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Akio HONDA （本多明生）[1] and Yoshiaki NIHEI （仁平義明）[1]

This research investigated the intelligibility of route descriptions and their translation into graphic sketches, portraying spatial representations of the text. In Study 1, route descriptions of a university campus were collected from 18 college students. Then, 72 college students (36 students knew the campus, 36 did not) were asked to rate the description's intelligibility. Results of Study 1 showed that the ratings of the descriptions garnered very similar responses from both groups of students. Particularly, good descriptions included the more frequent use of distinctive features in the environment and the more frequent use of verbs of movement than poor descriptions. In Study 2, students of other universities (n = 191) were asked to create maps using the given descriptions and to rate the degree of difficulty of their translatability. Results showed that the intelligibility of descriptions did not always translate easily into useful maps. Furthermore, the numbers of landmarks, pathways, and body-based frames of reference in the descriptions affected text-to-image translation processes. The contributing factors to intelligible route descriptions are discussed.

Key words: Route descriptions, Graphic sketch, Intelligibility

Introduction

Route description is the linguistic medium that is used to transmit navigational information to a person who is in a new environment (Denis, 1997). Route directions consist fundamentally of selecting those salient features in the environment which allow the user to create a visual model. Using those directions, a person will be able to anticipate crucial decision points that demand action (Daniel and Denis, 2004). Several researchers have attempted to identify components and structures in intelligible route descriptions (Allen, 2000; Denis, Pazzaglia, Cornoldi, & Bertolo, 1999; Honda & Nihei, 2004; Lovelace, Hegarty, & Montello, 1999). For example, Allen (2000) reported that remembering and following route directions were facilitated by the practices of: (1) presenting directions in correct temporal or spatial order, consistent with the principle of natural order; (2) concentrating information in statements related to choice points, consistent with the principle of referential determinacy, and, to some extent; (3) using simple spatial designations which most listeners would recognize, consistent with the principle of mutual knowledge. In addition, Lovelace et al. (1999) pointed out several aspects of good route descriptions based on the findings of earlier researchers. These aspects include (1) priming the traveler for upcoming choice points, (2) mentioning landmarks at choice points, (3) giving "you've gone too far if"

1 Department of Psychology, Faculty of Humanities, Iwaki Meisei University, 5-5-1, Chuodai, Iino, Iwaki, Fukushima, 970-8551, Department of Psychology, Graduate School of Arts and Letters, Tohoku University, 27-1, Kawauchi, Aoba-ku, Sendai, Miyagi, 980-8576

statements in case a choice point is missed, (4) giving landmarks rather than street names, (5) giving distance between choice points, (6) telling the traveler which way to proceed at a choice point, (7) providing information to allow recovery from errors, (8) providing clearly linear information (e.g., using 'then', and emphasizing a sequential rather than global view), and (9) providing a limited amount of redundant information (Lovelace et al., 1999).

For the present study, we investigated the intelligibility of route descriptions and their translation into graphic sketches, simulating spatial representations of the text. Sketch maps are frequently used to externalize an individual's environmental representation (Blades, 1990). Several researchers have suggested that the intelligibility of descriptions does not always translate easily into maps. For example, Franklin (1996) pointed out the difficulties of interpreting spatial relations from natural language. In addition, Fraczak (1998) reported that translation of texts into images is not an easy task because these two modes differ in their expressive capabilities. And Fraczak (1998) demonstrated that the ambiguity of route descriptions is not really perceived unless addressees want to derive a graphic representation of the route. Incomplete or vague information in route descriptions sometimes engenders addressees' misunderstandings. In fact, Shingaki & Nojima (1998) examined when and why people make use of external navigation sources (maps, landmarks, and guidance from other people). In their experiment, participants were asked to go to a local town in which they had to visit six destinations using information obtained from either a route guidance service or from pedestrians. The results indicate that several participants showed misunderstandings of the route guidance provided. This finding suggests that intelligible route descriptions lead not only to eased understanding of addressees, but also to restraint of incomplete or vague spatial information in route descriptions. However, few reports in the literature have described the relationship between the intelligibility of route descriptions and their translatability into maps. Moreover, few previous studies have examined what components in route descriptions inhibit the misunderstandings of route descriptions. In our previous studies (Honda & Nihei, 2001; 2003; 2004), we examined the characteristics of intelligible route describers and sex differences in wayfinding behaviors using written route descriptions. We did not investigate these aspects in the present study: instead, we examined the intelligibility of route descriptions (Study 1) and their translation into graphic sketches, portraying spatial representations of the text (Study 2).

Study 1

Study 1 was designed to analyze the intelligibility of route descriptions. We examined whether participants' environmental knowledge influences judgments of the intelligibility of route descriptions. Denis et al. (1999) reported that the ratings of the communicative value of the original individual protocols garnered very similar responses from judges who knew and did not know the target environment. We tried to confirm the findings of Denis et al. (1999). In addition, we investigated the components of intelligible route descriptions.

Method

Participants

Seventy-two graduate and undergraduate students were asked to participate in this study (age: 19-31). Thirty-six were familiar with the Tohoku University Kawauchi campus. The other 36 students from Yamagata University were unfamiliar with this campus.

Route descriptions

We collected route descriptions using the following procedure. First, 18 Tohoku University students were asked to write down the description of a route on their own campus so that a visitor who is unfamiliar with the campus might easily reach the designated room of a particular building. The starting point of the route was a post office next to the campus. The destination was a room in the Psychology Department. The distance separating them was about 800 m. The following instructions were given by the experimenter: "Imagine that a person who had never been to the Tohoku University Kawauchi campus asked you how to go from the Kawauchi post office to a laboratory in the Psychology Department on foot. Please write down the route description, as intelligibly as you possibly can, that can direct the person". The describers' handwritten descriptions were subsequently typed. The typist corrected only spelling errors (wrong characters): errors of grammar, punctuation, capitalization, and so forth were left uncorrected. The mean and standard deviation for the number of words were 453.3 (*SD* 179.0).

Procedure

In an earlier study, Denis et al. (1999) asked five students who were familiar with Venice and another five who were unfamiliar with the city to rate each of 19 navigational descriptions on a 7-point scale for their quality of navigational assistance. For the present study, all participants were asked to read and rate each of the 18 descriptions on a 7-point scale based on the verbal descriptions' intelligibility. The individual raters were given all of the route descriptions in the form of a booklet. The instruction was "Each of the 18 descriptions provides a person who has never been to the Tohoku University Kawauchi campus with directions explaining how to go from the Kawauchi post office to a laboratory in the Psychology Department. Your task is to rate each description on a 7-point scale for intelligibility. First, read all 18 descriptions without rating them; then re-read and rate them." The order of route descriptions was randomized among the individual raters.

Results and Discussion

Intelligibility of route descriptions and raters' environmental knowledge

A two-factor ANOVA of the ratings of each route description was performed considering differences of environmental knowledge (familiar, unfamiliar with the campus) and the route description (18) as a factor. The result underscored the main effect of the route descriptions ($F(17, 1190) = 10.32, p < 0.001$). No significant effect was found for the difference of environmental knowledge ($F(1, 70) = 0.60$, *ns*). Moreover, no indication was observed for any interaction between the two factors ($F(17, 1190) = 1.36$, *ns*). Agreement among the judges was assessed by

computing correlation coefficients for the ratings, for each route and for familiar and unfamiliar judges. The ratings of intelligibility of the descriptions indicated a very similar response from familiar and unfamiliar judges (r (18) = 0.77 $p < 0.001$). This result supports the findings of Denis et al. (1999). The similarities of ratings suggest that the components in the intelligible route descriptions were common, irrespective of the raters' environmental knowledge.

Components of the intelligible route description

We identified the components in the route descriptions as follows. First, we categorized the descriptions into components based on definitions presented in previous studies (Allen, 2000; Denis et al., 1999; Lovelace et al., 1999; Vanetti & Allen, 1988; Taylor & Tversky, 1996; Ward, Newcombe & Overton, 1986; Wunderlich & Reinelt, 1982). Second, we defined new components that were not used in previous studies but which seemed to provide important information for communicating route knowledge (see Table 1). Subsequently, we used half of the descriptions to categorize the new components. To verify that this categorization was reliable, the two authors independently categorized two descriptions chosen randomly from the remaining half of the descriptions. The categorization showed adequate reliability, the correspondence rate being 89.9%. Finally, the first author categorized all the descriptions again. Questions were resolved by discussion between the two authors if questions related to categorization arose. The average ratings of intelligibility of the route were calculated using the familiar and unfamiliar judges (M = 4.52 ± 0.55). Then, we divided the route descriptions into well written and poorly written descriptions according to the total average ratings of intelligibility from the familiar and unfamiliar judges. Mann-Whitney analysis was used to examine the differences of components between two types of the descriptions (see Table 2).

The results show that well-written route descriptions more frequently included distinctive features of the environment (U = 3.5, $p < 0.01$) and verbs of motion (U = 16.5, $p < 0.05$) than poor route descriptions. In addition, the intelligible route descriptions included slightly more frequent body-based frames of reference than poor route descriptions (U = 20.5, $p < 0.10$). For a previous study (Honda & Nihei, 2004), we investigated wayfinding behaviors using route descriptions. The results of our previous study revealed that directional errors occurred more frequently when using a simple orientation for landmarks ("… walk to the end of the path, there will be a building to your left …") in the route descriptions. In contrast, directional errors did not occur so frequently when using route descriptions which provided salient landmarks (… walk to the end of the path, there will be a nine-story building to your left. …). The results indicate that the salient and distinctive information of landmarks in the description facilitated wayfinding in a large-scale environment (Honda & Nihei, 2004). The results suggest that the number of distinctive features in the environment that were included in the explanation influenced the intelligibility of route descriptions, as judged by familiar and unfamiliar judges. In addition, results of the present study show that good descriptions contained more verbs of motion than did poor descriptions. Lovelace et al. (1999) reported that inclusion of more segments and turn mentions are correlated with higher-quality route descriptions. Results of the present study support those findings of Lovelace et al. (1999).

Table 1 Definitions of route description components

Components	Definitions
Landmarks	Landmarks are sub-goals that keep the traveler connected to both the point of origin and the destination along a specified path of movement ("Go towards *the building*").
Pathways	Pathways are nominals that refer to actual or potential channels of movements, such as streets, sidewalks, or trails ("Walk along *the main street*").
Choice points	Choice points are nominals that clearly refer to places giving options with regard to pathways ("*The intersection* is about 100 meters' distance from here").
Standard units	Standard units are distance designations that specify spaces separating points of reference using metric information ("Walk for about *500 meters* on the same street").
Temporal units	Temporal units are distance designations that specify spaces separating points of reference using temporal information ("Go towards the building about *5 minutes*").
Vague judgments	Vague judgments are distance designations that specify spaces separating points of reference using vague expressions of distance ("The intersection is *not far from* here").
Abstract frames of reference	Abstract frame of references are direction designations that specify spatial relations using cardinal directions ("Turn *east* onto College Street").
Environment-based frames of reference	Environment-based frames of reference are direction designations that specify spatial relations using object-centered directions ("*To the right of the church*, there is a path").
Body-based frames of reference	Body-based frames of reference are direction designations that specify spatial relations using viewer-centered directions ("There is a photocopy shop *on your right*").
Distinctive features in environments	Distinctive features in environments include descriptions of salient visual features or attributes of objects in environments ("There will be a *nine-story* building to your left." "*The room number is 731*"" You will see a gate. *It looks like a crossing bar.*").
Orders	Orders are ordinal numbers that are words, such as "third" and "fifth" that tell the traveler where a particular object occurs within a sequence of things ("Our house will be *the third* on your right").
Vague sizes or times	Vague sizes or times are adjectives that specify objects in environments using uncountable information such as "big" or "some" ("Please go straight ahead over *some* streets").
Verbs of movement	Verbs of movement, which can be distilled semantically into either "go" or "turn", connote directives, which tell traveler where he/she is supposed to go ("*Walk straight* ahead").
Errors in description	Errors in the description provide erroneous spatial information for the traveler, such as directions to turn left when, in fact, the turn should be a right.

Table 2 Means and standard deviations of the number of components in route descriptions

Components	Good (n = 9)	Poor (n = 9)
Landmarks	9.11 (3.59)	7.56 (3.43)
Pathways	6.22 (2.22)	5.33 (2.29)
Choice Points	1.11 (0.78)	1.00 (1.12)
Standard units	0.22 (0.44)	0.11 (0.33)
Temporal units	0.00 (0.00)	0.00 (0.00)
Vague judgments	1.89 (1.54)	1.67 (1.32)
Abstract frames of reference	0.11 (0.33)	0.00 (0.00)
Environment-based frames of reference	4.44 (1.42)	3.56 (1.59)
Body-based frames of reference	10.56 (3.00)	8.11 (2.32)
Distinctive features in environment	4.44 (1.81)	1.33 (1.00)
Orders	0.00 (0.00)	0.56 (0.73)
Vague sizes or times	1.57 (1.94)	0.78 (0.83)
Verbs of movement	15.22 (2.95)	12.22 (2.39)
Errors in description	0.22 (0.44)	0.30 (0.50)

Study 2

In Study 2, we investigated the relationship between the intelligibility of route descriptions and their translation into graphic sketches. Sketch maps are frequently used to externalize an individual's environmental representation (Blades, 1990). In particular, we examined that the intelligibility of route descriptions was related to the difficulty of their translatability into graphic sketches. Moreover, we investigated what route description components triggered misunderstandings of route descriptions.

Method

Participants

In all, 191 students (Yamagata University and Fukushima University) participated in this study (men = 83, women = 108). They had never visited Tohoku University's Kawauchi campus.

Route description

We used the same route descriptions as those used for Study 1.

Procedure

Participants were asked to draw a map from a route description. Each participant was randomly assigned to one of the 18 route descriptions. Participants were given an A3 size sheet of paper with one of the 18 route descriptions and a drawing space (17 cm × 17 cm). The instruction was: "The description provides a person who has never been to the Tohoku University's Kawauchi campus with knowledge of how to go from the Kawauchi post office to a

laboratory of the Psychology Department. Your task is to draw a map from the description. Please draw a map to aid navigation by an unfamiliar person from the Kawauchi post office to a laboratory of the Psychology Department. If you finish the map drawing, please rate the description on a 7-point scale for the ease of their translatability into graphic sketches." Participants were the tested group and were timed using a stopwatch; they were given 15 min for this drawing task. In a preliminary study, we asked two students to draw maps for each of 18 descriptions. The total average time of map drawings was about 15 min.

Results and Discussion

Intelligibility of route descriptions and their translation into graphic sketches

We investigated the correlation between the average ratings of intelligibility of the descriptions and the average ratings of the ease of their translatability into graphic sketches. The result showed no significant correlation (r (18) = -0.02, *ns*). In addition, we examined the correlation between the average ratings of intelligibility of the descriptions and the average rates of accomplished drawings. However, no significant correlation was found (r (18) = -0.36, *ns*). These results indicate that the intelligibility of descriptions did not always translate easily into maps. Moreover, the results supported the findings of Franklin (1996) and Fraczak (1998).

Components in the translatable route description

We conducted a cluster analysis to classify the route description using the average ratings of intelligibility, the average ratings of the ease of their translatability, and the average rates of accomplished drawing. The route descriptions were divided into four groups (see Fig. 1 & Table 3).

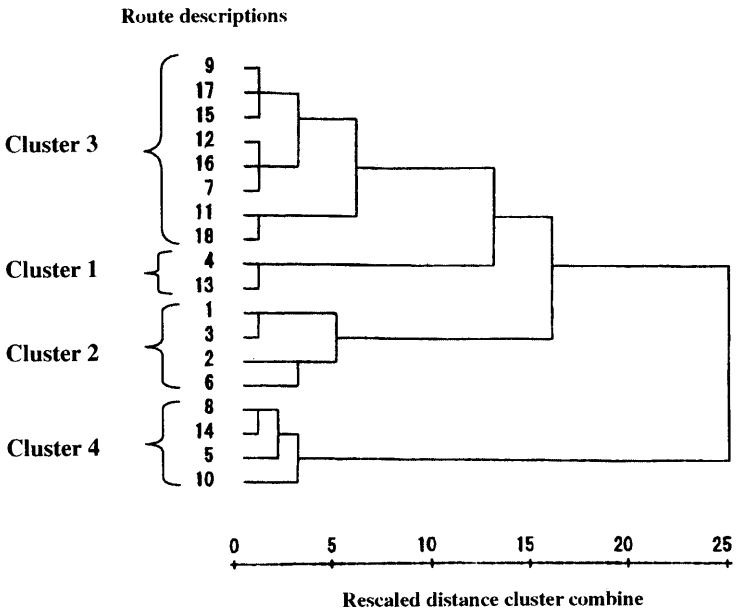


Figure 1. Results of route description cluster analysis

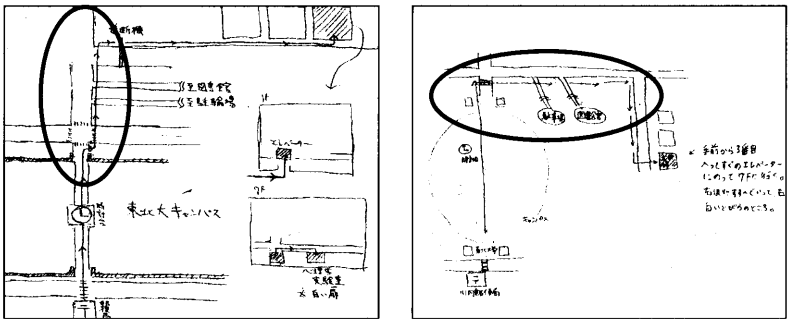
Table 3 Means and standard deviations of each cluster of route descriptions

	Intelligibility	Translatability	Rate of accomplished drawing
Cluster 1 (n = 2)	4.63 (0.24)	4.33 (0.32)	0.98 (0.06)
Cluster 2 (n = 4)	3.72 (0.45)	2.98 (0.66)	0.93 (0.04)
Cluster 3 (n = 8)	4.76 (0.33)	2.89 (0.42)	0.80 (0.08)
Cluster 4 (n = 4)	4.80 (0.36)	2.76 (0.44)	0.26 (0.12)

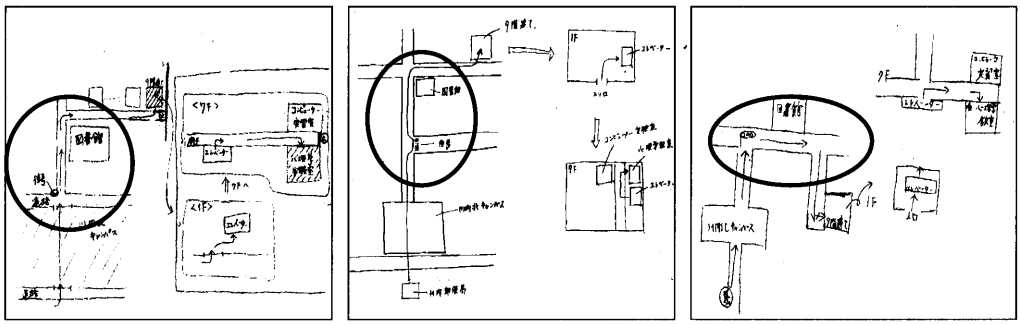
First, we investigated the components of the translatable route descriptions. We compared differences of components in Group 1 and Group 3. The results showed that the translatable descriptions more often included a body-based frames of reference (Group 1: $M = 9.25$ vs. Group 3: $M = 1.50$; $U = 0.50$, $p < 0.05$), but less often included choice points than untranslatable route descriptions (Group 1: $M = 4.56$ vs. Group 3: $M = 6.50$; $U = 0.00$, $p < 0.05$). Secondly, we examined that the components in descriptions were observed in the differences of rates of accomplished drawing. We compared differences of components in Group 3 and Group 4. Differences were apparent for landmarks (Group 3: $M = 7.13$ vs. Group 4: $M = 13.50$; $U = 1.50$, $p < 0.01$), pathways (Group 3: $M = 5.13$ vs. Group 4: $M = 7.50$; $U = 4.50$, $p < 0.05$), and body-based frames of references (Group 3: $M = 8.63$ vs. Group 4: $M = 12.25$; $U = 4.50$, $p < 0.05$) in the two groups. Finally, we investigated the components in the intelligible route descriptions. We compared differences of components in Group 2 and Group 3. The results revealed that the intelligible route descriptions more often included distinctive features in environments (Group 2: $M = 1.00$ vs. Group 3: $M = 3.13$; $U = 4.50$, $p < 0.05$) and choice points (Group 2: $M = 0.25$ vs. Group 3: $M = 1.50$; $U = 2.00$, $p < 0.05$) than poor route descriptions. Although intelligible route descriptions slightly more often provided body-based frames of reference (Group 2: $M = 6.75$ vs. Group 3: $M = 8.63$; $U = 5.50$, $p < 0.10$) than poor descriptions, no significant difference was found.

Characteristics of ambiguous route descriptions

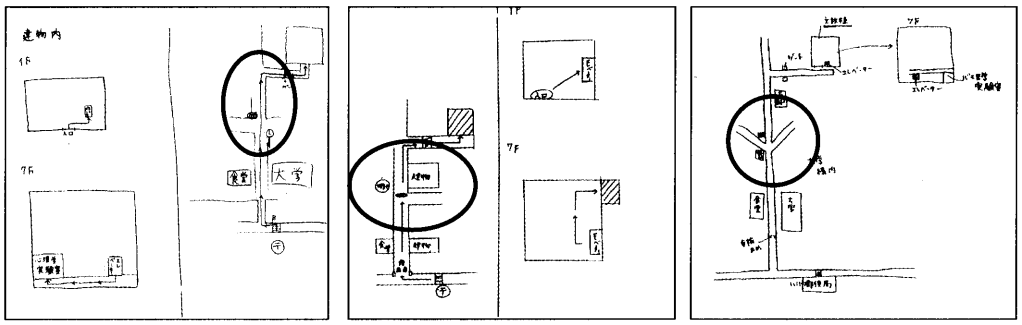
Some examples of ambiguous interpretations from route descriptions are presented in Fig. 4. These interpretations were observed in the same choice points on the sketch map. The left sketch maps are correct in their spatial configuration of a real environment. For example, several participants showed misunderstanding of "Use the crosswalk when crossing the street, then go toward the sidewalk (see Fig. 2a)" or "A T junction exists. Continue on the crosswalk using traffic signals (see Fig. 2b)" in route descriptions. Both descriptions provided directional information from the environment-based frames of reference. Interestingly, participants showed ambiguous interpretations of choice points from "A three-forked junction exists. Go straight at the crossing (see Fig. 3c)", but did not misunderstand the direction of traveler's wayfinding on the maps. Allen (2000) pointed out that effective wayfinding is enhanced by practices of including descriptive and concentrating delimiters at choice points. By classification, delimiters included distance designations and direction designations. Our results suggest that body-based frame of references in route descriptions are important to inhibit the misunderstanding of addressees.



(a) "Use the crosswalk when crossing the street, then go toward the sidewalk"



(b) "There is a T junction. Continue on the crosswalk using traffic signals"



(c) "There is a three-forked junction. Go straight at the crossing"

Figure 2. Examples of ambiguous interpretations of route descriptions

Discussion

In Study 1, we examined whether participants' environmental knowledge influences judgments of the intelligibility of route descriptions. The results show that the ratings of the descriptions engendered very similar responses of students who knew and did not know the

environment. This result supported the findings of Denis et al. (1999). In addition, good descriptions included the use of more distinctive features in the environment and verbs of motion rather than poor descriptions. Lovelace et al. (1999) reported that inclusion of more segments and turn mentions was correlated with higher-quality route descriptions. Results of the present study support those findings. In Study 2, we investigated the relationship between the intelligibility of route descriptions and their translation into graphic sketches. Moreover, we investigated what components of route descriptions triggered misunderstandings of route descriptions. The results showed that intelligibility of descriptions did not always translate easily into graphic sketches. Furthermore, the numbers of landmarks, pathways, and body-based frames of reference in the descriptions affected the text-to-image translation processes. Schneider & Taylor (1999) reported that overdeterminate route descriptions stressed addressees' working memory and influenced many aspects of their performance. This result supported the findings of Schneider & Taylor (1999). Moreover, our results indicated that the body-based frames of references in the descriptions inhibited the ambiguous interpretations from route descriptions translated into graphic sketches. Results of a previous study showed that spatial perspectives in route descriptions influenced the integration of information (Schneider & Taylor, 1999). In particular, our results indicated that body-based frames of references in the descriptions are important to inhibit misunderstandings during text-to-image translation processes. This study investigated the intelligibility of route descriptions and their translation into graphic sketches, portraying spatial representations of the text. Intelligible route descriptions are necessary to select necessary spatial information and to construct a plan for navigation with intelligible components. In fact, a previous study pointed out that route directions fundamentally require selection of salient features in the environment which allow the user to create a visual model; thereby, the navigator will be able to anticipate crucial decision points that will require some action (Daniel & Denis, 2004). Results of our studies suggest that: (1) intelligible route descriptions more frequently included distinctive features of the environment; (2) body-based frames of reference in the descriptions are important to inhibit the misunderstanding of addressees and to ease translation into graphic sketches. Future study is necessary to elucidate the relationship between the translatability of route descriptions and wayfinding behaviors in large-scale environments.

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