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Testing the Value of Route Directions Through Navigational Performance

Marie-Paule Daniel, Ariane Tom,
Elsa Manghi, and Michel Denis

Université de Paris-Sud, Orsay, France

Route directions to reach a target point on a campus were collected from undergraduates. A "good" description and a "poor" one were selected, based on ratings provided by judges in terms of their value for navigational assistance. People unfamiliar with the campus were then required to navigate to the target after studying one of these descriptions. In addition, a "skeletal" description, which contained the essentials needed for navigating, was constructed and used in the experiment. During navigation, we measured the frequencies of stops and of directional errors (whether these errors were self-corrected or corrected by the experimenter). Overall, the good and the skeletal descriptions resulted in better performance than the poor one. Their value as navigational aids was confirmed by measuring the navigation times. Analyzing the structure and content of the descriptions confirmed that the effectiveness of route directions depends on their ability to connect actions to landmarks, that is, to closely link the prescriptive and the descriptive parts of this specific type of spatial discourse.

Keywords: route directions, spatial cognition, navigational performance, wayfinding.

Getting one's bearings in an environment and finding one's way is undoubtedly one of the most important skills of human beings. It is essential for survival and is repeatedly required in everyday life. Spatial cognition is a major field of research in cognitive psychology and is central to any attempt to understand how

Correspondence concerning this article should be addressed to Marie-Paule Daniel, Groupe Cognition Humaine, LIMSI-CNRS, Université de Paris-Sud, BP 133, 91403 Orsay Cedex, France; email: mpd@limsi.fr.

people adapt to their environment. Tversky (2000) pointed out three types of space experienced by humans: navigation space, which is too large to be seen from a single vantage point; the space surrounding the body which, unlike navigation space, is conceptualized in three dimensions; and the body space itself, which is experienced kinesthetically from inside, as well as from outside. According to Tversky, knowledge related to each type of spatial cognition is essential "to finding our way in the world, to fulfilling our needs and to avoiding danger" (Tversky, Morrison, Franklin, & Bryant, 1999, p. 516).

Having to ask someone for route directions, in order to reach a goal by moving around in an unknown environment, is a very common situation. A remarkable fact about route directions is that they do not always make it easy for people to reach their goal. The research reported here was concerned with the communication of route knowledge. It involved testing the value of route directions by measuring navigational performance in a wayfinding task. Although language can also provide descriptions that allow readers to adopt a survey perspective on an environment (e.g., Mellet et al., 2000, 2002; Schneider & Taylor, 1999; Taylor & Tversky, 1992, 1996), we focus here on the capacity of spatial language to convey procedural knowledge that fits the route perspective typically adopted by people navigating through natural environments.

Communicating environmental knowledge requires verbal and spatial abilities in both the person producing the directions and the person attempting to understand them (see Allen, 2000; Golding, Graesser, & Hauselt, 1996; Vanetti & Allen, 1988). The production of route directions is generally assumed to involve three sets of cognitive operations. First, the speaker has to activate that portion of her/his spatial knowledge that is relevant to the route; secondly, she/he has to define a route in the subspace of the representation currently activated; and lastly, she/he has to formulate the procedure that the person given the instructions (the addressee) will have to use to progress along the route (see Denis, 1997; Klein, 1982). Thus, route directions have several characteristic features. Firstly, they belong to the more general class of procedural discourse, in that they are mainly generated to elicit actions. Secondly, although space is inherently multi-dimensional, a route description of that space must be organized linearly, and so the discourse sequence simply corresponds to the sequence of steps to be followed by the person moving along the route. Thirdly, landmarks play an important role in route descriptions. These ingredients are thought to be essential to assist navigation effectively.

The comprehension of route directions largely depends on their conciseness and clarity, which are determining factors in helping the person given them to construct a representation of the environment to be traversed. Ambiguous and confusing descriptions are known to be inefficient, but descriptions that are too long and too detailed, however correct, become too difficult to memorize and soon cease to be of any value for the addressee. Therefore, an adequate level of determinacy has to be preserved in the description. Schneider and Taylor (1999) found that both overdeterminacy and indeterminacy have a negative impact on the use of a mental representation of a route. Navigating for the first time in an unknown environment after having read or listened to a route description involves several cognitive operations: elaborating an internal representation of the described environment in which the navigational procedure is to be executed; keeping this internal representation in mind while moving along the route, and comparing it to the perceptual information available along the route; identifying the relevant landmarks in order to know which action to execute at which location. Thus, during the navigation procedure, an essential cognitive process is implemented in the walker's mind: matching the characteristics of the spatial mental model derived from the description with the characteristics of the environment that she/he perceives during the successive stages of navigation.

Route descriptions show an impressive diversity. The data collected in previous route description experiments (see Daniel & Denis, 1998, 2003; Denis, 1997; Fontaine & Denis, 1999; Lovelace, Hegarty, & Montello, 1999) revealed major differences between the descriptions provided by different speakers, especially regarding the length of descriptions, the number and nature of selected landmarks, and the kinds of actions prescribed by the speakers. However, when submitting a variety of descriptions of a route to people familiar with that route, it is easy to get a consensus about selecting the relevant criteria. Denis (1997) designed a method for abstracting the "skeletal description" of a route from a sample of individual descriptions. The method consisted of asking judges familiar with an environment to examine a "megadescription", that is, a compilation including every statement produced by every participant in a panel of respondents. The judges were then asked to remove any items they considered to be superfluous. The resulting skeletal description was found to reflect the essence of a described route and to concentrate the essential features of an ideal route description: conciseness, lack of redundancy, lack of over-specification, absence of ambiguity. Denis (1997) also showed that when comparing individual protocols to a skeletal description, the similarity of an individual description to this "ideal" skeletal one was a good predictor of the intrinsic communicative value of the description, as rated by judges. The main questions that arise are what characterizes good route directions, and how do they differ from poor ones. An empirical approach involves comparing the effects of several route descriptions on navigational performance. Denis, Pazzaglia, Cornoldi, and Bertolo (1999) conducted an experiment which provided behavioral validation of judges' evaluations. Three parameters were measured while participants navigated along a route of which they had received a verbal description, namely, directional errors, stops, and requests for information. Navigation based on good descriptions resulted in significantly lower error scores than navigation with poor descriptions, and skeletal descriptions resulted in scores similar to those of good descriptions.

The present experiment was designed to extend the comparison of various descriptions in terms of their effects on navigational performance by including time indicators in the analysis. A time measurement was recorded for each behavioral indicator considered in this experiment. Two descriptions were selected from amongst those available in a corpus of descriptions. One of these route descriptions had been assessed as having good communicative value, whereas the communicative value of the other one had been assessed as poor. The participants using the good description were expected to reach their destination with lower error scores than those using the poor one, and to do so with shorter navigational times.

The present study was also designed to check the value of a skeletal description in terms of navigational assistance. We expected to find that the skeletal description, which is an artefactual description abstracted from actual individual protocols and reflects the essential aspects of the route, would produce good results in terms of navigational time performance.

Method

Participants

The participants were 60 undergraduates from Paris universities: 30 males (mean age = 24.0, *SD* = 2.1) and 30 females (mean age = 23.6, *SD* = 2.5). All were native French speakers. They had no previous knowledge of the environment where the experiment took place. All the participants were seeing the place for the first time. Fifty-three participants were paid for their participation and seven participated to fulfill a course requirement. They were randomly assigned to three groups of 20 participants each (10 males and 10 females).

Materials

Study Area. The environment used for this study was the Orsay university campus. The route selected for the experiment was 417 meters long. It started from the hall of the Technology Institute and ended at the cafeteria of an engineering school (Supelec). The route comprised four segments which were delimited by the main points of reorientation. The first segment began in the hall of the Technology Institute and ended under an arch (Segment A: 37 m). The second segment began at the arch and ended at the entrance to a parking lot (Segment B: 100 m). The third segment extended from the parking lot to the main entrance to Supelec (Segment C: 210 m). Finally, the last segment went from the Supelec entrance to the cafeteria located in the building (Segment D: 70 m).

Route Directions. Three route descriptions were used in the experiment. The first two were selected from among a set of 20 protocols collected in a previous study (Daniel & Denis, 2003). The third was a description based on selecting the essential statements in the protocols of the same previous study.

In their experiment, Daniel and Denis (2003) collected 20 descriptions of the route described above. All these descriptions were submitted for assessment to 14 participants familiar with the route, who were invited to rate their values in terms of navigational assistance on a 20-point scale. The judges were asked to classify a description which would allow a pedestrian unfamiliar with the route to reach the destination without mistakes or hesitations as a good description, and a description that did not meet these criteria as a poor one. The average ratings of the 20 descriptions ranged from 4.7 (*SD* = 2.6) to 14.0 (*SD* = 2.9).

Each individual protocol was then analyzed in terms of minimal propositional units combining a predicate and one or two arguments. Each proposition was classified as belonging to one of five categories:

- Class 1: Prescription of an action without any reference to a landmark. This class included propositions that expressed a prescribed action without referring to any landmark. Examples: "Go straight ahead", "Turn right";
- Class 2: Prescription of an action with reference to a landmark. In this class, propositions explicitly connected an action to a landmark. Examples: "At the parking lot, turn right", "Cross the parking lot";
- Class 3: Introduction of a landmark. A new landmark is mentioned without any associated reference to an action to be executed. A spatial localization is sometimes specified. Examples: "There is a phone box", "On the left, there is a gymnasium";
- Class 4: Description of a landmark. In this case, the landmark is mentioned without specifying its localization or prescribing an action, but its characteristic features are described. Examples: "The path is made of white paving stones", "It is an entrance for pedestrians";
- Class 5: Commentary. This class contained comments that referred to the route without providing any relevant information. Examples: "It is not too far", "Be sure that it is the right parking lot".

Following Denis' (1997) procedure, all the propositions present in the 20 protocols were combined to form a "megadescription". This megadescription was submitted to the judgment of another 20 participants familiar with the route. These participants were required to select the most relevant items (by crossing out the irrelevant ones) to ensure that the person being directed could make adequate progress along the route. The items selected by at least 80% of the judges were used to compile the Skeletal description. This description was expected to contain the essential instructions needed to guide a person along an unfamiliar route (see Daniel & Denis, 2003; Denis, 1997; Denis et al., 1999).

Given that the present study was designed to compare the effects of various versions of route directions on navigational performance, the three descriptions had to be comparable in several respects. In particular, since they were to be memorized by the participants, the descriptions had to be of comparable length and constitute a comparable memory load. The Skeletal description contained 219 words. Consequently, the other two descriptions were selected to match this length. We used this length constraint in selecting the Good and Poor descriptions from among the 20 descriptions available. Among the descriptions that had received high ratings by the judges, we selected a 203-word description, which had received an average rating of 13.0 (*SD* = 5.5). This description was used as the Good description in the present experiment. Among the descriptions that had obtained low ratings, we selected a 219-word description that had received an average rating of 9.4 (*SD* = 4.5). This description was used as the Poor description in the present experiment. The three descriptions (Good, Poor, and Skeletal) are given in the Appendix. The class to which each proposition belongs is indicated. The three descriptions contain similar numbers of propositional units (37, 36, and 37, respectively).

The comparison of the three descriptions shows that despite being similar in length, they differ in many respects. Table 1 shows the frequency of occurrence of each type of proposition in the three descriptions. A critical feature of the Skeletal description is that it is heavily saturated with propositions connecting actions and landmarks. This characteristic had already been observed in previous experiments, and was thought to promote the adequate processing and use of route directions. The Good description showed similar features to the Skeletal description, whereas it differed markedly from the Poor description, in that the latter contained a very large number of landmarks unrelated to any prescribed action. Moreover, the Poor description contained several vague descriptions (for instance, it referred to the fact that in the Supelec building, "there are some notice-boards", whereas the Good description specified that "on the right, there are notice-boards"). These differences, which have already been reported to be correlated with the rated value of descriptions in terms of navigational assistance (Denis et al., 1999; Schneider & Taylor, 1999), will be discussed in more detail in the analysis of the results.

Lastly, to check whether the three descriptions were comparable in terms of memorability, we asked 60 undergraduates, all of whom were unfamiliar with the route, to study the written version of one of the three descriptions (they were

Table 1
Distribution of Proposition Types in the Three Descriptions

Type of proposition	Good description	Poor description	Skeletal description
Actions	8	2	3
Actions connected to Landmarks	17	10	23
Landmarks	7	16	9
Descriptions of Landmarks	5	6	2
Commentaries	0	2	0
Total	37	**36**	**37**

allowed a maximum memorization time of 5 min.) and to provide immediate written recall. The results showed that the three route descriptions were memorized to fairly similar extents. The participants memorized an average of 41.1% of the propositions of the Good description, 38.2% of the Poor one, and 43.8% of the Skeletal description.

Procedure

Participants were tested individually by two female experimenters. The procedure consisted of a first phase, during which the description was studied, followed by a second phase, during which the navigation task was performed. Participants were randomly assigned one of the three route directions. The study phase took place in the library of the Technology Institute. The participants were guided there by a route which did not intersect the experimental itinerary. The participants were allowed up to 5 min. to study the printed version of the description, although most of them actually took less than this. Individual study times were recorded.

At the beginning of the navigation phase, each participant was first positioned at the starting point, then invited to navigate along the route she/he had memorized. The participant was warned not to ask for help either from the experimenter or from other pedestrians. During navigation, she/he was followed at a distance of 5 m by the experimenter who recorded any occurrences of three behavioral indicators: stops, self-corrected errors, and experimenter-corrected errors. Stops were defined as pauses during walking (lasting at least 5 sec.). Self-corrected errors were defined as deviations from the nominal route lasting less than 60 sec. and followed by a spontaneous return to the route. By experimenter-corrected errors, we mean directional errors which participants had still not corrected after 60 sec. After this kind of error, the experimenter interrupted the participant and showed her/him the right way back to the point where the error had been made. If the participant's deviating navigation made her/him connect to a farther point of the nominal route within the 60 sec. time limit, she/he was interrupted before this limit and brought back to the point where the deviation took place. The duration and the point where these behavioral indicators took place were recorded. The total duration of navigation and the time taken to navigate each segment were recorded (but the time taken by the participant to return to the place where the error occurred was not counted as part of the navigation time).

Finally, when navigation had been completed, participants were asked to estimate the length of the longest segment of the route, namely, Segment C. This segment was perfectly straight, without any change in direction, and it was therefore thought that it would be easier to estimate than the other three segments. This measurement was expected to reflect the difficulties associated with each of the three sets of directions.

Results and Discussion

Study time

We compared the time the participants of the three groups needed for studying the route directions. Average study times for the Good, Poor, and Skeletal descriptions were 4 min. 2 sec., 3 min. 42 sec., and 3 min. 36 sec., respectively. The analysis of variance (ANOVA) did not reveal any significant effect of descriptions on study time, F (2, 57) < 1. This result confirms that the three descriptions were associated with similar levels of processing difficulty.

Frequency of occurrence of behavioral indicators

Figure 1 shows the frequency of occurrence of each behavioral indicator for the three descriptions. The ANOVA revealed that the number of stops and the number of self-corrected errors both differed significantly for the three descriptions, F (2, 57) = 7.54, $p < .001$, and F (2, 57) = 4.93, $p < .01$, respectively. Tukey *post hoc* analyses revealed that the Poor description elicited significantly more stops and self-corrected errors than the Good description (both $p < .05$) and the Skeletal description ($p < .001$ and $p < .01$, respectively). The analyses did not detect any significant difference between the Good and the Skeletal descriptions regarding the number of stops and self-corrected errors. Lastly, the ANOVA did not reveal any significant effect of the descriptions on the frequency of experimenter-corrected errors, F (2, 57) = 2.06, $p > .05$.

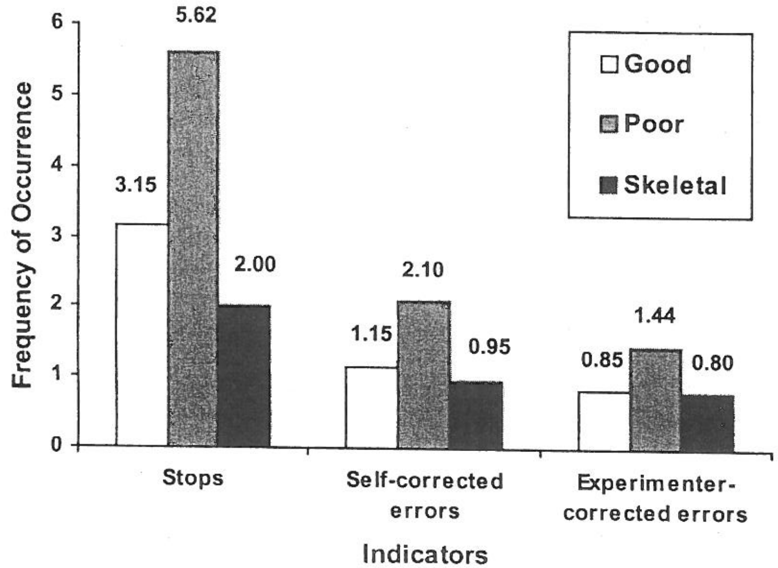

Figure 1. Frequencies of occurrence of behavioral indicators.

Overall, these results are consistent with the hypothesis that the Good description would provide more efficient navigational assistance than the Poor one. They also support the expectation that performance would be similar after processing the Good and the Skeletal descriptions.

Time measurements

Total navigation times. Figure 2 shows total navigation times for each description. The ANOVA revealed a significant effect of the descriptions on navigation times, F (2, 57) = 7.34, $p < .005$. *Post hoc* analyses revealed that the participants who had studied the Poor description took significantly more time to reach the goal than those who benefitted from the Good description ($p < .01$) or the Skeletal one ($p < .005$). There was no significant difference in navigation times following the study of the Good and the Skeletal descriptions.

Duration of behavioral indicators. Why did the participants who studied the Poor description take longer than the others to navigate the route? We examined the time measurements of the three behavioral indicators (stops, self-corrected errors, and experimenter-corrected errors) to assess whether they could account for the differences in total navigation times.

Figure 3 shows the total durations of the behavioral indicators. The ANOVA revealed that the descriptions had a significant effect on the duration of stops, F (2, 57) = 5.13, $p < .01$. *Post hoc* analyses revealed that stops lasted longer after the Poor description than after the Skeletal one ($p < .01$). There was no

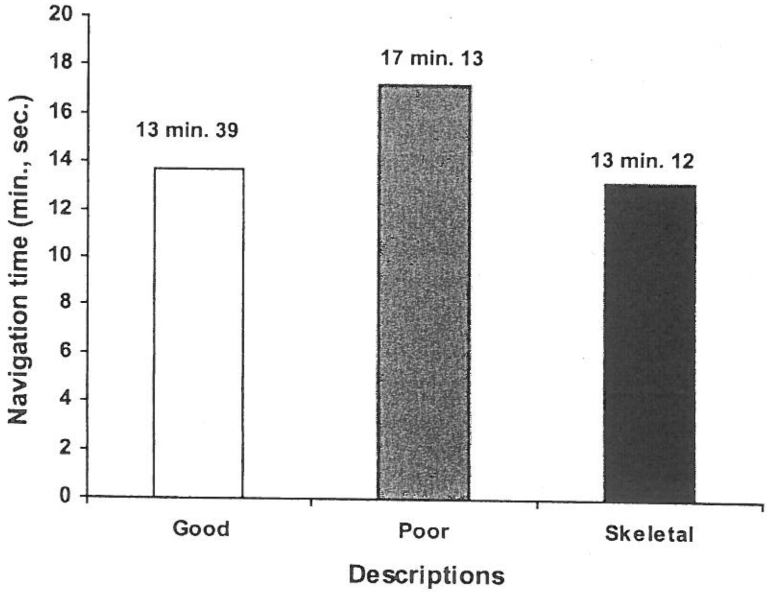

Figure 2. Total navigation times.

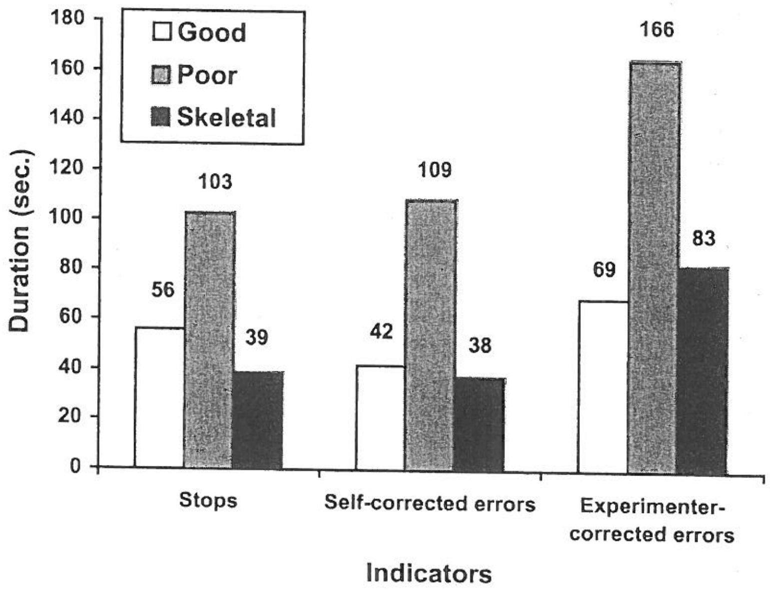

Figure 3. Total durations of behavioral indicators.

corresponding significant difference between the Poor description and the Good one, or between the Good and the Skeletal descriptions. Furthermore, a significant effect of the descriptions on the duration of self-corrected errors was found, F (2, 57) = 8.72, $p < .001$. *Post hoc* analyses showed that self-corrected errors lasted longer with the Poor description than with the Good one ($p < .005$) or the Skeletal one ($p = .001$). There was no significant difference between the Good description and the Skeletal one in this regard. There was no significant difference between the descriptions regarding the duration of experimenter-corrected errors, F (2, 57) = 2.96, $p > .05$.

After this analysis of the total duration of the behavioral indicators, we considered the possibility that the average duration of each individual behavioral indicator could differ for the three descriptions. We conducted a further analysis to check whether the mean duration of each stop, each self-corrected error and each experimenter-corrected error differed in the three groups of participants. Figure 4 shows the mean durations of each of these behavioral indicators. The description had a significant impact on the duration of self-corrected errors, F (2, 57) = 4.60, $p = .01$. *Post hoc* analyses showed that the self-corrected errors lasted longer after the Poor description than after the Good ($p < .05$) or the Skeletal description ($p < .05$). There was no significant difference between the Good description and the Skeletal one in this regard. The ANOVA did not show any significant difference among the descriptions as regards the mean durations of stops and experimenter-corrected errors.

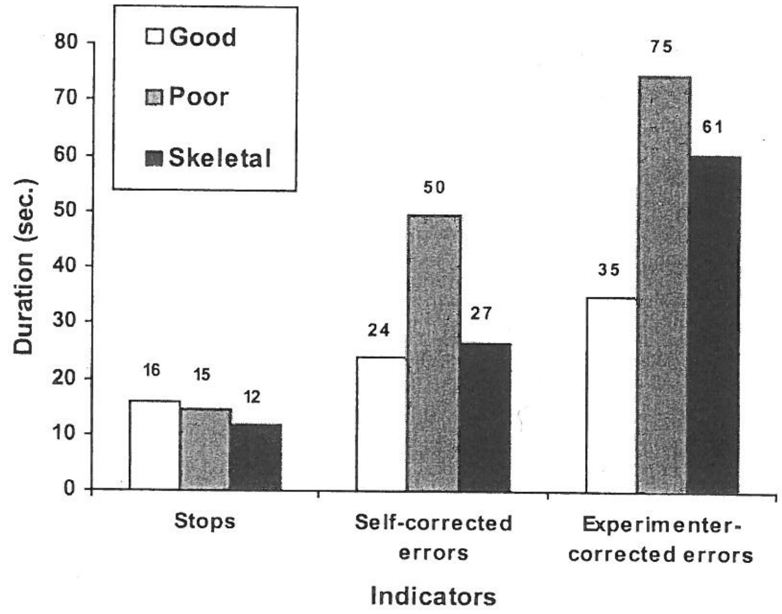

Figure 4. Mean durations of behavioral indicators.

The results regarding the duration of self-corrected errors are of particular interest. Not only did the Poor description induce more self-corrected errors than the other two, but each individual self-corrected error lasted longer. Put differently, with the Poor description, not only did participants stray more often from the nominal route but, moreover, each of these straying episodes lasted longer.

Although these findings are consistent with our expectations, they could also have resulted from differences in the individual walking pace in the three groups of participants. We therefore checked whether there were any differences in this respect. If there was such a difference, this could also have accounted for the differences in navigational performance. We subtracted the duration of stops, self-corrected errors and experimenter-corrected errors of each participant from the total navigation time of that participant. Figure 5 shows the times devoted to actual navigation for the three descriptions. The ANOVA did not reveal any significant effect of the description, F (2, 57) < 1, showing that the differences in total navigation times were essentially ascribable to the frequency and duration of the behavioral indicators.

Distance estimations

The third segment of the route was a straight road 210 meters in length. Figure 6 shows the participants' responses when they were asked to estimate the length of

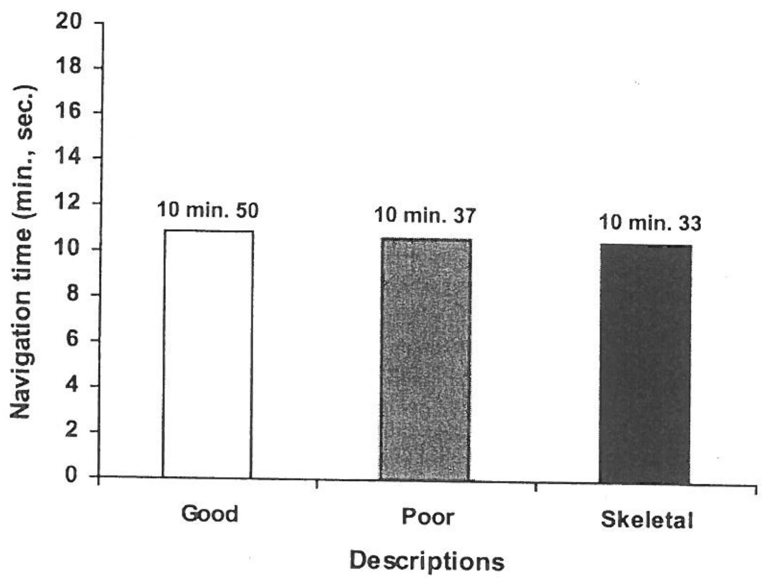

Figure 5. Actual navigation times.

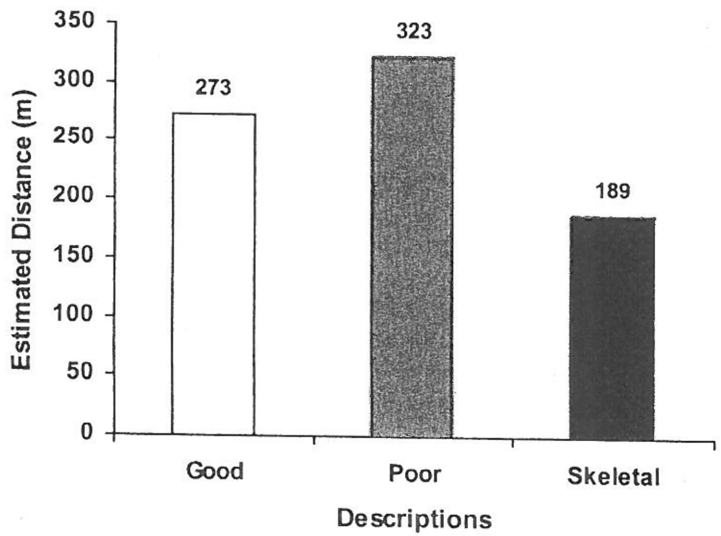

Figure 6. Estimated distances for segment C.

this segment. The participants who had received the Poor description produced a significant overestimation of the segment C (+54%), $p < .001$. The participants who had received the Good description overestimated this to a lesser extent than those who had been given the Poor description (+30%), but the overestimation was still significant, $p < .05$. The Skeletal description produced a slight underestimation (–11%), but the effect was not significant.

Detailed analysis of the behavioral indicators revealed that directional errors that had to be corrected by the experimenter occurred more frequently during Segment C among the participants who had been given the Poor description (0.82) than among those who had read the other two (Good: 0.47; Skeletal: 0.44), F (2, 57) = 3.51, $p < .05$. Experiencing directional errors is likely to interfere with the process of building an accurate representation of the route, and so it is not surprising that these errors resulted in changes in the estimation of distance. The overestimation of distances found in the present experiment is consistent with other well-established observations, such as the finding that distances are overestimated when participants encounter obstacles on their way (see Kosslyn, Pick, & Fariello, 1974; Newcombe & Liben, 1982; Thorndyke, 1981).

Analyzing the content of route directions

The data reported above reflect two major findings. Firstly, a description evaluated as a good one by independent judges results in better navigational performance than a description rated as "poor". Participants who have processed good route directions waste less time than those who have processed poor ones. The Good description actually allowed the participants to reach the final destination in a shorter time than the Poor one. Secondly, the functional value of the Skeletal description was confirmed and assessed by the similarity of performance by participants who processed the Good and the Skeletal descriptions. This similarity confirms the capacity of the Skeletal description to capture the most essential features of the original individual descriptions.

At this point, it is appropriate to identify the factors that explain why the Good route directions facilitated successful wayfinding, and which features of the Skeletal description are responsible for its qualities in terms of wayfinding. As they produced comparable results on navigational performance, the Good and Skeletal descriptions should present similar features, whereas in contrast, the Poor description should display some different characteristics. In the Method section, we referred to some aspects of this contrast. By looking at Table 1, which shows the distribution of the five classes of propositions, it is noticeable that the Good and the Skeletal descriptions, unlike the Poor description, display similar internal structures. Their main difference from the Poor description lies in the distribution of the first two classes of propositions, both of which are related to actions, and the third class, related to landmarks. In the Poor description, only one third of 36 propositions (2 in the class of actions and 10 in the class of actions connected to landmarks) referred to actions to be performed, whereas in the Good description, such propositions corresponded to 68% of the total (25 out of 37 propositions) and in the Skeletal description, to 70% (26 out of 37 propositions).

By connecting most of the landmarks to actions to be performed, the Good and the Skeletal descriptions are predominantly prescriptive in nature. On the other hand, the Poor description appears to be descriptive rather than prescriptive. All three descriptions allow the addressee to create representations of landmarks, but the Poor description fails to explain which appropriate action should be performed in relation to which landmark. This suggests that the way landmarks are included in route directions is crucial to their usefulness.

For each of the three route descriptions, we examined the links mentioned between landmarks and actions. In a given route description, a landmark can be mentioned in more than one proposition. It can be mentioned alone, with no link to any other landmark ("There is another walkway") or it can be first mentioned alone, and then related to an action to be executed ("There is a kind of archway", then "Go through this archway"), or even subsequently related to a further action ("There is a bar", then "Walk along the side of the bar", then "Just after the bar, turn left"). Table 2 shows the full list of landmarks that were mentioned in the three descriptions used in this experiment. This table shows that all but one of the 24 landmarks mentioned in the Skeletal description were sooner or later related to a prescribed action. The Good description mentioned only 5 landmarks out of 18 that were not connected to any action. The characteristic of the Poor description regarding this criterion is that it included more landmarks with no reference to any action than landmarks related to an action (12 vs. 10, respectively). This characteristic explains why the Good and the Skeletal descriptions succeeded better than the Poor one in providing an efficient description of the characteristics of the route, by allowing the addressee to identify which action had to be taken at which location.

Table 2
Distribution of Landmarks in the Three Descriptions

	Good description		**Poor description**		**Skeletal description**	
	Mentioned alone	Linked to at least one action	Mentioned alone	Linked to at least one action	Mentioned alone	Linked to at least one action
Segment A						
Hall		+	+			+
Notice-board			+			
Door				+		+
Courtyard		+				+
Covered walkway		+				+
Building of lecture halls		+		+		
Junction			+			+
Segment B						
Archway				+		+
Walkway 1						+
Cafeteria building		+		+		+
Stone-paved walkway		+		+		+
Walkway 2					+	
Parking lot		+	+			+
Building			+			
Segment C						
Road		+		+		+
Stadium	+					
Cross junction		+				+
Gymnasium	+					
CNEF building	+					
Supelec parking lot				+		
Supelec building		+		+		+
Sign-board			+			
Entrance						+
Chains		+				
Stairs			+			+
Segment D						
Hall						+
Corridor			+			+
Notice-boards	+		+			
Indoor sports ground	+		+			
Little hall						+
Cafeteria				+		+
Drink-vending machine						+
Stairs 1				+		
Bar		+				+
Exit			+			
Stairs 2		+	+			+
Restaurant						+
	5	13	12	10	1	23
	18		22		24	

In an attempt to assess the informational similarity between the Good and the Skeletal descriptions (and the dissimilarity of both from the Poor one), we computed an index of inter-description agreement in terms of landmark introduction. Among the set of landmarks common to two given descriptions, we counted the number that were introduced in the same way in the two descriptions (either mentioned alone or linked to an action) and the number that were treated differently. If the first set of landmarks is larger than the other, this should be taken as reflecting similarity between the two descriptions with regard to how landmarks were introduced. Based on these measurements, we computed three chi-square values. The values corresponding to the comparisons between the Good and the Poor descriptions and between the Poor and the Skeletal descriptions were not significant. For the comparison between the Good and the Skeletal descriptions, we obtained χ^2 (1) = 6.50, $p < .025$. This is a further indication of the shared features between the two descriptions, which also explains the similarity of their effectiveness as navigational aids.

Conclusions

The purpose of this study was to provide empirical data regarding the effects of three route descriptions on navigational performance. Two of these route descriptions were selected from a corpus of actual descriptions: one, according to the judgments of experts, was a Good description and the other a Poor description. The third was a Skeletal description, which was constructed by other experts and consisted of the most important statements included in the original route descriptions. We checked that all three descriptions made comparable demands on the working memory, given their similar length and number of propositions. The results confirmed data previously reported in experiments on the navigational value of route directions (e.g., Allen, 2000; Denis et al., 1999; Garden, Cornoldi, & Logie, 2002; Schneider & Taylor, 1999). They provided evidence that the Good description enabled the participants to achieve better navigational performance than the Poor one. The participants who were exposed to the Good description successfully reached the assigned goal in shorter times than those who processed the Poor description. The differences in total navigation times stemmed mainly from the number and duration of stops, self-corrected errors, and experimenter-corrected errors. We found also that the Poor description led participants to hesitate more often, and that each of their self-corrected errors lasted longer. Another remarkable result was the overestimation of distance induced by the Poor description.

In terms of their content, the three route descriptions all referred to similar numbers of landmarks. The differences observed on navigational performance should thus be attributed to the stated relations between landmarks and actions. Actions and landmarks are key ingredients of any route directions (see Burnett, Smith, & May, 2001; Cornell & Heth, 2000; Golledge, 1999; Michon & Denis, 2001; Raubal & Winter, 2002). The findings of this experiment strongly suggest that the effectiveness of a route description depends on the adequacy of the link

established between conspicuous landmarks and the actions to be performed in their vicinity. To summarize, an effective route description is a description which explicitly tells the addressee which actions have to be executed at which places by referring to relevant landmarks. Providing route directions implies the ability to convey to an addressee an adequate representation of the environment. On the addressee's side, remembering and using route directions not only involves the construction of an accurate representation of this environment, but also the representation of the sequence of actions to be performed. Thus, the efficiency of route directions depends on the extent to which they enable their users to construct a well-organized action plan along the route. Undoubtedly, the relevance of landmark/action connections is the key to helping people to achieve this task.

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Appendix

The Good description

(A: Action; AL: Action connected to Landmark; L: Landmark; DL: Description of Landmark; C: Commentary)

Segment A
Go out of the main hall (*AL*)
Go into the courtyard (*AL*)
Follow the walkway (*AL*)
Do not go into the front building (*AL*)
It is a covered walkway (*DL*)
Turn right (*A*)
Then go straight ahead (*A*)
One part of the walkway is still covered (*DL*)
Go straight ahead (*A*)

Segment B
Walk along the cafeteria building (*AL*)
Follow the paving stones (*AL*)
These paving stones curve to the left (*DL*)
At the end of this walkway, turn right (*AL*)
At the parking lot, turn left (*AL*)
Cross the parking lot (*AL*)

Segment C
You come to the road (*L*)
Turn right (*A*)
Follow the road (*AL*)
On the right, there is a stadium (*L*)
There is a perpendicular road (*L*)
Cross this perpendicular road (*AL*)
Keep straight on (*A*)
On the left, there is a covered gymnasium (*L*)
On the right, there is the CNEF Building (*L*)
Keep going until you can see the "Supelec" name (*AL*)
The "Supelec" name is written in big letters at the top of a building (*DL*)
Turn left (*A*)
Go past the chains (*AL*)
The chains stop cars coming in (*DL*)

Segment D
Go inside the Supelec building (*AL*)
Continue straight ahead (*A*)
On the right, there are notice-boards (*L*)
There is a gymnasium (*L*)
Go as far as the bar (*AL*)
Turn right (*A*)
Go past the bar (*AL*)
On the left, go down the stairs (*AL*)

The Poor description

Segment A
You are in the main hall (*L*)
There is a notice-board (*L*)
Facing the notice-board, take the door on your right (*AL*)
The building in front of you is the building of Lecture Halls 1 and 2 (*DL*)
Turn to the right just before this building (*AL*)
A few meters further on, there is a junction (*L*)

Segment B
There is a kind of archway (*L*)
Go through this archway (*AL*)
Follow a stone-paved walkway across the lawn (*AL*)
You go along the cafeteria building (*AL*)
It is crowded (*DL*)
You come to a parking lot (*L*)
There is another building (*L*)
The building has outside stairs (*DL*)

Segment C
Further on, there is a road (*L*)
In front of this road, turn right (*AL*)
It is on the opposite side from the Technology Institute (*L*)
Go straight on as far as a parking lot on the left (*AL*)
Be sure that it is the right parking lot (*C*)
There are some low stairs (*L*)
There is a sign-board on which the "Supelec" name is written (*L*)

Segment D
Go inside the building (*AL*)
There are several corridors (*L*)
Go straight on (*A*)
There are some notice-boards (*L*)
There is an indoor sports ground (*L*)
Go on up to the cafeteria of Supelec (*AL*)
In front of the cafeteria, there are stairs (*L*)
The stairs lead down (*DL*)
Do not go down these stairs (*AL*)
There is an other exit on the left (*L*)
Go straight on (*A*)
There are some more stairs (*L*)
The second stairs have the same shape as the first ones (*DL*)
On one side is written "Crous" and on the other "Pilote" (*DL*)
Now, choose what you want to eat (*C*)

The Skeletal description

Segment A
You are in the central hall (*L*)
Go out of the hall by the door (*AL*)
Cross the courtyard (*AL*)
Follow an alley for 20 meters (*AL*)
Go as far as a junction (*AL*)
At the junction, turn right (*AL*)

Segment B
Go under a little archway (*AL*)
There is a walkway in front of you (*L*)
Take the walkway (*AL*)
Walk along the cafeteria building (*AL*)
You reach the stone-paved walkway (*L*)
Go along this walkway (*AL*)
There is another walkway (*L*)
It is perpendicular (*DL*)
Turn right (*A*)
You reach the Technology Institute parking lot (*L*)
Cross the parking lot (*AL*)

Segment C
Go on to the road (*AL*)
Outside the parking lot, turn right (*AL*)
Go straight ahead (*A*)
Go to a cross junction (*AL*)
Go to the entrance of Supelec Building (*AL*)
This is an entrance for pedestrians (*DL*)
Go up the stairs of the building (*AL*)

Segment D
Go inside the hall (*AL*)
There is a corridor in front of you (*L*)
Take the corridor (*AL*)
Go on to another hall (*AL*)
Go straight ahead (*A*)
Walk to the cafeteria (*AL*)
Turn right after the drink-vending machine (*AL*)
There is a bar (*L*)
Walk in front of the bar (*AL*)
Just after the bar, turn left (*AL*)
You can see some more stairs (*L*)
Go down these stairs (*AL*)
At the bottom, you have reached the restaurant (*L*)