34
12. 2-way Interaction of Language and Modality in Cardinal Term Usage.....	34
13. 2-way Interaction of Perspective and Modality in Cardinal Term Usage.....	35
14. Main effect of Modality in Relative Term Usage.....	36
15. 2-way Interaction of Language-Modality in Relative Term Usage.....	37
16. 2-way Interaction of Modality and Perspective in Relative Term Usage.....	37
17. Example of Korean Map (Seoul).....	42
18. Example of U.S. Map (NYC)	43
19. Appendix A: Verbal Instruction (Text).....	57
20. Appendix B: Coding Instruction and Dependent Variables.....	58
21. Appendix C: English Proficiency Test.....	59

22. Appendix D: Statistics for Native speakers.....	62
23. Appendix E: Statistics for Non-native speakers.....	63
24. Appendix F: Table of Descriptive Statistics.....	64
25. Appendix G: Example of Participant's Answer (Map-Route Condition).....	67
26. Appendix H: Example of Participant's Answer (Map-Survey Condition).....	67
27. Appendix I: Example of Participant's Answer (Text-Route Condition).....	68
28. Appendix J: Example of Participant's Answer (Text-Survey Condition).....	68

The Role of Presentation Type and Spatial Perspective on Wayfinding

The term *wayfinding* pertains to finding one's way from place to place. It is an essential activity for survival and requires a diverse range of cognitive abilities (Hund, 2016; Spires & Maguire, 2008). Wayfinding activity reflects the cognitive functioning of humans: thus, the way people give directions (i.e., descriptive features) may reflect human functioning as well. The present study examined how modality, spatial perspective, and language background influence descriptive features of directions, and also investigated how each factor interacts with other factors and how factors mutually contribute to wayfinding. The results could be informative not only for wayfinders but also encourage development in technology, cognitive science, and spatial skills (Feng, Spence, & Pratt, 2007; Gilbert, 2005).

Cognitive Processing And Wayfinding

Cognitive style was defined as an individual difference in regard to organizing and processing information (Januchta et al., 2017; Messick, 1984). Within wayfinding, there are two types of information processing based on modality: *visual and verbal processing* (Taylor & Tversky, 1992). For instance, when navigators start a journey, they need to decide which is a short and effective way, and whenever they make turns, they have to recognize and remember visual or verbal cues that they have seen (e.g., map, directions from someone). Previous studies on wayfinding demonstrated considerable differences between the two modalities and have further exhibited a range of individual differences in habits, skills, and strategies for learning an unfamiliar environment (e.g., Kraemer et al., 2016).

First, *verbal processing* refers to cognitive styles that are more word focused; that is, they rely more on verbal description (i.e., text; Mendelson & Thorson, 2004). Verbal processing

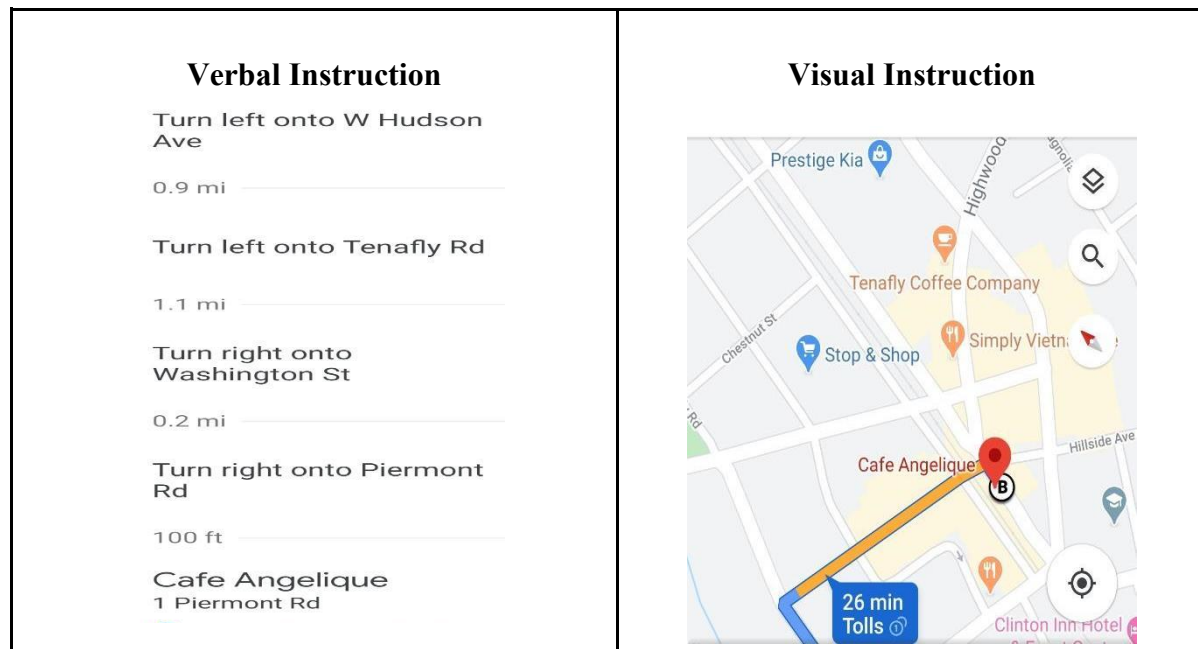
constructs information semantically without forming images and is one of the crucial tools used in making judgments for solving cognitive tasks (see Figure 1; Soroli & Hickman, 2009). Many psychological studies claim that people who respond to verbal information can construct mental images concerning past and future events and that these mental images can provide the basis for judgments and decisions (Chomsky, 1975; Clark & Clark, 1978; Pinker, 1989; Soroli & Hickman, 2010; Wyer et al., 2008). However, there is a lack of research addressing the advantages of verbal descriptions during spatial learning and navigation in real environments (Allen, 1997; Denis, Pazzaglia, Comoldi, & Bertolo, 1999; Lovelace, Hegarty, & Montello, 1999; Tversky, 1996). Moreover, such studies would be based on static text so it would be hard to change the participants' physical movement through the space (Giudice et al., 2007).

Meanwhile, *visual processing* refers to representing information that is pictured rather than being described (Fodor, 1981; Homer & Gauntt, 1992). Former studies from Childers et al. (1985) also distinguished that visual processing constructs visual images based on reading or thinking about situations and events. Brown (2015) suggested that humans are neurologically linked to visual sensory ability, so visual material is an easier way to recall and process information than words. Kosslyn (2005) also found that the human brain stores visual and verbal information in separate areas of the brain. Kosslyn compared the participants' reaction time when they scan the overall map, participants spent a shorter time when they looked at the visual objects than verbal objects. Kosslyn suggested that visual objects may have mental representation with lower thresholds, which leads to faster recognition in the initial phases of tasks. Previous studies have found another advantage of using visual materials for wayfinding (Giudice et al., 2005). Ko and Kim (2017) demonstrated that people can navigate unfamiliar environments without structural information (e.g., verbal information) because people can

process the necessary information from visual information such as landmarks or signs within the environment. Pazzaglia and Moè (2013) also found a general superiority of the visual map condition. The results indicated that participants who were assigned to a verbal description had more hesitation and learned the route more slowly than those assigned to a visual map condition. Moreover, visual processing may include more active decision making than verbal processing (Schwering et al., 2017). Participants who read the text could not have active decision making because their decision making has been replaced by detailed verbal instruction. Besides that, text often contains abstract information, which is difficult to visualize, and people may think it might be harder to remember than a map (Krucka et al., 2020).

Figure 1.

Comparison of Verbal and Visual Instruction



Spatial Perspectives

Within wayfinding, there are two different perspectives: route and survey (Bloom, Peterson, Nadel, & Garrett, 1996; Portugali, 1996). These perspectives refer to how a person

specifies the location of objects concerning other objects, and they are necessary to provide directions. For instance, in wayfinding, a wayfinder will receive visual (map) or verbal materials (text), and decide which direction (route or survey) they want to take. **Route direction** means “first-person” perspective relies on a relative direction (e.g., left-right), contains a wayfinder’s relative frame (i.e., people ask the direction on the street), and knows how to get from one location to another. **Survey direction** means “third-person” perspective relies on a cardinal direction (e.g., using N,E,W,S and people see the map through the entire view), and reconstruct accurate rendering of the area (Wickens et al., 1984) with absolute frame. Previous research has found that different spatial perspectives may shape human memory for spatial information and affect the representation of spatial information in direction-giving (Shelton & McNamara, 2004).

Figure 2.

Comparison of Spatial Direction

Route direction:	Survey direction:
“... Turn right on Green Avenue and on your right, you will see the stock market. Past the stock market, on your right on Green Avenue, you will see the mortgage bank. On your right on Green Avenue, past the mortgage bank is the legal firm” (Lee & Tversky, 2005).	“... South of the stock market on the west side of Green Avenue is the mortgage bank. On the west side of Green Avenue, south of the mortgage bank is the legal firm” (Lee & Tversky, 2005).

The frames of reference. Setting a *frame of reference* is also necessary to find a destination or a specific object (Surtees et al., 2012; Tomasello, 2008). Three frames of reference are usually identified: relative, absolute, and intrinsic. Firstly, the relative frame usually accepts egocentric views. Thus, the relative frame tends to adopt the relative dispositions of

locations/objects from a particular point of view. They tend to adapt left-right term use and often mention 'you' to describe the wayfinding process (see figure 2; Levinson, 1997). Thus, a wayfinder can easily understand the information. Conversely, the absolute frame of reference prefers to use cardinal terms such as survey direction (Majid et al., 2004). The absolute frame of reference avoids using left-right and the speaker's viewpoint. They can provide detailed information concerning the whole environment at once. They do not mention 'you' in their direction (see figure 2) and describe the map and each location with an entire and precise view. Lastly, the intrinsic frame of reference means that a location/object is described concerning another object (e.g., "the building is beside the restaurant"; Majid et al., 2004). According to Dey et al. (2018), the frames of reference are the main components of the spatial perspectives: survey perspective and route perspective. For example, the relative frame of reference is more related to the route perspective because they both prefer to take relative terms and egocentric views. On the other hand, the absolute frame of reference is related to survey perspectives, which use cardinal terms. The intrinsic frame of references can be described with both perspectives (e.g., "the building is on the *left* of you," or "the destination is to the *south* of the building").

Route perspective. *A route perspective* refers to a mental tour with a changing viewpoint from within the environment (Taylor & Tversky, 1992). The term presents a space, its landmarks, and their spatial relations from an egocentric perspective (or path view). It also uses an intrinsic frame of reference, such as "to your left" or "in front of you." A route perspective requires adopting a first-person's (e.g., traveler's) spatial perspective, and it offers a procedure for exploring through the environment. Thus, a route perspective adopts left and right terms within a traveler's sight for describing the environment. A navigator with a route perspective has a more natural perspective to describe a route, and that is the reason why a route perspective uses more

viewer-relational terms (e.g., “turn to your right-hand side”) and more motion verbs (e.g., “go to your left and find the destination in front of you”) than a survey perspective does (Tversky & Taylor, 1996).

Survey perspective. A *survey perspective* is defined as a mental tour that scans an environment from a single viewpoint (Taylor & Tversky, 1996). This term represents the space from an allocentric perspective (bird's eye view) and uses an extrinsic frame of reference such as compass directions (North, South, East, and West), and mentions precise distances/streets (Lawton, 1996; Shelton & Gabrieli, 2002; Taylor & Tversky, 1996) more than a route perspective does. A survey perspective speaker adapts a third-person perspective to see the whole environment at once (i.e., aerial view; Hund et al, 2012). Current researchers suggest that survey knowledge may be conceptualized as a map-like environment, which contains information about the physical characteristics of an environment (Chrastil & Warren, 2014; Ishikawa & Montello, 2006; Montello, 1998; Thorndyke & Hayes-Roth, 1982), consequently, a speaker with a survey perspective tends to mention more deictic words on wayfinding directions (e.g., ‘there’; Andonova, 2010). Table 1 shows additional comparisons of route and survey perspectives, while Figure 2 visually depicts the perspectives.

Table 1.

Comparison of Route and Survey Perspective

Route Perspective	Survey Perspective
Ground-level navigation / Focusing the segments of a route	Aerial or map-like perspective / An overview of the entire environment

<p>Left – right term use</p> <p>Travel with a specific path</p> <p>Landmark action association</p>	<p>N, E, S, W term use</p> <p>Allow to construct novel routes, shortcuts, indicate the direction of an unseen goal</p> <p>An objective frame of reference concerning the environment</p>
--	--



Figure 3.
Comparison of Route and Survey perspective (picture)

When the researchers compared the effectiveness of both perspectives, they found that a route perspective may lead to better wayfinding performance (MacEachren, 1992). For example, some researchers found that U.S. participants showed a more positive effectiveness rating on the directions under the route perspective than under the survey perspective (Denis et al., 1999;

Hund et al., 2012; Padgitt & Hund, 2012). According to Pyers et al. (2015), when speakers adapted the same spatial perspectives with their recipients (route perspective), they shared outstanding wayfinding communication with recipients: they tended to give accurate directions for their recipients (Schober, 1993). It is important to note that the perspective of wayfinding instruction influences overall wayfinding performance, and route perspective may lead to better wayfinding performance from a speaker and recipient.

Lastly, in the spatial perspective studies, Hund et al. (2009) found a notable difference between route and survey perspective with American and Dutch subjects. They would like to examine how factors (e.g., culture, spatial perspective) affect descriptive features that people provided in wayfinding directions; Thus, the researchers created a fictitious visual map using landmarks, streets, and avenues. This map was given to participants and they were asked to write down the directions for someone to get from the starting point to the destination. They needed to provide six directions, three in which participants imagined giving directions to a wayfinder driving in the town (route perspective) and three in which they imagined giving directions to a wayfinder who seeing the map (survey perspective); The researchers measured the frequency of cardinal, left-right, street names and landmark descriptors from the directions, and found Americans used more cardinal directions under survey perspective than Dutch subjects. Moreover, participants used more left-right terms under the route perspective than the survey perspective. By contrast, they used more cardinal terms under the survey perspective than route perspective; These results indicate the difference of spatial language between two different cultures and the flexibility of a wayfinder's spatial perspective.

Language Background

Meanwhile, only a few studies have investigated the impact of different cultural/language backgrounds on wayfinding. Previously, Hund et al. (2012) found that different language and cultural backgrounds may influence the different consequences of wayfinding. U.S. participants usually provided street names more frequently than Dutch participants. Americans often preferred to use cardinal descriptions (i.e., North, East, West, South) more than Dutch participants when they are accepting a survey perspective. Lawton (2001) suggested that U.S. lands are usually designed with a grid system of streets and operated by address numbering and street names. Hence, Americans are more accustomed to using cardinal terms than Europeans. These findings supported that wayfinding direction can be differentiated depending on cultural or geographical backgrounds. Language background also influences spatial cognition. One cognition study demonstrated that participants using different languages perform differently on many spatial relation tasks such as color discrimination tasks (Wolff & Holmes, 2011). The researchers mainly assumed that when English speakers and Korean speakers describe the same scenes, they tend to use different spatial terms. English speakers used preposition words more frequently than Korean speakers, which may indicate that even the same scene can be encoded differently across language (Holmes et al., 2017).

Significant differences have been found between native speakers and non-native speakers as well. Kisser et al. (2012) compared two groups (native vs. non-native) on four different language tasks with neuropsychological measures. The results revealed that non-native English speakers showed poorer performance on language mediated tasks given in English (i.e., letter and category fluency, cognitive estimation test) than native speakers. Another study (Boone et al., 2007) also demonstrated that native English speakers outperformed on digit span, Boston

naming test, and word generation tasks more than non-native speakers. However, non-native speakers scored relatively higher on visuospatial tasks when compared to native speakers. This finding revealed that native and non-native may perform differently depending on modalities.

Aim of the Current Study and Hypotheses

Wayfinding is a necessary activity for everyday survival. Despite all of these factors being related to wayfinding and its performance, previous studies have examined each factor in separate contexts, but have not often examined them in the same context. Thus, this thesis investigated the wayfinding directions of 62 participants with regard to the effect of three sets of factors on direction giving: (a) role of modality (visual vs. verbal), (b) spatial perspectives (survey vs. route perspective), and (c) role of language (native English speakers vs. non-native speakers). Based on the descriptive features (accuracy, cardinal term, relative term, and landmark usage), the researcher assessed how applying different modality, perspective, and language background influence overall wayfinding performances.

There are two research questions: (1) Do different cognitive processing, spatial perspective, and language backgrounds influence wayfinding directions? (2) If so, how can the directions be differentiated by three factors? It was predicted that:

- (1) Overall, comparing map and text, accuracy would be better with a map than with text.
- (2) Comparing route and survey, accuracy should be higher and people should include more relative terms and fewer cardinal terms in route the perspective than the survey perspective.
- (3) Comparing natives and non-natives, accuracy would be better in natives than non-natives.
- (4) The type of modality and spatial perspective might interact in different ways; the

combination of route and map might be associated with the best performance, because they would give more effective directions among other four conditions.

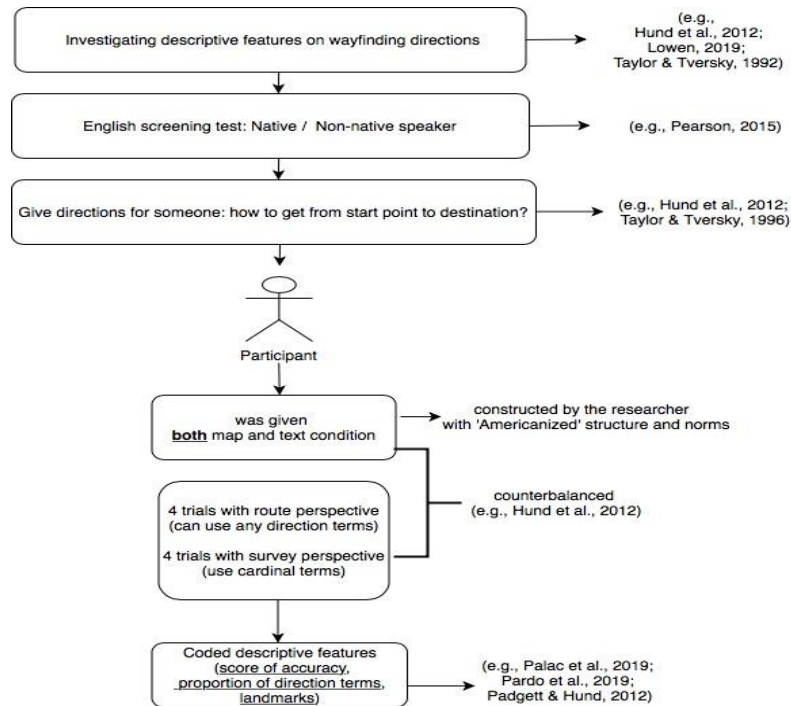


Figure 4.

Summary of The Procedure and References

Based on former studies (e.g., Hund et al., 2012; see page 17) and the hypotheses, the present study recruited participants (native and non-native English speakers), and they were tested via an online (after COVID-19 outbreak) or lab environment. Each participant completed the eight wayfinding trials with two different modalities (map and text) constructed by the present researcher (see figure 3). To assess participants' wayfinding directions, participants needed to answer under two different spatial perspectives (route and survey). Note that each condition was carefully manipulated and counterbalanced by the researcher, and it was used by previous studies as well (e.g., Hund et al., 2009; see methods section below). Under route

perspective, the researcher made participants apply any direction terms they wanted. Under survey perspective, participants needed to use cardinal terms. In the data analysis section, the researcher coded and assessed **the score of direction accuracy** and **proportion to the total number of words of other descriptive features** (mentioning cardinal/relative/landmarks). The results from descriptive features may be used to assess the quality of wayfinding and how participants use their wayfinding ability under different conditions, and how the results can be used for real society.

Methods

Participants

Sixty-two participants took part in this experiment, including 23 men and 38 women (see Table 3). The participants' mean age was 21.2 years. Thirty-three participants were native English speakers (F = 18, M = 14) and 29 participants were non-native English speakers (F = 20, M = 9). The criterion for native/non-native speaker is specified on page 25. Thirty-six participants (F = 19, M = 16) participated in the lab study, while 26 participants (F = 19, M = 7) participated in the online study. Overall, 10 native speaking participants and 16 non-native participants did the online study. Ten native males and six non-native males did the lab study. Twelve native females and seven non-native females did the lab study. The participants identified themselves as being White/Caucasian (n = 23), Asian (n = 23), Latina/o (n = 9), Black/African American (n = 5), and others (n = 2) on the demographic data section of the survey. Participants were not excluded based on their ethnicity and gender. Detailed descriptions are presented in Table 2. Meanwhile, 15 participants' data in the verbal condition were removed because of non-adherence to the protocol: Before changing the protocol, participants were shown

two texts at the same time. The researcher found this process may cause research bias, therefore, the part of protocol was changed. After changing the protocol, participants saw only one text during the experiment. Overall, participants (58%) who were recruited through the Department of Psychology college student participant pool (SONA) received credit for class fulfillment. Other participants (42%) from snowball sampling (e.g., recruited the researcher's friends, families, or co-workers) did not get the credits for a class (see table 2). All participants provided informed consent, and the study was approved by the Institutional Review Board at Montclair State University.

Table 2.

Participants' Demographics Descriptive Statistics

Variable		N	Note
Gender	Female	38	
	Male	23	
	Missing	1	
Ethnicity	White/Caucasian	23	
	Asian	23	Indian = 2, Vietnamese = 1, Korean = 20
	Black/African-American	5	
	Latinx	9	

	Others	2	Afro-Latinx, Black & White
Recruiting	SONA	33	F = 18, M = 14, Missing = 1 Native = 27, Non-native = 6
	Snowball sampling	29	F = 20, M = 9 Native = 6, Non-native = 23
Language	Native	33	F = 18, M = 14, Missing = 1
	Non-native	29	F = 20, M = 9 European Language (Polish, German, Spanish, etc) = 6 Asian Language (Korean, Indian, Vietnamese) = 23
Site	Lab	36	F = 19, M = 16, Missing = 1 Native = 23, Non-native = 13
	Online	26	F = 19, M = 7 Native = 10, Non-native = 16

Note: F: female, M: male

Participant Screening

For the language proficiency screening, non-native English speakers who participated in the online study had to pass the English proficiency test before they started the survey and experiment (Pearson, 2015; see Appendix C). The researcher asked a few questions about the participants' English education history. First, participants who never took any English classes in their schools were excluded from the study. Second, participants who were not born in English speaking countries, and that did not learn English before Kindergarten age were classified as a

non-native speaker. For the English proficiency test, a listening test from the U.S. middle schools was administered to participants. Participants started with a listening task with a visual map and audio file. Then, they needed to hear the wayfinding direction and choose the right answer on the visual map. If they could not choose the right answer, they were dropped out of the study. As a result, there were no dropped out participants.

Materials

The map and text condition consisted of an entire view (e.g., Hund et al., 2012), and the researcher did not find any structural issue in two conditions. Both map and text condition used the same spatial layout: whole view of town since the researcher aimed to describe an ‘entire’ fictitious model town such as previous research did (e.g., Hund et al., 2012; Taylor & Tversky, 1996). In both conditions, nine landmarks (e.g., burger, lobster) and four streets/ three avenues (e.g., New St., Second Ave) were used to describe the environment for participants. In text condition, the information was provided in English and presented on a computer. In the map condition, they described different contents (landmarks) but maintained the same number of landmarks with the text condition. The landmarks were displayed using emoticons with colors. The same number of streets/avenues were also depicted using thick black lines and printed names (see Figure 3).

The Way of Map and Text Were Generated

The fictitious environments were described using an Apple Macintosh and the software and were presented on a monitor. Both conditions’ environments are not different in the number of streets/avenues and landmarks. Both instructions contained nine landmarks. The map and text were adapted to similar structures from previous research (Hund et al., 2009; Taylor & Tversky, 1992). The present study generated the map and text containing common Americanized names

and structures (e.g., name of the streets, landmarks). It should be noted that for consistency of the map and text, both conditions were maintained in the same structure, but have different contents (name of street/avenue/landmarks). Thus, it would not affect the reliability of each condition.

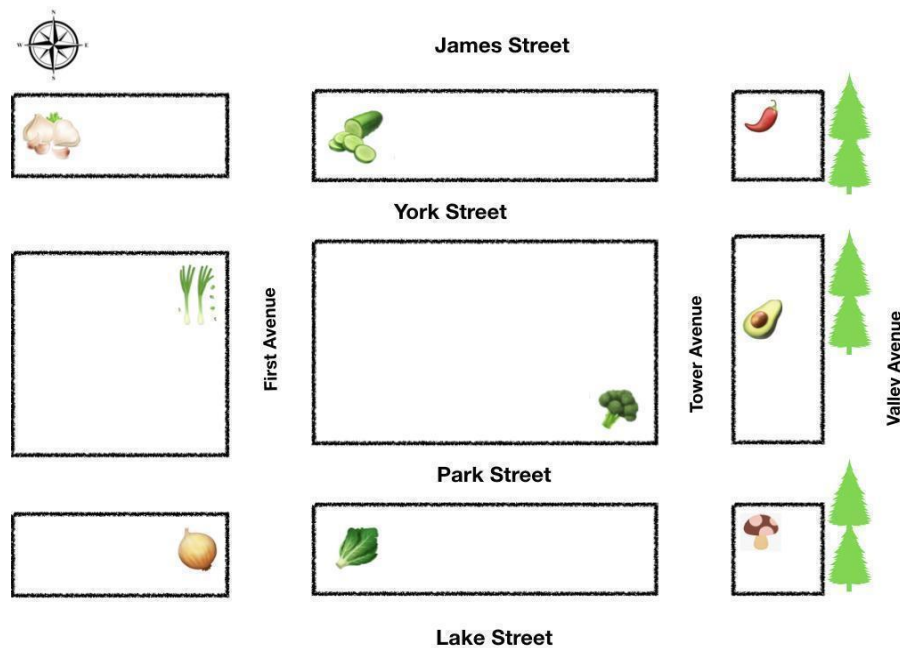


Figure 5.

Visual Map

It should be noted that all participants received the same visual map (see figure 5); When participants were given the material, the order of materials (i.e., Map first, Text second vs. Text first, Map second) and the order of perspectives (i.e., Route perspective trials measured first vs. Survey perspective trials measured first) were counterbalanced to minimize order effect and other research biases. Additionally, the researcher constructed two texts (No.1 and No.2; see Appendix A). Half of the participants received the No.1 text, and the remaining participants received the No.2 text. Note that both texts consisted of a survey perspective (e.g., using cardinal terms, entire view of the environment) with the same landmarks, streets, and avenues to maintain

the consistency between the two texts.

Procedures

Prior to the experiment, participants were asked to answer the demographic questions via Qualtrics. First, if applicable, they had to disclose their ethnic, immigration, first-language, and parents' backgrounds. Then, they needed to complete wayfinding strategies related questionnaires: Object-Spatial Imagery and Verbal Questionnaire (OSIVQ; Blazhenkove & Kozhenvnikov, 2009), The Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977), Santa Barbara Sense of Direction Scale (SBSOD; Hegarty, Richardson, Montello, Lovelace, & Subbiah, 2002), and The Wayfinding Strategy Scale (Lawton, 1994). The results are not enumerated in this thesis, but are intended for use in further wayfinding research.

After the participants completed the questionnaires, they were given the experiment. They were asked to see the material on the monitor for familiarization. During the familiarization stage, participants were given 30 seconds to look at the material. For participants, the researcher noted visually and verbally the four cardinal directions, pointing to each direction. A compass rose also appeared at the bottom of the map indicating the cardinal directions (e.g., N, E, W, S). The starting points and destinations were noted by the experimenter (e.g., start from the garlic to red pepper (See Figure 3 and Appendix A). After the familiarization stage, participants completed a total of eight trials. There were two different conditions: map and text. For each condition, participants completed four trials. In two trials, participants imagined giving directions to a person using a route perspective (i.e., giving direction for someone who is driving). With a route perspective, people could use any terms they wanted. Meanwhile, in two other trials participants imagined giving directions to a person again using a survey perspective (giving

direction for someone who is walking with a map) for each condition (see figure 5). With a survey perspective, participants needed to use cardinal terms for direction-giving. After participants completed each trial, they were asked to type the answers on the computer on how they would help someone to get from the starting point to reach the destination. Participants were allowed to take as much time as needed, and they could refer to the map and text again when they typed the answer on the computer. To complete trials, participants did not copy/paste a paragraph from the original text. All of them answered with their own thoughts and language.

Data Analysis: coding

The Qualtrics program stored the participants' answers concerning the wayfinding tasks. After data collection, the researcher coded the frequency with which participants used descriptive features. Regarding cardinal term usage, a coder coded the frequency of cardinal direction terms. Regarding relative term usage, a coder coded the frequency of relative direction terms (e.g., go straight, left, right, turn right-hand side, etc). Regarding landmarks, a coder coded the numbers of landmarks mentioned. At the results, the overall numbers were converted to proportion (number of frequency/ total number of words).

Regarding accuracy, a coder scored the directions of participants from 0 to 10. Scale of pointing is quite common measurements to assess wayfinding performances (e.g., Palac et al., 2019; Pardo et al., 2019; Padgett & Hund, 2012), the present study partially adapted the previous research's measurements and criterions: When participants provided completely wrong direction, so they arrived different landmarks or paths, they received 0, whereas they gave perfect direction, so they arrived at the right landmarks, they received a score of 10. If participants did not find the right destination, but if they could arrive on the same side of the destination, wrong side of the destination, or two blocks away from a correct destination, they could receive the

partial of full scores (score of 8, 6 or 4) More details are represented in Appendix B.

Data Analysis: program and variables

All data were analyzed with JASP version 0.11.1, Microsoft Excel program, and post-hoc comparisons using the Bonferroni test. The frequency of specific descriptive features (e.g., cardinal term usage) was coded from the data of the experiment. Descriptive features were analyzed using separate 2x2x2 mixed-design Analysis of Variance (ANOVAs) with cognitive processing (map vs. text), spatial perspective (route vs. survey) as two within-subjects variables, and language background (native vs. non-native) as a between-subject variables.

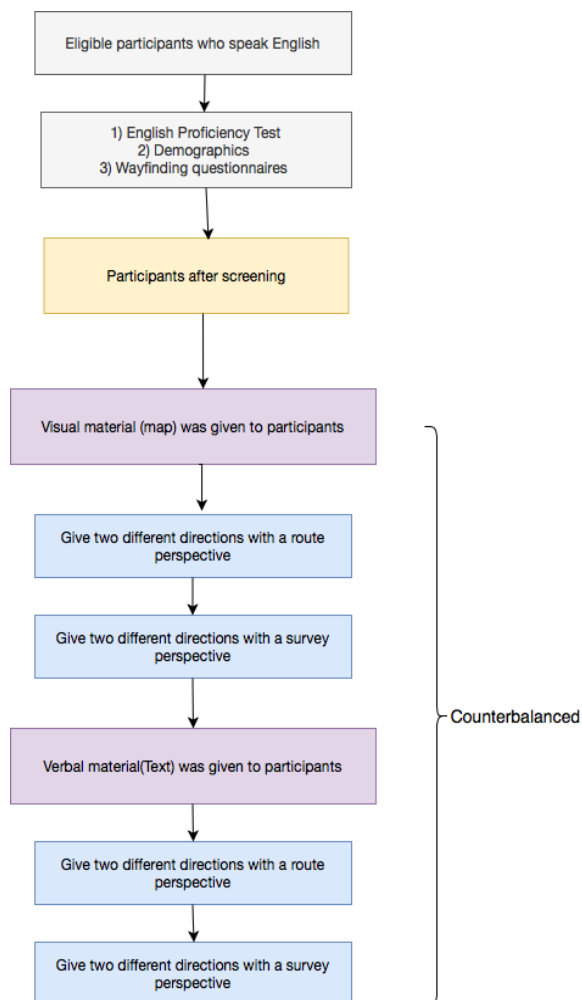


Figure 6.***Flow Chart of the Procedure*****Results**

As dependent variables, frequency with which participants provided 12 descriptive features: total words, phrases, sentences, verbs, cardinal terms (N, E, W, S), relative terms (e.g., left, right, turn or go straight), landmarks (i.e., nine named objects in each map/text), and names of street and avenue (i.e., a total of seven named streets/avenues in each map/text), preposition (e.g., along, toward, between, or within), articles (a, an, the), deictic words (e.g., this, these, there), and accuracy of wayfinding directions were used. Note that among these variables, the researcher only focused on ***mean score of accuracy*** of wayfinding direction, ***proportion of cardinal, relative terms, and landmark usage***. To get the proportion, # of total words (i.e., the sum of total words that each participant used) and # of direction terms (i.e., cardinal and relative term usage) were used. The proportion was calculated for each participant individually, then the results were summed. The researcher used the Microsoft Excel program to calculate the proportion of direction terms / (\div) total words.

Detailed instruction for coding is also presented in the above data analysis and Appendix B section. Descriptive tables are presented in Table 3, Appendix D, and Appendix E. Examples of participants' answers are also presented in Appendix G to J; Significant effects were indicated at the $p < 0.05$ level.

Wayfinding Accuracy

Analyses showed that the main effect of cognitive processing on ***accuracy*** of wayfinding

direction was statistically significant, $F(1,45) = 26.33$, $p < 0.001$, $\eta^2 = 0.10$. Based on the coding criterion (see Appendix B), a coder assessed participants' score of wayfinding accuracy.

Participants showed high scores of wayfinding accuracy when the map was provided ($M = 8.85$, $SD = 0.31$) than when the text was provided ($M = 6.61$, $SD = 0.52$). The two-way interaction between cognitive processing and spatial perspective on accuracy was statistically significant, $F(1,45) = 5.67$, $p = 0.02$, $\eta^2 = 0.01$. This indicates that the effect of cognitive processing on accuracy differs on the level of spatial perspective (route vs. survey). Post-hoc test suggested that map ($M = 9.09$, $SD = 0.35$) is better than text ($M = 6.07$, $SD = 0.57$) in a route perspective ($p < 0.001$). Moreover, map ($M = 8.60$, $SD = 0.48$) is also better than text ($M = 7.14$, $SD = 0.57$) in a survey perspective ($p < 0.009$). The difference was larger for the route perspective ($MD = 3.01$) than for the survey perspective ($MD = 1.45$). The three-way interaction effect between cognitive processing, spatial perspective, and language on accuracy was not statistically significant (see Table 3).

Figure 7.

Main Effect of Modality in Accuracy

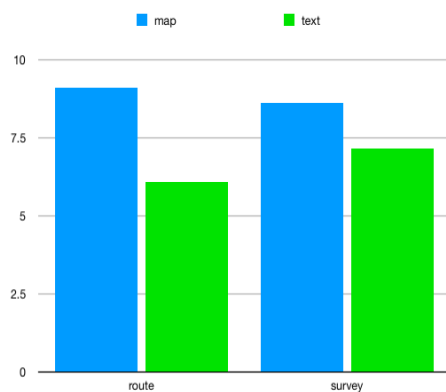
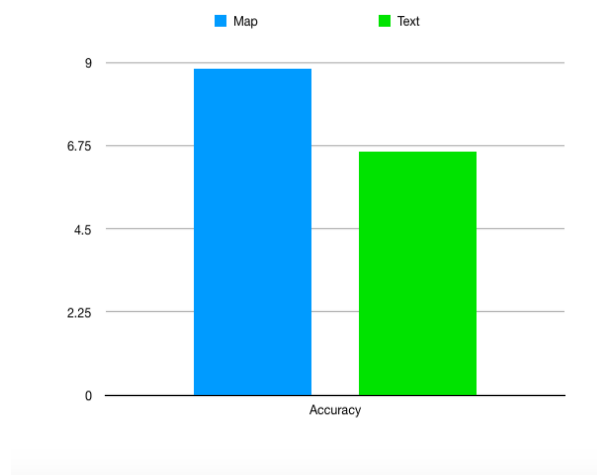


Figure 8.

2-way Interaction of Modality-Perspective in Accuracy

Cardinal terms

Analyses showed the main effect of cognitive processing on cardinal term usage was statistically significant, $F(1,45) = 4.94$, $p = 0.03$, $\eta^2 = 0.03$. **Based on the proportion of total words and cardinal term usage** (see page 32; total words: 6050.5), people used more cardinal terms when the text was provided (**0.039**) than when the map was provided (**0.029**). The analysis also demonstrated the main effect of spatial perspective on cardinal term usage was significant,

$F(1,45) = 17.15$, $p < 0.001$, $\eta^2 = 0.04$. Participants used more cardinal terms when the survey perspective was applied (**0.040**) than when the route perspective was applied (**0.029**). The two-way interaction between cognitive processing and language background on cardinal term usage was statistically significant, $F(1,45) = 5.12$, $p = 0.03$, $\eta^2 = 0.03$. This indicates that the effect of language background on cardinal term usage differs on the level of cognitive processing (map vs. text). Post-hoc comparisons suggested that under the native speaking condition ($p = 0.002$; total words: 3013), the text (**0.049**) included more cardinal terms than the map (**0.030**). Under the non-native speaking condition (total words: 3037.5), there were no significant differences between text (0.029) and map (0.029).

Moreover, the two-way interaction between cognitive processing and spatial perspective on cardinal term usage was statistically significant, $F(1,45) = 4.83$, $p = 0.03$, $\eta^2 = 0.01$. Post-hoc test suggested that under the route perspective ($p < 0.006$; total words: 3048.5), the text (**0.04**) included more cardinal terms than the map (**0.02**). Under the survey perspective (total words: 3002), there were no significant differences between text (0.04) and map (0.04).

The three-way interaction effect between cognitive processing, spatial perspective, and language on accuracy was not statistically significant (see Table 3).

Figure 9.

Main Effect of Modality in Cardinal Term Usage

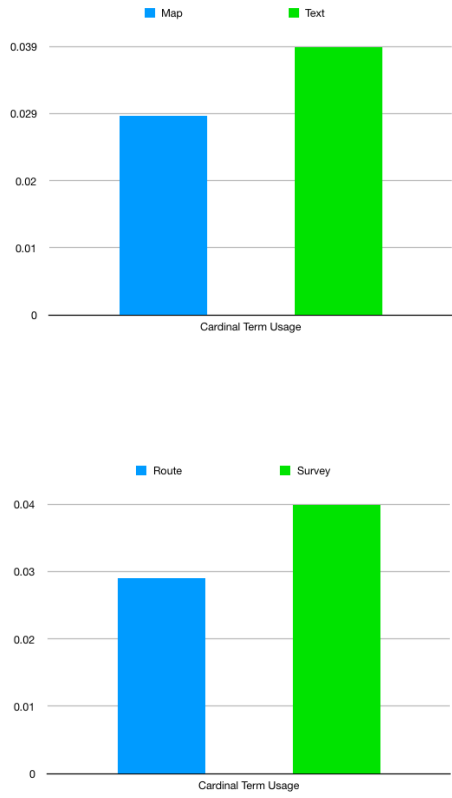


Figure 10.

Main Effect of Spatial Perspective in Cardinal Term Usage

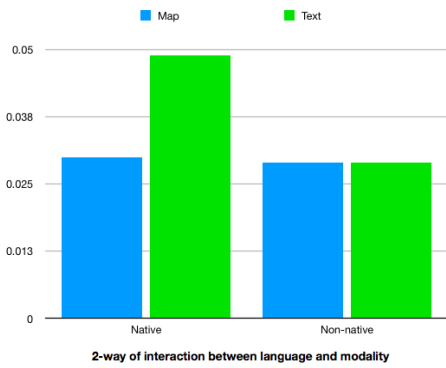


Figure 11.

2-way Interaction of Language and Modality in Cardinal Term Usage

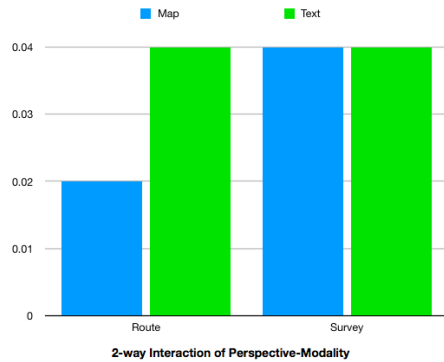


Figure 12.

2-way Interaction of Perspective and Modality in Cardinal Term Usage

Relative terms

Analyses showed the main effect of cognitive processing on relative term usage was statistically significant, $F(1,45) = 15.45$, $p < 0.001$, $\eta^2 = 0.07$. Based on the proportion of total words and relative term usage, participants used more relative terms when the map was provided (**0.063**) than when the text was provided (**0.044**). The two-way interaction between cognitive processing and language background on relative term usage was marginally significant, $F(1,45) = 4.22$, $p = 0.05$, $\eta^2 = 0.02$. This indicates that the effect of language background on cardinal term usage differs on the level of cognitive processing (map vs. text). Post-hoc comparisons suggested that under the non-native speaking condition ($p = 0.05$), the map (**0.07**) included more relative terms than the text (**0.041**). Under the native speaking condition, there were no significant differences between map (0.06) and text (0.05). The two-way interaction between cognitive processing and spatial perspective on relative term usage was statistically significant, $F(1,45) = 8.74$, $p < 0.01$, $\eta^2 = 0.02$. This indicates that the effect of spatial perspective on relative term usage differs on the level of cognitive processing. Post-hoc test suggested that under the route perspective ($p < 0.001$), the map (**0.07**) included more relative terms than the text

(0.043). Under the survey perspective, there were no significant differences between map (0.06) and text (0.05). The three-way interaction effect between cognitive processing, spatial perspective, and language on accuracy was not statistically significant (see Table 3).

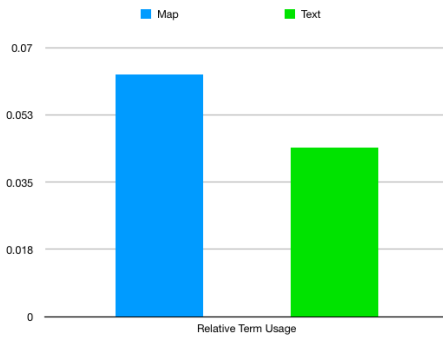


Figure 13.

Main effect of Modality in Relative Term Usage

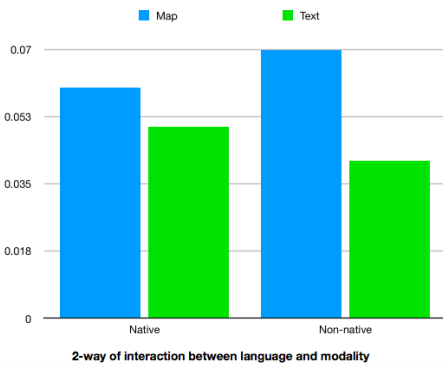


Figure 14.

2-way Interaction of Language and Modality in Relative Term Usage

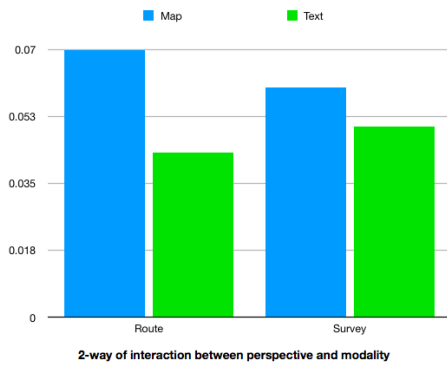


Figure 15.

2-way Interaction of Modality and Perspective in Relative Term Usage

Landmark Usage

Analyses showed there were no statistically significant main effects. Although the primary ANOVA analysis indicated that there were interactions between cognitive processing, spatial perspective, and language on landmark usage, post-hoc tests suggested that they were not statistically significant. These results indicated one of two possibilities: a false positive finding or that post-hoc tests lack power.

Discussion

The primary goal of this thesis was to examine how cognitive processing, spatial perspective, and language background influenced wayfinding direction giving. The experiment investigated the frequencies of each descriptive feature comparing natives and non-natives, and observed how directions would be differentiated by modality and spatial perspective. Based on previous research, it was hypothesized that: (1) Comparing map and text, accuracy would be better in map than text, (2) Comparing route and survey, accuracy should be higher and people should include more relative terms and fewer cardinal terms in the route perspective than in the

survey perspective, (3) Comparing natives and non-natives, accuracy would be better in natives than non-natives, and (4) A combination of route and map might yield the best performance, whereas a combination of survey and map might yield the worst performance among all four conditions.

Cognitive processing: map and text. The results showed a significant main effect for cognitive processing (map vs. text), on the accuracy of wayfinding. The researcher found *map* was better than text on *accuracy*. From these results, this first hypothesis was supported. Shabiralyani et al. (2015) suggested that visual materials may provide easy learning for recipients. In this experiment, the researcher found that the relationship between abstract objects could be easily clarified through visual processing. Based on previous researchers, in the present experiment participants could learn to use a map better than a text because they can see exactly where they should start and the destination. Of course, the text also gave detailed information, but participants needed to 'imagine' the map one more time to personally visualize each location. This might give a higher workload and decrease the accuracy in text condition. The *Map* condition was also better than the text condition on *relative terms usage*. For instance, visual information uses several ranges of points of view mixed with the information presented in graphical formats. This information does not restrict the viewer's opportunity to view and interpret the materials (Bignell, 2005). However, the text of the present study adopted strict writing formats (e.g., using only cardinal terms). The present study also anticipated that map would be better than text on landmark usage. However, the results of ANOVA were significant, but the post-hoc tests revealed that the main and interaction effects were not significant. These results might indicate a false-positive error or the lack of power in the post-hoc tests. Or,

landmark usage might not be associated with three factors. For example, a person might use verbal processing to mention landmarks regardless of modality, whereas they cannot do the same for cardinal/relative term usage.

Furthermore, *text* included more *cardinal terms* than map included. As Hund et al. (2012) demonstrated, the priming effect could have influenced the relation between the text condition and cardinal term usage. In line with previous literature such as Ehrenbrink and Hillmann (2017), priming refers to the psychological effect associated with a semantic activation. Reading a priming word may activate semantically related words and increase their usage. For instance, when the verbal stimulus 'North' is presented, participants might be able to activate similar words such as 'South' because these are semantically associated with each other. Overall, modality is a determining variable on accuracy and direction term usage. To sum up, use of a map is an efficient way to give accurate directions using more relative terms than are used with text. To convey accurate directions for someone, a speaker should use visual maps rather than text.

Spatial perspective: route and survey. There were no significant main effects of spatial perspective on accuracy. Contrary to findings of Denis et al. (1999) that the route perspective gives less ambiguity and more detailed instruction than the survey perspective, differences were not found in the present study. Meanwhile, there was no significant main effect of route perspective on more relative term usage. From these results, this second hypothesis was not supported. However, there were significant main effects of spatial perspective on *cardinal term usage*: under *survey perspective*, participants included more *cardinal terms* than under the route perspective. A survey perspective looks through the overall environment at once and tends to describe the entire overview of an environment layout using global frames of reference (e.g., the

sun or the lake range; Hund et al., 2012). Thus, a speaker mostly adopts cardinal terms (Lawton, 1996; Shelton & Gabrieli, 2002; Taylor & Tversky, 1996). Overall, it is plausible to say that the spatial perspective is not a determining factor for accuracy, but it might be crucial for cardinal term usage on wayfinding direction. That is, with the survey perspective speakers adopt cardinal terms more than with the route perspective. Note that the researcher instructed participants to use cardinal terms under survey perspective and use any terms participants wanted under route perspective. However, interestingly, some participants clearly preferred to use relative terms even under survey perspective, or some of participants presented ‘mixed’ (using both cardinal and relative terms together) terms to present their direction. Moreover, surprisingly, there were some participants who preferred to use cardinal directions under route perspective as well. Even though the results itself reflected those unexpected results of subjects, this clearly showed participants still included more cardinal terms under survey perspective. However, spatial perspective is not a determining factor for accuracy and relative term usage. The researcher also suggests that adopting the survey perspective and including cardinal terms might be associated with modality. For instance, cardinal term usage is mainly associated with the text condition since it consists of cardinal directions. Thus, participants with the text condition might consciously or unconsciously adopt cardinal term usage rather than relative term usage.

Language background and cognitive processing. The researcher could not find the main effect of language background on accuracy. From these results, the third hypothesis was not supported. However, there were significant interactions between cognitive processing and language background on direction terms: For *Native* participants, the text condition included more *cardinal terms* than the map condition. Non-natives did not show significant differences between map and text on cardinal term usage. Regarding language processing, native speakers

could process and understand more about verbal information than non-native speakers (Lev-ari, 2015), perhaps due to natives' higher cardinal term usage on the text than non-native speakers. Several Korean participants said that they were not used to including cardinal terms in directions because they always use relative terms since their childhood. These cultural or geographical differences (see Figures 5 and 6) may be linked to non-native participants' relatively low cardinal term usage as well. For *non-native speakers*, the map included more *relative terms* than the text. Previous studies argued that understanding visual material would be more helpful for non-natives than understanding verbal material (Kisser et al., 2012; Sanford, 2002; Sturt et al., 2004;). Further, although non-native speakers tend to struggle more than natives in processing all the information, and provide less accurate wayfinding performances (Sanford, 2002; Sturt et al., 2004), the present study did not find no significant differences in accuracy between language conditions. In the experiment, some native speakers had more difficulties with the text condition than the map. Not surprisingly, the same happened to non-natives. Regardless of language background, a visual map may work better for effective communication than a text. Therefore, for better wayfinding communication it is necessary to consider cultural and language differences.

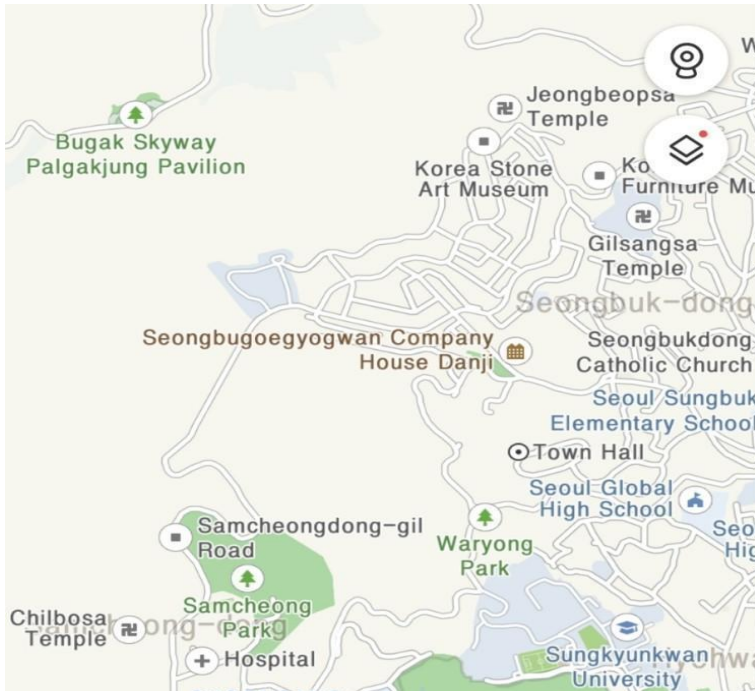


Figure 16.

Example of Korean Map (Seoul)



Figure 17.

Example of U.S. Map (NYC)

Cognitive processing and spatial perspective. Significant *interaction* effects of cognitive processing and spatial perspective were also found: under the *map* condition, people with a survey perspective provided more *cardinal terms* than with those with a route perspective. The results of the current study support those of Taylor and Tversky (1996), who suggested that the survey perspective mentions more cardinal terms than the route perspective. People in the present study also had significant differences in directions due to their spatial perspectives. Under the *route perspective*, a map was better than a text on *wayfinding accuracy*. Padgitt and Hund (2012) also supported this finding: participants made fewer errors with route perspective directions than with survey directions. Note that when participants gave directions using a visual map, 80% of participants adopted a route perspective. They also felt more confident and conveyed information more precisely toward other people (Denis et al., 1999; Lowen et al., 2017) This may indicate that participants may have more tendency to use a route perspective to give clear directions for someone. Meanwhile, under the *map* condition, both the route and survey perspectives on *accuracy* are statistically significant compared to text condition. Even though the difference was larger in the route perspective, the survey perspective still showed better accuracy under the map condition than under the text condition. This finding indicates that people can flexibly adjust their perspective to a map to give accurate directions. Thus, regardless of perspective, people could give accurate direction with a map. Additionally, under the *route perspective*, the text provided more *cardinal terms* than the map. This indicated that cardinal term usage may be differentiated depending on modality (map vs. text). Ward et al. (1986) found participants included cardinal terms more when primed by the verbal instruction that verbally noted the cardinal directions. Further, under the *route perspective*, the map included more *relative terms* than the text did. These results support the findings conducted in previous studies

(e.g., Beckermann, 1995; Kemmerer, 2014). Previous researchers also found that under the route perspective, participants included relative terms for a map more than they did for a text. A route perspective usually adopts "a viewer's perspective," and includes more relative terms than a survey perspective (e.g., Tversky & Taylor, 1996). This may indicate the interaction of map and route perspectives could provide clearer and more precise directions than other conditions.

Furthermore, when participants had no specific detailed guideline (text) and used their own terms (relative direction), they could give accurate directions for someone. This may indicate that when people apply their own wayfinding structures, they find detours and paths more accurately than when they are given detailed instruction. Thus, the combination of route and map showed better interaction performance than the other four conditions, whereas the survey and map combination presented less efficient performance than other conditions. From the results, the fourth hypothesis was supported.

Implications

This thesis aimed to assess the quality of wayfinding performances using descriptive features. From the results of the study, the researcher can imply that modality, perspective, and language influence wayfinding direction. However, previous research mostly focused on one factor such as how different spatial perspectives affect directions and how different modality affects route learning (Hund et al., 2012; Levinson, 2003; Li et al., 2015). Previous research has not compared several cognitive factors together in the same context. In this thesis, the researcher compared several factors (e.g., route and map) and how they affected performance together. Studying interactions between factors helps explain how to give better wayfinding directions and facilitate wayfinding communication processes.

Furthermore, another goal of this study was to understand how language background

affects wayfinding directions. Previous wayfinding research has focused on cross-cultural or gender comparisons (e.g., Lawton, 2012; Suzuki, 2013), but there was a lack of research comparing native versus non-native English speakers. In this thesis, language background (Native vs. non-native) and its interactive effects on wayfinding was one of the factors investigated. This finding can apply to further research for developing new wayfinding tools. For example, user experience (UX) designers can apply this information of how native and non-native English speakers differ in the use of route and survey perspectives. This insight could be fundamental for travelers across different cultures who need to use maps and GPS. According to Kim and Kang (2017), some countries have developed and shared wayfinding software (e.g., Google map). However, these programs reflect more Western geographical information and cannot be applied to non-Western countries. For instance, U.S. travelers who go to Korea might find it challenging to locate places using an American GPS that is not adapted to Korean geography (Ko & Kim, 2017). At the same time, if U.S. travelers try to ask directions from Koreans using cardinal terms without a visual map, Koreans might find it difficult to provide directions for Americans. With these findings, this study would tell how wayfinding communication can be more productive and efficient for travelers.

Limitations

One limitation of the present study is the reliance on a visual map. The present study was conducted with a two-dimensional (2D) design town map. The 2D visual map was shown through a monitor, and participants typed their answers on computers. However, the town map could not represent a relatively larger space such as a country. Moreover, even though the researcher recruited participants who lived in different cultures, the structure of the map (e.g., name of streets and avenues) was Americanized (Hund et al., 2008), which makes it harder to

replicate the research to other cultures. Further wayfinding research should make a map that has more universal structures.

Future Studies

With more universal maps, a future researcher can recruit more participants from various places. For instance, the present study focused on people who speak English, and most participants were from the United States and East Asia. However, it is important to know how different first language users have different wayfinding description styles. Future studies can involve a varied group such as residents in Latin America or Africa. This cross-cultural setting will allow discovery of a variety of similarities and differences in spatial cognition and wayfinding.

Conclusion

The present study suggested the effect of modality and spatial perspective on wayfinding directions. Results showed that wayfinding accuracy and use of relative terms were better under the map condition than under the text condition, but the use of cardinal terms was more predominant under the text condition. On the other hand, when route and survey perspectives were compared, more cardinal terms were used under the survey perspective than under the route perspective. Furthermore, wayfinding accuracy and use of relative terms within the map was better under the route perspective than under the survey perspective. Besides that, under the route perspective, more cardinal terms were used with the text than with the map. Under the non-native condition, people used more relative terms, but fewer cardinal terms were used under the map condition than under the text condition. However, compared to non-natives, natives used more cardinal terms with a text than with a map. Overall, the results suggest visual processing

may be the better choice than verbal processing for accuracy. Moreover, using relative terms under a route perspective may be more supportive of conveying clearer wayfinding communication than using cardinal terms under a survey perspective. These findings may contribute to advanced direction-giving from a wayfinder. For instance, what kind of instructions do they see? Which perspective do they take? Depending on their decision, the consequence of wayfinding and its effectiveness (e.g., accuracy) can be differentiated. Knowing the characteristics and interactions of each factor significantly promotes better wayfinding communication and strategies. Lastly, it would be beneficial to conduct further research using multiple kinds of maps. It would be important for future researchers to recruit more participants from various regions to examine the differences in direction effectiveness for wayfinding of individual ethnic groups.

References

- Andonova, E., Tenbrink, T., Coventry, K. R. (2010). Function and context affect spatial information packaging at multiple levels. *Psychonomic Bulletin & Review*, 17(4), 575-580.
- Bower G. H., Morrow D. C., (1990). Mental modules in narrative comprehension. *Science* 247:44-48.
- Bloom, P., Peterson, M.A., Nadel, L., Garrett, M.F.: Language and space. The MIT Press, Cambridge (1996).
- Brown, T. M. (2016). Using light to tell the time of day: sensory coding in the mammalian circadian visual network. *Journal of Experimental Biology*, 219(12), 1779.
- Chomsky, N. (1975). Reflections on language. New York: Pantheon.
- Clark, H. (1992). Arenas of language use. Chicago: University of Chicago Press.
- Childers, T. L., Houston, M. J., & Heckler, S. E. (1985). Measurement of individual differences in visual versus verbal information processing. *Journal of Consumer Research*, 12(2), 125–134.
- Chrastil, E. R., & Warren, W. H. (2014). From cognitive maps to cognitive graphs. *PLoS ONE*, 9(11), 1–8. Davies, D., Bathurst, D., and Bathurst, R. (1990). The telling image. The changing balance between pictures and words in a technological age, Clarendon Press Oxford.
- Denis, M., Pazzaglia, F., Cornoldi, C., Bertolo, L.: Spatial discourse and navigation: An analysis of route directions in the city of Venice. *Applied Cognitive Psychology*, 13, 145–174 (1999).

- Ehrenbrink, Patrick & Prezenski, Sabine. (2017). Causes of psychological reactance in human-computer interaction a literature review and survey.
- He, Q., McNamara, T.P. & Brown, T.I. Manipulating the visibility of barriers to improve spatial navigation efficiency and cognitive mapping. *Sci Rep* 9, 11567 (2019).
- Holmes, K. J., & Wolff, P. (2012). Does categorical perception in the left hemisphere depend on language?. *Journal of Experimental Psychology: General*. Advance online publication.
- Holmes, K.J., Moty, K. & Regier, T. (2017). Revisiting the role of language in spatial cognition: Categorical perception of spatial relations in English and Korean speakers. *Psych on Bull Rev*, 24, 2031–2036.
- Hund, A. M., Haney, K. H., & Seanor, B. D. (2008). The role of recipient perspective in giving and following wayfinding directions. *Applied Cognitive Psychology*, (7), 896.
- Hund, A. M., & Schmettow, M. & Noordzij, Matthijs. (2012). The impact of culture and recipient perspective on direction giving in the service of wayfinding. *Journal of Environmental Psychology*. 32. 327-336.
- Ishikawa, T., & Montello, D. R. (2006). Spatial knowledge acquisition from direct experience in the environment: Individual differences in the development of metric knowledge and the integration of separately learned places. *Cognitive Psychology*, 52(2), 93–129.
- Kim, S., & Kang, Y. (2017). Development and validation of the way-finding ability scale for middle-aged and older adults. *Dementia and Neurocognitive Disorders*, 16.
- Kisser, J. E., Wendell, C. R., Spencer, R. J., & Waldstein, S. R. (2012). Neuropsychological Performance of Native versus Non-native English Speakers. *Archives of Clinical Neuropsychology*, 27(7), 749–755.

- Ko, E., & Kim, E. Y. (2017). A vision-based wayfinding system for visually impaired people using situation awareness and activity-based instructions. *Sensors (Basel, Switzerland)*, *17*(8), 1882.
- Koć-Januchta, M., Höffler, T., Thoma, G.-B., Prechtel, H., & Leutner, D. (2017). Visualizers versus verbalizers: Effects of cognitive style on learning with texts and pictures – An eye-tracking study. *Computers in Human Behavior*, *68*, 170–179.
- Kosslyn, S. M. (2005). Mental images and the brain. *Cognitive Neuropsychology*, *22*(3-4), 333–347.
- Kraemer, D. J., Schinazi, V. R., Cawkwell, P. B., Tekriwal, A., Epstein, R. A., & Thompson-Schill, S. L. (2017). Verbalizing, visualizing, and navigating: The effect of strategies on encoding a large-scale virtual environment. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*(4), 611–621.
- Krukar, J., Anacta, V. J., & Schwering, A. (2020). The effect of orientation instructions on the recall and reuse of route and survey elements in wayfinding descriptions. *Journal of Environmental Psychology*, *68*.
- Lawton, C.A. *Sex Roles* (1994) 30: 765.
- Lawton, C. A. (1996). Strategies for indoor wayfinding: The role of orientation. *Journal of Environmental Psychology*, *16* (2), p. 137-145.
- Lawton C. A., & Kallai, J. (2002). Gender differences in wayfinding strategies and anxiety about wayfinding: A cross-cultural comparison. *Sex Roles*, *47*(9-10), p. 389-401.
- Levinson, S.C.: Frames of reference and Molyneux's question: Crosslinguistic evidence. In: Bloom, P., Peterson, M.A., Nadel, L., Garrett, M.F. (eds.) *Language and space*,

- pp. 109-169. The MIT Press, Cambridge, MA (1996).
- Levinson, S.C., Kita, S., Haun, D.B.M., Rasch, B.H. (2002). Returning the tables: Language affects spatial reasoning. *Cognition*. 84. 155–188.
- Lev-Ari S. (2015). Comprehending non-native speakers: theory and evidence for adjustment in manner of processing. *Frontiers in psychology*, 5, 1546.
- Li, Yao & Brown, Michael & Pinchin, James & Blakey, John. (2015). Comparison of methods to support in-hospital navigation: A pilot study in healthy volunteers.
- Löwen, H., Krukar, J., & Schwering, A. (2019). Spatial Learning with Orientation Maps: The Influence of Different Environmental Features on Spatial Knowledge Acquisition. *ISPRS International Journal of Geo-Information*, 8(3), 149.
- MacEachren, A. M. (1992). Visualizing uncertain information. *Cartographic Perspectives*, (13), 10-19.
- Majid, Asifa & Bowerman, M. & Kita, Sotaro & Haun, Daniel & Levinson, Stephen. (2004). Can language restructure cognition? The case of space. *Trends in Cognitive Sciences*, 108-114.
- Meneghetti C, Cardillo R, Mammarella IC, Caviola S, Borella E. The role of practice and strategy in mental rotation training: transfer and maintenance effects. *Psychol Res*. 2017;81(2):415-431.
- Meilinger, T., & Knauff, M. (2008). Ask for directions or use a map: A field experiment on spatial orientation and wayfinding in an urban environment. *Journal of Spatial Science*, 53 (2), p. 13-23.
- Messick, S. (1984). The nature of cognitive styles: Problems and promise in educational practice. *Educational Psychologist*, 19(2), 59–74.

- Montello, D. R. (1998). A new framework for understanding the acquisition of spatial knowledge in large-scale environments. In M. J. Egenhofer & R. G. Golledge (Eds.), *Spatial and temporal reasoning in geographic information systems* (pp. 143–154). New York, NY, US: Oxford University Press.
- Montello D. R., & Sas, C. (2006). Human factors of wayfinding in navigation maintenance effects. *Psychological Research*. 81.
- Majid, A., Bowerman, M., Kita, S., Haun, D. B. M., & Levinson, S. C. (2004). Can language restructure cognition? The case for space. *Trends in Cognitive Sciences*, 8, 108–114.
- Padgitt, A. J., & Hund, A. M. (2012). How good are these directions? Determining direction quality and wayfinding efficiency. *Journal of Environmental Psychology*, 32(2), 164–172.
- Pardo, J. S., Urmanche, A., Gash, H., Wiener, J., Mason, N., Wilman, S., Francis, K., & Decker, A. (2019). The montclair map task: Balance, efficacy, and efficiency in conversational interaction. *Language & Speech*, 62(2), 378–398.
- Pazzaglia, F., & Moè, A. (2013). Cognitive styles and mental rotation ability in map learning. *Cognitive Processing*, 14(4), 391–399.
- Péruch, Patrick & Chabanne, Vanessa & Nesa, Marie-Pascale & Thinus-Blanc, Catherine & Denis, Michel. (2006). Mental scanning of images constructed from visual experience or verbal descriptions: The impact of survey versus route perspective. *Quarterly Journal of Experimental Psychology*. 59. 1950-67.
- Pyers, J. E., Permiss, P., & Emmorey, K. (2015). Viewpoint in the Visual-Spatial Modality: The coordination of spatial perspective. *Spatial cognition and computation*, 15(3), 143–169.
- Robert S. Wyer Jr., Iris W. Hung, & Yuwei Jiang. (2008). Visual and verbal processing

- strategies in comprehension and judgment. *Journal of Consumer Psychology*, 18(4), 244.
- Sanford, A. J., & Workshop on Pragmatics and Cognitive Science. (2002). Context, attention and depth of processing during interpretation. *Pragmatics and Cognitive Science*, 17(1–2), 188–206.
- Schober M. F. (1993). Spatial perspective-taking in conversation. *Cognition*, 47(1), 1–24.
- Schwering, A., Krukar, J., Li, R., Anacta, V. J., & Fuest, S. (2017). Wayfinding through orientation. *Spatial Cognition & Computation*, 17(4), 273–303.
- Shabiralyani, G., Hasan, K. S., Hamad, N., & Iqbal, N. (2015). Impact of visual aids in enhancing the learning process case research: District dera ghazi khan. *Journal of Education and Practice*, 6(19), 226–233.
- Shelton, A. L., Gabrieli, J. D. E. (2002). Neural correlates of encoding space from route and survey perspectives. *Journal of Neuroscience*, 22, 2711-2717.
- Shelton, A.L., McNamara, T.P. Spatial memory and perspective taking. *Memory & Cognition* 32, 416–426 (2004)
- Soroli, E. & Hickmann, M. (2009). Spatial cognition in french and in english: Some evidence from eye-movements. *International Conference Language and Space*. Pisa.
- Spiers, H. J., & Maguire, E. A. (2008). The dynamic nature of cognition during wayfinding. *Journal of Environmental Psychology*, 28 (3), p. 232-249.
- Suzuki, K. (2013). A cross-cultural comparison of human wayfinding behavior using maps and written directions. *Geographical Review of Japan Series B*. 85. 74–83.
- Symonds, P., Brown, D. H. K., & Lo Iacono, V. (2017). Exploring an absent presence: wayfinding as an embodied sociocultural experience. *Sociological Research Online*, 22(1), 48–67.

- Sturt, P., Sanford, A.J., Stewart, A. (2004) Linguistic focus and good-enough representations: An application of the change-detection paradigm. *Psychonomic Bulletin & Review*, 11, 882–888.
- Taylor, H. A., Tversky, B., (1992) Mental models, pictures and text : integration of spatial and verbal information. S. I. ; 1991-05-02). Descriptions and depictions of environments. *Memory & Cognition*, (5), 483.
- Taylor, H. A. & Tversky, B., (1996). Perspective in spatial descriptions. *Journal of Memory and Language*. 35. 371-391.
- Tomasello, M. (2000). Do young children have adult syntactic competence? *Cognition*, 74, 209-253.
- Thorndyke, P. W., & Hayes-Roth, B. (1982). Differences in spatial knowledge acquired from maps and navigation. *Cognitive Psychology*, 14(4), 560–589.
- Tversky, A., Gati, I.: Studies of similarity. In: Lloyd, E., Rosch, B.B. (eds.) *Cognition and Categorization*, pp. 79–98. Lawrence Erlbaum, Hillsdale, NJ (1978).

Appendices

Appendix A.

Verbal Instruction(Text)

[Survey Perspective 1]

One of the largest food markets in the town is held each year. This food market map represents the locations where each food is sold.

The district consists of nine rectangular blocks of foods sold at the market.

There are six different blocks in the district.

This district contains three different avenues running North to South.

From West to East, they are Second Avenue, Third Avenue, and Parkway Avenue.

There are four different streets running East to West.

From North to South, they are Church Street, New Street, Ridgefield Street and River Street.

In the most Northwest block between New Street and Second Avenue, there is bacon.

Moving South, there is a salad in the next block.

In the most Southwest block between Second avenue and Ridgefield street, there is a chicken.

Moving East, there is a burger in the next block.

In the most Southeast block between Third Avenue and Ridgefield Street, there is a steak.

Moving North, there is a lobster in the next block.

In the most Northeast block between Third Avenue and New Street, there is bread.

Moving West, there is a cake in the next block.

In the Southeast block between Third Avenue and Ridgefield Street, there is a donut.

[Survey Perspective 2]

Starting from the Southwest corner, begin moving towards the East side of the market on River Street.

As it continues on River Street, go up North onto Second Avenue.

There will be chicken on the West and the burger on the East.

At the intersection, head East onto Ridgefield Street.

A Little farther along Ridgefield Street, there is a donut on the North.

At the intersection of Ridgefield Street and Third Avenue, there is a steak on the Southeast.

Next, head North onto Third Avenue. There is a lobster in the East.

At the intersection of Third Avenue and New Street, head North.

After that, there is bread in the Northeast.

At the intersection of Church street and Third Avenue, head West.

There is a cake in the South.

Head South onto Second avenue.

Then head West onto New Street.

A Little farther along New Street, there is a salad to the South and bacon to the North.

APPENDIX B.**Coding Instruction and Dependent Variables**

DV	Measures
Cardinal terms	North, South, East, West

Relative terms	Left, right, go straight, turn, or other relative terms relevant to first-person perspective.
Accuracy	<p>If a participant gave the right answer, a coder gave the score '10'</p> <p>If a participant got to the wrong destination, but it's still on the same side of the right path, a coder gave the score '8'</p> <p>If a participant got to the wrong destination, but it's on the wrong side of the right path, a coder gave the score '6'</p> <p>If a participant got to the wrong destination, and it's more than two blocks away in any direction without regard to the right path, a coder gave the score '4'</p> <p>If a participant completely missed, a coder gave the score '0'.</p>
Landmarks	Mentioned Specific objects (e.g., name of vegetables or foods)

APPENDIX C.

English Proficiency Test

For Q1, Q2, Q3 and Q4: if a participant selects 'Never', they will be screened out. For Q5, the

answer is 'A' ; if a participant selects 'B', 'C', or 'D', they will be screened out.

Q1. How many English classes did you take in your high school?

- Never
- Please specify
- I graduated from high school in an English speaking country(e.g., United States, Canada)
- I graduated from international school in a non-English speaking country(e.g., China, Thailand)

Q2. How many English classes did you take in your high school?

- Never
- Please specify
- I attend or graduated from college/university in an English speaking country(e.g., United States, Canada)
- I attend or graduated from college/university in a non-English speaking country, but most of the courses offered during regular semesters were lectured in English.

Q3.How many times do you use English per week?For example, having conversations with English, taking English lessons, writing essays in English, or reading English books/journals.

- Never
- Please specify
- I always use English in my daily life.

Q4.Did you take any official English test before?For example, TOEIC, TOEFL, IELTS, GRE verbal, TOEIC Speaking or OPIC. If it's applicable, please type the name of the test and your score here.

- Never

- Please specify
- I did not take any official test but English is my mother language.
- I did not take any official test but I graduated schools from English speaking countries(e.g., United States, Canada)

Q5. Please look at the map and play the audio file below. Then, choose the answer. Now, you will hear the listening script the direction, and solve the question; you will look at the graphic above while listening to the script, then decide which option, labeled A, B, C, or D in the graphic, is correct and mark it on the answer document. Please look at the map and play the audio file below. Then, choose the answer.



Question: Where will you work on your group science project tomorrow?

Audio script (dictated only)

Listen to the phone message from your classmate from school. Hi, this is Julie. I hope you got the science books from the library. Let's meet at 2:00 o'clock tomorrow at my house and then walk over to Sam's—his house is at the corner of Sunset and River Road. We can finish our project on recycling there. Don't forget—we've got to turn in all our work to Mr. Thomas at

school next Thursday.

Answer options: A, B, C, D (Correct answer is A)

Appendix D.

Native speakers' mean, SE, and range (CI 95% lower-upper bound) frequency of mention of descriptive features during eight trials for each perspective. (Standard error is listed in parenthesis)

Native Speakers

DV	Map		Text	
	Route	Survey	Route	Survey
Accuracy				
Mean(SE)	9.05(0.68)	8.63(0.68)	6.88(0.68)	7.38(0.68)
Range	7.69-10.00	7.28-9.98	5.53-8.23	6.30-8.73
Cardinal terms				
Mean(SE)	1.24(0.34)	2.57(0.34)	2.86(0.34)	3.36(0.34)
Range	0.56-1.91	1.89-3.24	2.19-3.54	2.69-4.04
Relative terms				
Mean(SE)	4.06(0.42)	3.14(0.42)	3.23(0.42)	2.85(0.42)
Range	3.22-4.90	2.31-3.98	2.39-4.06	2.01-3.69

Landmarks

Mean(SE)	1.80(0.27)	1.98(0.27)	2.09(0.27)	2.28(0.27)
Range	1.26-2.33	1.45-2.52	1.55-2.62	1.74-2.81

Note. Mean(SE); Range= 95% CI; lower-upper bound

Appendix E.

Non-native speakers' mean, SE, and range(CI 95% lower-upper bound) frequency of mention of descriptive features during eight trials for each perspective. (Standard error is listed in parenthesis)

Non-Native Speakers

DV	Map		Text	
	Route	Survey	Route	Survey
Accuracy				
Mean(SE)	9.14(0.69)	8.57(0.69)	5.27(0.69)	6.92(0.69)
Range	7.77-10.00	7.21-9.93	3.90-6.63	5.55-8.28
Cardinal terms				
Mean(SE)	1.53(0.35)	2.45(0.35)	1.79(0.35)	2.07(0.35)
Range	0.85-2.21	1.67-3.04	1.11-2.47	1.39-2.75

Relative terms

Mean(SE)	5.06(0.43)	4.00(0.43)	2.34(0.43)	3.13(0.43)
Range	4.22-5.91	3.15-4.84	1.50-3.19	2.28-3.97

Landmarks

Mean(SE)	2.14(0.27)	1.57(0.27)	1.09(0.27)	1.44(0.27)
Range	1.60-2.68	1.03-2.11	0.55-1.63	0.90-1.98

Note. Mean(SE); Range= 95% CI; lower-upper bound

Appendix F.***Table of Descriptive Statistics***

Source(df)	<i>F</i>	<i>p</i>	η^2
Accuracy			
CP (1,45)	26.33	<.001 ***	0.10
SP (1,45)	0.93	0.34	0.00
Language (1,45)	0.48	0.49	0.01
CP * Language (1,45)	1.46	0.23	0.01

SP * Language (1,45)	0.68	0.41	0.00
CP * SP (1,45)	5.67	0.02 *	0.01
CP * SP * Language (1,45)	0.98	0.33	0.00

Cardinal terms

CP (1,45)	4.94	0.03 *	0.03
SP (1,45)	17.15	<.001 ***	0.04
Language (1,45)	3.04	0.09	0.06
CP * Language (1,45)	5.12	0.03 *	0.03
SP * Language (1,45)	1.04	0.31	0.00
CP * SP (1,45)	4.83	0.03 *	0.01
CP * SP * Language (1,45)	0.21	0.65	0.00

Relative terms

CP (1,45)	15.45	<.001 ***	0.07
SP (1,45)	2.93	0.09	0.01
Language (1,45)	0.55	0.46	0.01
CP * Language (1,45)	4.22	0.05 *	0.02

SP * Language (1,45)	1.20	0.28	0.00
CP * SP (1,45)	8.74	0.00 **	0.02
CP * SP * Language (1,45)	2.61	0.11	0.01

Landmarks

CP (1,45)	0.68	0.42	0.00
SP (1,45)	0.19	0.67	0.00
Language (1,45)	2.37	0.13	0.05
CP * Language (1,45)	5.99	0.02 *	0.03
SP * Language (1,45)	2.65	0.11	0.00
CP * SP (1,45)	5.16	0.03 *	0.01
CP * SP * Language (1,45)	5.16	0.03 *	0.01

Note. CP: Cognitive processing, SP: Spatial cognition; *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$

Appendix G.

Example of Participant's Answer (Map-Route Condition)

Start point: garlic building Destination: mushroom building Answer: Hi you are in the garlic building. The destination is the mushroom building. First, go straight 2 blocks on york street and turn right. If you go one more block, you will see the mushroom building on your left.

Appendix H.

Example of Participant's Answer (Map-Survey Condition)

Start point: cucumber Destination: mushroom Answer: When will this questionnaire end? Anyway. My dear friend, You're in cucumber now. To go to the mushrooms, Just one block east of york street. And then go another block south. Then you will see mushrooms on your left.

Appendix I.

Example of Participant's Answer (Text-Route Condition)

Starting point : Bacon Destination : Burger Answer : on 2th avenue, go south until you ridgefield street. Than turn left and go straight until between third avenue and ridgefield street.

Appendix J.

Example of Participant's Answer (Text-Survey Condition)

Start point: chicken Destination: lobster Answer: First, go south one block. And then moving North, there is a lobster in the next block.

