APPLIED COGNITIVE PSYCHOLOGY
Appl. Cognit. Psychol. **13**: 145–174 (1999)

Spatial Discourse and Navigation: An Analysis of Route Directions in the City of Venice

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SUMMARY

We report four studies in which we investigated the production of spatial discourse designed to help people move around in unfamiliar environments. In Study 1, descriptions of three routes were collected from residents of the city of Venice. Analysis of the descriptions revealed the variety of ways used to describe each route. Typical features of route directions were found, in particular the uneven distribution of the landmarks mentioned, which tended to concentrate at critical points where an orientation problem had to be solved. Study 2 used individual protocols to construct more abstract ('skeletal') descriptions, reflecting the essentials needed for navigation. New subjects selected those units of information they judged necessary and sufficient to guide a person travelling along the routes. The contents of the skeletal descriptions were very similar, whether they were established by people familiar with Venice or complete strangers, suggesting that people can judge the relevance of information in route directions, regardless of their knowledge of the environment described. Study 3 showed that the ratings of the communicative value of the original individual protocols also resulted in very similar responses from familiar and unfamiliar judges. Finally, Study 4 assessed the value of individual descriptions for assisting navigation by testing the navigational performance elicited by these descriptions. Subjects unfamiliar with the city of Venice were given skeletal descriptions or descriptions which had been rated 'good' or 'poor' in the previous study. Navigation with good descriptions gave significantly lower error scores than navigation with poor descriptions, and skeletal descriptions gave scores similar to those of good descriptions. Poor descriptions also resulted in more errors from subjects who tended to use a survey perspective than from subjects expressing a preference for visual memories of landmarks. We suggest that the efficiency of route directions as navigational aids depends not only on their intrinsic characteristics but also on the mode of processing adopted by the users.

INTRODUCTION

The processes involved in the mental representation of space have been a major concern of cognitive psychologists even before the emergence of the research domain

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Contract grant sponsor: Commission of the European Communities
Contract grant number: CHRXCT940509

CCC 0888–4080/99/020145–30 $17.50

Accepted 8 January 1998

labelled ‘spatial cognition’ (cf. Piaget and Inhelder, 1948; Tolman, 1948). Studies on the construction of internal spatial representations and their use in everyday spatial reasoning paralleled the development of the concept of the ‘cognitive map’ (cf. Lynch, 1960; Scholl, 1987; Siegel and White, 1975; Thorndyke, 1981). Navigation and the visual inspection of surrounding environments were extensively investigated as primary sources of spatial knowledge, but indirect sources of information based on symbolic media were also considered. Two of these indirect sources of symbolic information are geographical maps (e.g. Giraudo and Pailhous, 1994; McNamara *et al*., 1984; Pearce, 1981; Thorndyke and Hayes-Roth, 1982; Tversky, 1981) and spatial discourse (e.g. Denis and Zimmer, 1992; De Vega, 1994; Kulhavy *et al*., 1993; Taylor and Tversky, 1992, 1996).

Special efforts have been made over the past decade to develop a better understanding of the processes by which people use language to exchange information about space, with interest focusing on the interactions between the spatial and linguistic systems within the cognitive architecture (cf. Bloom *et al*., 1996; Bryant, 1997; Landau and Jackendoff, 1993). A number of studies have examined the contrast between the multidimensional nature of spatial information and the one-dimensional, linear structure of linguistic output. Speakers must deliver information in a sequential order even though the objects or environments they describe are distributed across two- or three-dimensional space. This was referred to as the ‘linearization problem’ by Levelt (1982, 1989). Even very simple spatial configurations can be described according to a variety of linear orders, although there is also evidence that the majority of speakers tend to use limited subsets of discourse strategies.

For example, in the description of apartments, speakers usually adopt (and produce outputs designed to have their addressees adopt) the perspective of a person who is walking through the apartment, starting from the entrance, and visiting each room in turn (Linde and Labov, 1975). A typical description of a room is a gaze tour along the walls, sometimes involving jumps to non-adjacent areas (Shanon, 1984; Ullmer-Ehrich, 1982). Investigation of the linearization problem from a cognitive point of view revealed that the discourse strategies adopted by the majority of adult speakers consist of delivering information according to sequences that fit the expectations of their addressees. Speakers tend to select descriptive sequences that minimize the amount of information that must be kept in working memory during discourse production (cf. Bisseret and Montarnal, 1996; Daniel *et al*., 1996; Ehrich and Koster, 1983; Robin and Denis, 1991).

A specific case of spatial discourse, the description of routes, has received attention in recent years. This kind of spatial discourse had long attracted the interest of linguists (cf. Klein, 1982; Wunderlich and Reinelt, 1982), but it is only recently that cognitive psychologists have started conducting systematic research in this domain (e.g. Galea and Kimura, 1993; Golding *et al*., 1996; Lloyd, 1991; Wright *et al*., 1995). This line of research is developing in parallel with the efforts of computer scientists to improve the capacity of human–machine communication systems designed to provide navigational aids (cf. Chown *et al*., 1995; Gapp and Maass, 1994; Glasgow and Papadias, 1992). In particular, modelling the cognitive functions involved in communication about space has been shown to benefit the design of on-board systems providing on-line assistance to drivers (cf. Briffault and Denis, 1996; Höök, 1991; Riesbeck, 1980; Streeter *et al*., 1985).

Route directions are produced when one person has to provide another with information to help him or her to navigate in an unfamiliar environment. They are responses to the typical request: 'How do I go from (starting point) to (destination)?' The production of route directions relies on the implementation of three sets of cognitive operations by the speaker (cf. Denis, 1997; Klein, 1982). The speaker first activates that portion of his or her spatial knowledge that is relevant to the route. This internal representation is generally assumed to be non-linguistic in nature. The second operation consists of defining a route in the subspace of the representation currently activated, that is, to determine a sequence of segments connecting the starting point to the destination. This operation is based on specialized algorithms, such as finding the shortest route, or computing the route with smallest angular discrepancy with respect to the goal at each intersection (cf. Gärling, 1989; Golledge, 1995). The last operation is the formulation of the procedure that the user will have to use to move along the route to eventually reach the destination. The resulting verbal output is a composite of descriptive discourse (describing the nature and position of the landmarks which will be encountered along the route) and instructions (specifying which actions should be executed at critical points along the route).

This outline of operations provides a conceptual framework for our analysis of route directions and makes it clear that route directions constitute a very special subset of spatial discourse, which has at least three peculiar features. One is that the description and the described object share the same linear structure. Second, landmarks are significant components of route directions. Lastly, landmarks are given special relevance in those parts of routes that require careful orientation. We examine each of these features below in turn.

The first remarkable feature of route directions is that they offer a type of spatial discourse in which the linearization problem is not crucial. The 'object' to be described – the route – is not a multidimensional entity but one with an intrinsic linear structure. The discourse sequence simply adheres to the sequence of steps to be followed by the person moving along the route. It is still possible that discourse reflects a higher-order organization of the route, especially if the speaker provides the addressee with a macrostructural outline of the route in advance. However, although such information may be conveyed by speakers, it is far from being dominant in normal situations. Giving route directions typically results in a form of procedural discourse having a strong sequential component.

While the descriptive and instructional parts of spatial discourse are closely intertwined, they remain conceptually and functionally distinct. The descriptive part consists of declarative statements about the environment, mainly landmarks. It reflects the speaker's 'place knowledge' (knowledge of non-spatial information about places) and his or her 'spatial knowledge' (knowledge of their spatial relations) (cf. Gärling *et al.*, 1984; Hirtle and Mascolo, 1986). These pieces of knowledge are conveyed to the addressee with the intent of having him or her build an internal representation of the environment to be traversed and identify those 'places' where decisive actions are to be executed. The procedural component of route directions therefore consists of stating which actions should be executed in specific 'places', some of which are more critical than others.

Route directions essentially assist movers by providing them with action plans (cf. Gärling *et al.*, 1997). Their aim is to assist physical displacement, while using largely indirect (language-based) aids. A consequence is that the use of methods more directly articulated to the physical environment is limited. In particular, route directions that are not given on the spot cannot include pointing gestures, which are highly relevant cues in the environment. The fact that a description is produced in a remote location creates specific demands that can be satisfied only by using symbolic devices.

Three modes of purposeful navigation are commonly accepted, namely, proceeding towards a landmark, following a pre-existing path, or following a compass heading. Most instances of route directions in natural urban environments do not make use of compass instructions, if only because the metrics involved are not compatible with common forms of human spatial dialogue. The existence of intervening physical obstacles also make compass orientation of limited use in the contexts typically investigated by researchers. In contrast, heading towards landmarks and following pre-existing paths (streets) are essential for most forms of human navigation. Consequently, they are expected to be found in route directions as relevant cues for orienting addressees, and they should constitute a substantial part of this type of discourse.

The quasi-mandatory reference to landmarks in route directions opens the issue of their selection. In general, only a small subset of the landmarks that punctuate a route are mentioned in route directions. What are the criteria for their selection? Is selection based on the landmarks' intrinsic cues (visual appearance, salience, etc.) or their functional value, or both? Most approaches include hypotheses about the functional role of landmarks in route directions, by considering three major roles: (1) signalling places where actions are to be accomplished; (2) locating other landmarks; and (3) confirming that an action is being or has been correctly executed (cf. Denis, 1997). Still another problem is how the landmarks are distributed along the described route. Previous analyses of route directions have given no indication that the distribution of landmarks is based on random sampling, or that it is governed by systematic non-relevant regularities (e.g. mentioning the landmarks that are to be found every 50 meters exactly). Instead, observations suggest that distribution is far from arbitrary or random. Long segments may be reported without mention of landmarks, whereas concentrations of landmarks are typically found at specific points of the route. These points are usually nodes where reorientation is required. Actually, because landmarks are cues for orientation, it is likely that they are found in those places where an orientation problem has to be solved. This is the case for the starting point, where there is ordinarily a variety of options for the first direction to take. Here, objects or buildings in the environment are used as landmarks to orientate the mover. This is also the case at any further points where reorientation is required. Still another place where the density of landmarks is likely to be substantial is the arrival point, where landmark description is used mainly for confirmation (cf. Golding *et al.*, 1996; Vanetti and Allen, 1988).

Beyond these general features, an important issue to consider is that of the differences among individuals. Not only is a subset of the landmarks offered by the environment employed in route directions, but individuals differ greatly as to the number of landmarks they mention, as well as the specific landmarks they select (cf. Galea and Kimura, 1993). Thus, the variety of ways in which any route may in fact be described is an important feature of spatial discourse aimed at providing route directions. Even in overlearned environments, and for subjects with similar verbal capacities and socio-cultural backgrounds, the variety of outputs is impressive, as is evident from the analysis of materials collected in natural situations (cf. Briffault and Denis, 1996; Gryl, 1995; Klein, 1982).

The considerable range of linguistic productions in this domains creates a challenge for students of spatial discourse. Their primary objective is to uncover the invariant structures underlying the various individual protocols. In a previous study (Denis, 1997), we used a statistical procedure to analyse a corpus of route descriptions collected on a university campus and thus extract an average route description. The resulting 'skeletal' description contained the essential landmarks and a minimal set of prescriptions that guaranteed adequate progress for the user. Each individual description was then compared to this average description, and an index was computed which reflected its similarity to the average description. The analyses revealed that the individual descriptions which were most similar to the skeletal description possessed special features. They were rated by independent judges as the best descriptions in terms of their communicative value for a potential addressee (cf. also Daniel and Denis, in press).

The present study was designed to extend the above work to a new environment and provide a wider perspective in which to test our hypotheses. The conclusions drawn from studies on route directions may to some extent depend on the specific features of the environment investigated. Therefore, several environments must be tried, if only to test the robustness of findings and delineate those aspects of the results that are independent of any specific environment. The present study was carried out in a new, very specific spatial environment, the city of Venice. This environment has a number of features that make it special. First, Venice is a city that is also an island, connected to the mainland by a long bridge. Second, the city is topographically very complex, with narrow, mostly winding streets, which all look very similar. Third, it has two superimposed networks, the streets and the canals, and people usually move through the city by using them both. When people are walking, the canals act as barriers to their progress, and pedestrian navigation requires knowledge of the location of bridges to cross the canals. Lastly, the particular structure of the streets often means that the final, or even an intermediate, goal is not visible until the very last moment. The absence of any wide-open view to the horizon makes it difficult to create a 'survey representation' and probably favours the use of 'route representations' based on successions of landmarks (cf. Taylor and Tversky, 1992).

The present investigation had four phases. In Study 1, we collected descriptions of three routes from residents of the city of Venice. The descriptions were analysed to identify the characteristic features of this form of spatial discourse. We paid special attention to the role of landmarks in the descriptions. Landmarks have been repeatedly shown to be crucial components of route directions (cf. Chown *et al*., 1995; Galea and Kimura, 1993). We specifically tested the hypothesis that the landmarks mentioned in descriptions were not uniformly distributed along the routes, but were concentrated at critical points along the route. The existence of such concentrations was thought to reflect the significant contribution of landmarks to the description of places where an orientation problem has to be solved. In Study 2, we used a procedure from Denis (1997) to extract skeletal descriptions of the routes from the whole set of individual descriptions. New subjects were presented with the whole set of information provided by the respondents of the previous study and they were asked to select the items which were both necessary and sufficient to guide a potential addressee to the destination. An additional objective was to test the hypothesis that people's capacity to identify which components of route directions are important is based upon shared metacognitive knowledge independent of knowledge of the environment. Two groups of subjects were compared. One group of subjects was familiar with the routes, while the other subjects knew nothing of the city of Venice. Both groups of subjects were required to select the items that they considered essential for navigation. Although the two groups differed in their familiarity with the environment, they were expected to have similar capacities for judging the relevance of individual pieces of information in the route directions. A similar comparison was undertaken in Study 3, in which subjects who were familiar or unfamiliar with Venice rated the communicative value of the individual descriptions collected in Study 1. Again, we expected the two groups to produce similar ratings, indicating that they had adopted similar criteria that were to some extent independent of their knowledge of the environment.

The last study was designed to obtain behavioural validation of the evaluations provided by the subjects in the previous two studies. In the Denis (1997) study, the communicative value of the individual descriptions was essentially based on the subjective ratings provided by independent subjects. The present study assessed the quality of individual descriptions by the actual navigational performance that they produced. Very few studies have investigated the effects of verbal instructions on subjects' performance in the execution of navigational tasks, with measures of duration and/or number of errors along the route (cf. Streeter *et al.*, 1985; Vanetti and Allen, 1988). This kind of investigation is costly in empirical terms, but its ecological value is considerable, since the quality of navigational instructions is evaluated through a behavioural test, and this test is based on measures of the very behaviour which is believed to be served by spatial discourse (cf. Gärling *et al.*, 1997). This is the approach used in Study 4, where we examined the efficiency of users of descriptions rated as good or poor for their communicative value in moving through the city of Venice.

Lastly, Study 4 examined the influence of individual differences in mental spatial representation on the use of verbal descriptions during navigation. The contrast between survey and route perspectives in the mental representation of space is now well established (cf. Taylor and Tversky, 1996; Tversky, 1996). We compared the navigational performances of two groups of subjects who differed in their preferred way of mentally representing space. One group was inclined to use survey representations to solve navigational tasks, that is, to manipulate bird's-eye representations of the environment. The other group preferred to refer to visual landmarks seen from an ego-centred perspective to orientate themselves in their environments. Our objective was to test the hypothesis that the preference for a given type of representation influences a subject's capacity to use route directions for navigation.

STUDY 1

The goal of the first study was to collect descriptions of three routes in Venice and analyse their characteristic features. Protocols were analysed in terms of their length and their reference to landmarks. First, the length of any spatial descriptions differs greatly from one subject to another (cf. Daniel *et al.*, 1996). We checked for individual consistency in this respect as possibly reflecting individual styles. Second, as it has been suggested that route directions essentially reflect action plans with emphasis on landmarks and places where actions are to be executed (cf. Chown *et al.*, 1995), we looked for evidence of this. Third, we tested the hypothesis that the distribution of landmarks is not uniform along the route, and that landmarks tend to be concentrated at critical nodes (or at the approach to these nodes), in particular those points of the route where reorientation is required. This pattern was found in the descriptions of routes in a university campus (Denis, 1997). Similar findings in the particular environment of Venice would indicate that it is a general feature.

Critical nodes were defined as places requiring special attention during navigation, and therefore expected to be described with special care in route directions. Three classes of places were considered as critical nodes:

(1) Starting squares of routes: special care in the description of landmarks was expected here because the mover is supposed to start from the middle of an open environment, with a large number of candidate directions to take; referring to landmarks should be the most common way to help the mover select the correct orientation.
(2) Reorientation places: squares or crossroads encountered along the routes should again make it necessary to choose among several directions; describing landmarks helps select the correct one among several options. Note that the correct way may, strictly speaking, involve reorientation by inviting the mover to deviate from a straight line, but it may also require going in the same direction straight across an intersection.
(3) Terminal squares: these places are expected to elicit numerous landmark descriptions, not for helping orientation proper but to provide confirmatory information about the finishing point.

Method

Subjects

A group of 19 adults, 10 women and 9 men, aged 19–40, who knew Venice well, participated in this study. All had been born in Venice, except for one subject who had lived there for 10 years.

Materials

Three routes were selected, each connecting two well-known locations. They all connected the starting point and the destination fairly directly, but they all deviated from a simple straight line. Route 1 connected Campo Santo Stefano (also known as Campo Francesco Morosini) to Campo Manin (350 m). Route 2 started from Campo de la Pescaria (Rialto fish market) and ended at Campo San Salvador (450 m). Route 3 ran from the Santa Lucia train station to Campo San Simeon (300 m). All three routes were selected as variants of typical itineraries in the city of Venice, alternating moves along narrow streets and wide-open squares.

Procedure

Subjects were given the following instructions: 'Imagine that a person who is in Venice for the first time asks you how to go from a particular place to another on foot, and that you must tell him/her how to do it. You must do this for three routes, giving all the information you consider to be important for the person to reach the desired goal.' Subjects were tested individually, in their homes or at their working places, and were asked to give an oral description of the three routes. They were informed that their descriptions were not supposed to be given at the starting point of the routes but in the place where testing was occurring. The routes were proposed in the same order to all subjects.[1] The subjects' responses were recorded.

Results and Discussion

The subjects' protocols were transcribed for analysis. Most of the protocols described exactly the same itinerary for each route. Very few descriptions offered an alternative itinerary (2 out of 57), and this occurred for only small parts of the routes. This differentiates the specific environment of Venice from other environments, where more alternative routes are usually given by respondents (cf. Denis, 1997). This may be due to the constraints imposed by the structure of the city, in particular the bridges connecting streets, which reduced the number of options in the wayfinding process. Alternative routes would have been longer, more difficult to describe, and less accessible to the respondents.

The lengths of the protocols varied greatly. The number of words used ranged from 33 to 302 for Route 1, from 36 to 371 for Route 2, and from 22 to 190 for Route 3. The same subjects provided the shortest descriptions of all three routes (Subject 4), and the longest descriptions for all three routes (Subject 17). However, despite these dramatic differences in length, the descriptions provided in Subjects 4 and 17 followed exactly the same itineraries. These differences reflect individual styles, at least in terms of length of descriptions. The correlation coefficients between the numbers of words used by subjects for the three routes were $r(17) = 0.89$ for Routes 1 and 2, $r(17) = 0.89$ for Routes 1 and 3, and $r(17) = 0.91$ for Routes 2 and 3, all p's < 0.01. These significant values support the notion that subjects tend to be consistent in their use of specific descriptive strategies, regardless of the routes described.

Each individual description was rewritten in a standard format, following the method used by Denis (1997). Each sentence was expressed in the form of minimal information units with a predicate and one or two arguments. For example, the sentence 'When you arrive at an iron bridge, cross it' was analysed in three statements: 'You arrive at a bridge,' 'The bridge is made of iron,' and 'Cross the bridge.' The length of each protocol was then measured in terms of these information units. Again, the ranges were large, from 7 to 38 for Route 1, from 4 to 58 for Route 2, and from 5 to 30 for Route 3. The correlation coefficients between the number of units used for describing routes were $r(17) = 0.92$ for Routes 1 and 2, $r(17) = 0.92$ for Routes 1 and 3, and $r(17) = 0.94$ for Routes 2 and 3, all p's < 0.01. These values confirm the great consistency of each subject's descriptions.

In addition to differences in the length of the descriptions, we looked for information likely to reflect the content of the descriptions. We drew up a list of all landmarks mentioned in all the protocols. We avoided any risk of subjective interpretation on our part by counting all the physical entities reported in the protocols, including ground-level two-dimensional entities (squares, streets, etc.) and three-dimensional entities (buildings, shops, monuments, etc.). Any physical entity likely to be designated

[1]The routes were given to the subjects in the same order because in pilot testing, some subjects tended to refer to features of Route $N - 1$ when describing Route N. This pattern did not occur frequently, but we wanted to avoid any possible increase in the variability among the descriptions given by different subjects for the same route.

verbally was counted as a landmark. The number of landmarks for a given route varied widely among the protocols, from 6 to 14 for Route 1, from 3 to 26 for Route 2, and from 4 to 14 for Route 3. There were no significant correlations among the total number of landmarks across routes, but calculations involving only three-dimensional landmarks (which are expected to be of special relevance in route descriptions; see below) resulted in significant values. The correlation coefficients were $r(17) = 0.69$, $p < 0.01$, for Routes 1 and 2, $r(17) = 0.47$, $p < 0.05$, for Routes 1 and 3, and $r(17) = 0.65$, $p < 0.01$, for Routes 2 and 3. These values attest for subjects' consistency in the frequency of reference to landmarks.

Tables 1–3 list all the landmarks mentioned in the protocols, and their frequency of citation. Landmarks shown in bold type are those which were present in more than 50% of the protocols. Street and bridge names in parenthesis are provided for the reader's information, although these proper names were not systematically given by the respondents.

Landmarks were of two types. The first were two-dimensional, horizontally extended entities that were walked on, thus supporting navigation proper. They included: (1) streets to walk along; (2) bridges to cross; and (3) squares (campi). The squares were the starting points and destinations of the routes, as well as places crossed along the way. The second class of landmarks included a wide variety of physical objects which were parts of the environment and were mentioned to help the addressee to locate other relevant landmarks or signal directions to follow. Most of them were three-dimensional buildings, but some were streets which should not be entered.

The most frequently mentioned landmarks were ground-level entities which supported navigation, and a list of them may be considered as a summary of the route to be followed. The streets and bridges to follow and squares to cross represented 64.4% of the landmarks mentioned for Route 1, 60.2% for Route 2, and 67.7% for Route 3. Some subjects even considered it sufficient to refer to these items alone, as was strikingly illustrated for Route 3, for which eight subjects mentioned no other landmarks. The most frequently mentioned items in descriptions of Route 1 provide a nice illustration of typical pedestrian progress in Venice, iterating the standard campo/street/bridge triplet.

The remaining (three-dimensional) landmarks were far less frequent choices, although some of them, like the Church Santo Stefano (Route 1) and the monument to Goldoni in Campo San Bartolomeo (Route 2), were mentioned by substantial numbers of subjects. We examined the distributions of landmarks in the different parts of the routes by distinguishing those landmarks present at critical nodes from those along the segments connecting the nodes. While the former were thought to contribute to orienting the mover at decision points, the latter were essentially intended to confirm that the mover is walking in the correct direction. Tables 4–6 show the frequencies of three-dimensional landmarks mentioned at the critical nodes and along the segments of the three routes.

The tables show clearly that landmarks were quite unevenly distributed throughout the descriptions, and concentrated where they were expected to help orientation or reorientation. For Route 1, 79.7% of the landmarks mentioned were at nodes, as were 71.7% of these for Route 2, and 92.7% of these for Route 3, and this was the case despite the fact that critical nodes represented only a small portion of the entire routes. Although the three routes differed in structure (Route 2 was more tortuous than the other two), landmarks were always mentioned more frequently at or close to

Table 1. Landmarks along Route 1 and their frequency of mention*

Landmarks	Frequency
Campo Santo Stefano	**13**
Church San Vidal	1
Florist's shop	1
Conservatory	1
Monument to Tommaseo	4
Ice cream shop (Paolin)	2
Bar	1
Newspaper kiosk	7
Bell tower	1
Church Santo Stefano	9
Church door	5
Street (Calle dei Frati)	**11**
Pastry shop	1
Tobacco shop	2
Glass shops	2
Bridge (Ponte dei Frati)	**18**
Signpost	1
Campo Sant'Angelo	**19**
Steps	1
Building	1
Newspaper kiosk	4
Street on left (Calle dei Avocati)	2
Street on right (Calle del Cafetier)	1
Food shop	1
Calle della Mandola	**19**
Shops	4
Fruit shop	1
Barber shop	1
Bookshop	2
Bridge (Ponte de la Cortesia)	**19**
Campo Manin	**17**
Monument to Manin	3
Winged lion	1
Marble pedestal	1
Marble pillars	1
Bank	1
Toy shop	1

*Here and in Tables 2 and 3 bold type indicates landmarks that were present in more than 50% of the protocols.

critical nodes than along segments. The critical nodes were relatively close to each other in Route 3, and very few landmarks were mentioned along the segments. These findings confirm those reported previously (Denis, 1997), indicating that landmarks are not included in descriptions just as adjuncts or irrelevant items but for their actual information value, in particular when reorientation is required.

STUDY 2

The objective of this study was to build 'reduced' versions of the descriptions of each route, based on the protocols collected in Study 1. These shortened versions were

Table 2. Landmarks along Route 2 and their frequency of mention

Landmarks	Frequency
Campo de la Pescaria	**16**
Grand Canal	4
Arches	5
Square (Campo de la Becarie)	3
Fountain	3
Narrow street on right	1
Bridge on right	3
Bar	3
Wide street (Ruga del Spezier)	**15**
Shops	3
Butcher shop	1
Computer shop	2
Fish shops	2
Dress shops	1
Crossroads	3
Bank	4
Street (Ruga dei Oresi)	3
Rialto market	4
Fruit shops	1
Arches	3
Souvenir shops	2
Rialto Bridge	**19**
Shops	1
Jewelleries	1
Dress shops	1
Street (Salizada Pio X)	4
Campo San Bartolomeo	**19**
Monument to Goldoni	8
Bar	1
Jewellery	1
Street (Marzarieta Due Aprile)	**13**
Bank	2
Dress shops	2
Shoe shop	1
Purse shop (Marforio)	3
Campo San Salvador	**17**
Church San Salvador	4
Florist's shop	1
Scuola San Teodoro	1
Column	5

expected to contain the essential landmarks and actions needed to walk along the routes. First, all the pieces of information given for each route by the subjects of Study 1 were compiled to give 'megadescriptions' of each route. The megadescriptions were then shown to new groups of subjects, who were required to select the most relevant items to ensure a mover's adequate progress along the route. The responses of two groups of subjects, one composed of people familiar with Venice and the other with non-Venetians, were compared.

This comparison was intended to contrast two major sources of knowledge likely to guide a selection process. The first relevant source is obviously place and spatial

Table 3. Landmarks along Route 3 and their frequency of mention

Landmarks	Frequency
Train station	**16**
Steps	4
Square	1
Scalzi Bridge	**19**
Grand Canal	7
Quay	2
Church San Simeon Piccolo	2
Little square	1
Newspaper kiosk	2
Street (Calle Lunga)	**18**
Electricity shop	1
First street on left (dead end)	1
Second street on left (Calle Bergami)	**14**
Paper shop	1
Bridge (Ponte della Bergama)	**19**
Campo San Simeon	**14**
Church San Simeon Grando	5

Table 4. Frequencies of three-dimensional landmarks in successive portions of Route 1

(1) Landmarks at starting node (Campo Santo Stefano)	32	50.0%
(2) Landmarks along the first segment (Calle dei Frati + Ponte dei Frati)	5	7.8%
(3) Landmarks at intermediate node (Campo Sant'Angelo)	11	17.2%
(4) Landmarks along the second segment (Calle della Mandola + Ponte de la Cortesia)	8	12.5%
(5) Landmarks at terminal node (Campo Manin)	8	12.5%

Table 5. Frequencies of three-dimensional landmarks in successive portions of Route 2

(1) Landmarks at starting node (Campo de la Pescaria + Campo de la Becarie)	19	25.7%
(2) Landmarks along the first segment (Ruga del Spezier + Ruga dei Oresi)	13	17.6%
(3) Landmarks at first intermediate node (Rialto Bridge)	13	17.6%
(4) Landmarks along the second segment (Salizada Pio X)	0	0.0%
(5) Landmarks at second intermediate node (Campo San Bartolomeo)	10	13.5%
(6) Landmarks along the third segment (Marzarieta Due Aprile)	8	10.8%
(7) Landmarks at terminal node (Campo San Salvador)	11	14.9%

knowledge specific to the environment where the displacement should take place. Subjects familiar with the environment should be able to select those landmarks that they know to be relevant for guiding a mover. On the other hand, any subject naive about an environment is nevertheless capable of identifying which items of information are of primary or secondary importance in a description. This capacity is based on metacognitive knowledge of those pieces of information that are crucial for

Table 6. Frequencies of three-dimensional landmarks in successive portions of Route 3

(1) Landmarks at starting node (Square in front of Train Station)	20	48.8%
(2) Landmarks along the first segment (Fondamenta dei Scalzi)	0	0.0%
(3) Landmarks at intermediate node (Scalzi Bridge)	13	31.7%
(4) Landmarks along the second segment (Calle Lunga + Calle Bergami + Ponte della Bergama)	3	7.3%
(5) Landmarks at terminal node (Campo San Simeon)	5	12.2%

assisting navigation, irrespective of the specific environment where it occurs. For instance, it is common sense that any information on change in direction is helpful to wayfinders.

Metacognitive knowledge has been shown to shape the content of procedural discourse (e.g. Dixon, 1987; Hayes and Flower, 1980), but there is little, if any, documentation of this issue in the domain of spatial discourse (e.g. Denis, 1996). We compared the responses provided by subjects familiar and unfamiliar with the described environment in order to identify a potentially important feature. Given the assumptions stated above, we expected the selections of relevant units made by the two groups of subjects to overlap greatly. This outcome should support the view that selecting crucial units in route directions is based on knowledge that is largely independent of the specific environment.

Method

Subjects

A total of 46 young adults, aged 20–30, participated in this study. Half of them (23) were familiar with the city of Venice, while the other half were not. Each group contained 15 women and 8 men. The familiar subjects were students at the University of Venice, and were all living in Venice. The unfamiliar subjects were students at the Universities of Florence, Padua, Pisa, and Trieste, who declared that they did not know the city of Venice.

Materials

The megadescriptions from which reduced versions would be abstracted were compiled from individual descriptions cut up into minimal information units. Units present in several protocols were included in the megadescription only once. When such units were reported in different formulations by several subjects, the most frequent version was used in the megadescription. The megadescriptions also contained every informational unit that had been given by any single subject. The only items that were excluded were a few encyclopedic references to monuments totally unrelated to the routes described (e.g. the Bridge of the Academy). The items in a megadescription were listed in the order of their appearance along the corresponding route. The megadescription for Route 1 contained 64 units, that for Route 2, 68 units, and that for Route 3, 41 units.

Procedure

Each subject was presented with the items in the megadescriptions together with the following written instructions: 'In the following pages, you will find a list of pieces of information describing the route from (starting point) to (destination). All the elements mentioned are exact. However, it is likely that they far exceed the information necessary for a person without any knowledge of the city to follow this route. Read the whole set of items, then read them again and strike out the elements you consider unnecessary, while retaining those which are necessary and sufficient to guide the person along the route. When you have completed this task, read the items that remain again and check that they provide what is necessary (and only what is necessary) in order to follow the route. When you have finished this task for the first route, do the same for the other two routes.' All subjects processed the three megadescriptions in the same order, starting with Route 1.

Results and Discussion

There was no difference between the average number of units selected by the familiar and unfamiliar subjects, 30.2 and 32.7 for Route 1, 34.5 and 32.3 for Route 2, and 21.7 and 21.8 for Route 3, respectively. This suggested that both groups of subjects adopted similar constraints in selecting units.

Reduced ('skeletal') descriptions were obtained for each route from the selections made by the familiar subjects and by the unfamiliar subjects. Only the information units that were selected by at least 70% of the subjects (17 subjects) in each group were included in the skeletal descriptions. This resulted in the descriptions shown in Tables 7–9, where the items common to the two groups of subjects are shown in bold type.

Skeletal descriptions superficially resemble individual protocols in that they contain lists of information units. However, their nature is different, in that they do not reflect the output of a given subject, but the abstracted essence of each route. The skeletal descriptions are consequently saturated with relevant information. They contain the minimal set of landmarks and instructions needed to ensure progression along a route. They contain the essentials of the navigational procedure, without any embellishment or noise resulting from overspecification. These features are clearly illustrated by the skeletal descriptions of all three routes, which contain only landmarks indispensable for guiding the mover, and exact minimal information at decision points.

Table 10 summarizes the number of elements in the original megadescriptions, in the two resulting skeletal descriptions, and the number of elements shared by the two skeletal descriptions, for each route. This latter piece of information reveals that the number of shared elements was very high, exceeding the number that would have been expected if the two groups had made independent choices. This suggests that the two groups used similar criteria to select the items, and that their perception of which items to include in, or exclude from, route directions is largely independent of their knowledge of the specific environment under study. The structures of the resulting skeletal descriptions were virtually the same.

However, the skeletal descriptions compiled from the responses of the two groups contained a few diverging features. First, the skeletal descriptions based on the responses of the unfamiliar subjects contained a few more items than those based on the responses of familiar subjects. This is not surprising, since the unfamiliar subjects may have felt the need for items that were considered to be irrelevant by familiar subjects. Second, the items whose choice differed most between the two groups

Table 7. Skeletal descriptions of Route 1*

Skeletal description based on the responses of familiar subjects
You are in Campo Santo Stefano.
Use the monument as landmark.
Walk in the direction of Rialto Bridge.
Walk towards the newspaper kiosk.
Go straight.
The square becomes narrower.
You arrive at a narrow street.
Continue for about 60 metres.
You will find a bridge.
Cross the bridge.
You will arrive at a square.
It is Campo Sant'Angelo.
Go along its longer side.
At the end, you will find a street on the left, one on the right and one in front of you.
Go straight ahead.
Walk for about 100–150 metres.
The street is called Calle della Mandola.
You will arrive at a bridge.
You are in Campo Manin.
Skeletal description based on the responses of unfamiliar subjects
You are in Campo Santo Stefano.
Use the monument as landmark.
There is a church.
Walk towards the newspaper kiosk.
Go straight.
You will reach the church.
Walk across the door of the church.
You have the church on your right and a bar on your left.
You arrive at a narrow street.
Continue for about 60 metres.
You will find a bridge.
Cross the bridge.
You will arrive at a square.
Go along its longer side.
At the end, you will find a street on the left, one on the right and one in front of you.
Go straight ahead.
Walk for about 100–150 metres.
The street is called Calle della Mandola.
You will arrive at a bridge.
The bridge is called Ponte de la Cortesia.
You are in Campo Manin.

*Here and in Tables 8 and 9 bold type indicates the items common to the two groups of subjects.

(a difference of at least ten choices) indicated that familiar subjects preferred items likely to prevent users from making errors, such as 'Do not enter the street,' 'It is a blind street' (Route 3). On the other hand, unfamiliar subjects preferred the direct assistance provided by topological descriptions of landmarks at decision

Table 8. Skeletal descriptions of Route 2

Skeletal description based on the responses of familiar subjects
You are in Campo de la Pescaria.
Stand with your back to the Grand Canal.
The fish market is under arches.
Walk along the entire length of the fish market.
You will find a little square.
Turn to the left.
Go straight along a street.
You will arrive at a crossroads.
Go straight ahead.
You will go through the fruit market.
You will see the steps of a bridge.
It is the Rialto Bridge.
Cross the bridge.
After the bridge there is a street.
Go straight ahead.
You will arrive in a square.
It is Campo San Bartolomeo.
In the middle, there is a monument.
Turn right.
You are in a large street.
Go along it for 100 metres.
You are in Campo San Salvador.
There is a column in the middle of the square.

Skeletal description based on the responses of unfamiliar subjects
You are in Campo de la Pescaria.
Stand with your back to the Grand Canal.
Walk along the entire length of the fish market.
You will find a little square.
Turn to the left.
Go straight along a street.
You will arrive at a crossroads.
Go straight ahead.
You will go through the fruit market.
You will see the steps of a bridge.
It is the Rialto Bridge.
Cross the bridge.
After the bridge there is a street.
Go straight ahead.
You will arrive in a square.
It is Campo San Bartolomeo.
Turn right.
You are in a large street.
It is Calle Due Aprile.
Go along it for 100 metres.
You are in Campo San Salvador.
There is a column in the middle of the square.

Table 9. Skeletal descriptions of Route 3

Skeletal description based on the responses of familiar subjects
Leave the railway station.
Turn to the left.
There is a bridge.
Cross the bridge.
Go straight along the street.
Continue for about 50 metres.
There is a second street on the left.
Turn left.
Go straight ahead.
There is a bridge.
Cross the bridge.
You are in Campo San Simeon.

Skeletal description based on the responses of unfamiliar subjects
Leave the railway station.
Walk down the steps.
Turn to the left.
Continue for about 20 metres.
There is a bridge.
Cross the bridge.
You will find a newspaper kiosk.
Close to the newspaper kiosk, there is a street.
Go straight along the street.
Continue for about 50 metres.
There is a first street on the left.
There is a second street on the left.
Turn left.
Go straight ahead.
There is a bridge.
Cross the bridge.
You are in Campo San Simeon.

Table 10. Number of items in the megadescriptions, in the skeletal descriptions based on the responses of familiar and unfamiliar subjects, and number of items common to both skeletal descriptions, for each route

	Megadescription	Skeletal description (familiar subjects)	Skeletal description (unfamiliar subjects)	Common items
Route 1	64	19	21	16
Route 2	68	23	22	21
Route 3	41	12	17	12

points, for instance: ‘The church is on your right,’ ‘There is a bar on your left,’ etc. (Route 1).

Apart from these few differences, the main result of Study 2 was the overall agreement in the selection of items by familiar and unfamiliar subjects. This supports our assumption that familiar and unfamiliar subjects both recognize which information units are important for navigation, and that the knowledge base used for this selection is distinct from knowledge of the environment described. This observation is in line with the fact that the clarity of route directions can be perceived even by subjects who have no prior knowledge of the environment described (cf. Riesbeck, 1980).

STUDY 3

The previous study showed that a simple statistical procedure based on the subjects' selections of relevant information units can be used to extract a skeletal description that provides a sound summary of the route from a corpus of individual descriptions. More importantly, the judgements of what is important or unimportant in route directions resulted in subjects who were familiar and unfamiliar with the area producing very similar outputs. While the subjects of Study 2 processed previously elaborated lists of items extracted from original protocols and reformatted as standard expressions, Study 3 was designed to collect judgements on the original protocols. New groups of subjects were invited to assess the quality of individual original descriptions, just as if these descriptions were used in a natural context.

Ratings were collected and analysed to provide two sorts of information. First, they were examined to see whether knowledge of the environment influenced assessment of the communicative value of descriptions. This was done by comparing the responses of judges who were familiar with the city of Venice with those of subjects who did not know Venice. As in Study 2, we hypothesized that megacognitive knowledge of what are important features of route directions is more determinant than is knowledge of the environment. In line with the previous study, we expected similar patterns of ratings by familiar and unfamiliar judges. The judges were interviewed after the experiment to collect more information on these supposedly important features. Lastly, the judges' ratings were analysed to obtain information on the intrinsic characteristics of the respondents of Study 1, such as whether a respondent who provided good directions for one route provided equally good directions for another. In other words, we looked for evidence that subjects could be identified as 'good' (or 'poor') describers.

Special care was taken in formulating the instructions given to the judges. We tried to prepare instructions that did not interfere with spontaneous insight or criteria adopted by the judges, but we were also concerned that totally unspecific instructions would create a fuzzy situation for the judges. The task was very demanding, since it required subjects to read a large number of descriptions with very similar contents and to develop an internal scale for comparing them as minutely as possible. In the absence of any specification of what was expected by the experimenters, the judges could have experienced some confusion or interference. We therefore chose to be explicit about the objective of the task instead of leaving the value judgements entirely to the judges. Explicitness, however, was not achieved by providing very specific statements, such as 'Judge positively a description in which every reorientation occurs after mention of a landmark,' or 'Judge negatively a description where a landmark is posited in an indeterminate way and judge positively a description where a landmark is posited "to the left" or "to the right" of another.' The indications provided in the instructions remained rather general, focusing on the expected clarity of the mental representation constructed by the mover and by the ease of his or her navigation.

Method

Subjects

The judges were 10 young adults aged 19–27. Five of them (2 women, 3 men) knew Venice well, according to the criteria used in Study 1, and had lived in Venice for many years. The other five (2 women, 3 men) were students from other Italian cities.

Materials

The materials consisted of printed copies of the 57 route descriptions collected in Study 1.

Procedure

The context in which the descriptions of routes had been collected was explained to the judges. The judges were then given copies of the 19 descriptions of Route 1 and invited to rate them on a seven-point scale for quality in navigational assistance. The instructions were: 'Some of these descriptions will appear to be good or even excellent to you, in that they provide clearly and quite exactly the information needed by the person who reads them to build an accurate representation of the route, its landmarks, and the actions to take. Such descriptions contain all useful information, but only really useful information. Other descriptions may create major difficulties for the person who reads them, so that he/she may not be able to correctly build a representation of the route, the landmarks at their correct locations, and the actions to take. Some of these descriptions are too succinct, while others contain excess information. Between these extremes are descriptions of intermediate quality. Your task is to rate all the descriptions on a seven-point scale. A score of 7 should be given to a mostly adequate description enabling a user to build easily a clear representation of the route and reach the goal without error or hesitation. A score of 1 should be given to a poor description containing insufficient information or more information than is really useful, that does not enable the user to build a consistent representation. The other scores should be used for intermediate descriptions. You should first read all 19 descriptions without rating them, then re-read and rate them.' The judges were subsequently asked to follow the same procedure for the descriptions of Routes 2 and 3.

Results and Discussion

Agreement among the judges was first assessed by computing correlation coefficients for the ratings, for each route and for familiar and unfamiliar judges. The average value of these coefficients was $r(17) = 0.57$ for the familiar judges (above the critical value corresponding to the 0.02 significance level), and it was $r(17) = 0.28$ for the unfamiliar judges. A total of 16 of the 30 coefficients based on the familiar judges' ratings were greater than $r(17) = 0.58$ (above the critical value corresponding to the 0.01 significance level), whereas this occurred only in five cases for the unfamiliar judges. These data suggest that the familiar judges used more similar criteria in their ratings than did the unfamiliar judges.

The two groups also showed some similarities. The average scores attributed by the familiar and unfamiliar judges to each description were computed. The two sets of scores were significantly correlated, $r(17) = 0.60$ for Route 1, $r(17) = 0.82$ for Route 2, and $r(17) = 0.90$ for Route 3, all p's < 0.01. These correlation coefficients suggest that the two groups used similar criteria for rating descriptions, despite the greater consistency of the familiar judges.

The familiar judges were asked to provide more comments on their perception of what were 'good' descriptions. They declared that the protocols given the highest scores were clear and complete, with a sufficient number of landmarks, but with no redundancy or indeterminate descriptions. Table 11 shows a description that was considered to be very good by the familiar group (average rating: 7.0) and by the unfamiliar group (average rating: 6.0). This description was judged to be very clear, focusing on the essentials, providing necessary and sufficient information for adequate navigation. In contrast, the descriptions that received the lowest scores were considered to be too redundant or to provide insufficient information. They were also considered to be unclear and confusing. Table 12 shows a description that received the lowest possible score from all 10 judges (average rating: 1.0). This description contains all the possible deficiencies of this kind of spatial discourse. It is too long, contains extraneous comments and irrelevant information, and does not specify landmark locations.

Finally, we considered the correlations between routes based on the mean ratings of the familiar judges. Correlation coefficients were $r(17) = 0.49$, $p < 0.05$, for Routes 1 and 2, $r(17) = 0.44$, $p < 0.07$, for Routes 1 and 3, and $r(17) = 0.40$, $p < 0.09$, for Routes 2 and 3. These results limit any conclusion we may draw about the general descriptive capacities of the respondents. Some subjects appeared to be consistently very good or very poor describers. For instance, the subject who gave the very poor

Table 11. An example of a description given a high rating (Route 3, Subject 13)

Stand with your back to the station. Walk to the left. The Scalzi Bridge will be in front of you. It is a very high bridge which crosses the Grand Canal. Walk across the bridge. You will reach a street which is a continuation of the bridge. At a given time, take the second street on your left. You will reach an obliquely oriented bridge made of iron and stone. Walk across the bridge. The Church San Simeon will be just in front of you.

Table 12. An example of a description given a low rating (Route 1, Subject 17)

Campo Santo Stefano is a wide square. At one end, it joins Campo San Vidal, which is recognizable from a church with a florist's shop in front of it. You reach Campo San Vidal by a wooden bridge, the only wooden bridge in Venice, the Bridge of the Academy. When you are in Campo Santo Stefano, you may notice a little wooden newspaper kiosk at the end of the campo and a small place with an ice cream shop and a bar. In the middle of the campo, there is a monument. I think it is a statue of Tommaseo. As you walk along, you will see the tower of Santo Stefano which is easy to recognize since it is crooked and leaning a little. You can still see it as you walk across a bridge which is rather low and wide, with a few steps. You arrive in Campo Sant'Angelo. It is a raised campo, that you enter by steps up from the surrounding little streets. From there, you still can see the tower of Santo Stefano. You proceed and enter a street whose name I do not remember, Calle della Fava, maybe. It is a very long street, rather straight, which goes to the Manin Bridge. It is a stone bridge. Just before the bridge, there is a bookshop. After the bridge is the campo with another monument. It is a monument to Manin, on which there is a lion, the winged lion of Venice. It is on a marble pedestal surrounded by four cube-shaped marble pillars. In front of the monument, there is a bank, which is easy to recognize because it is a building without any Venetian feature at all. It is a modern building in reinforced concrete, a sort of fortified bank. You are on Campo Manin.

description of Route 1 mentioned above (Subject 17) obtained very low ratings for all three descriptions (1.0, 1.2, and 1.6). On the other hand, the author of the best description of Route 3 (Subject 13; see below, Study 4) obtained ratings of 3.0, 2.8, and 7.0. These findings suggest that a general descriptive capacity may interact with other factors to generate a good description. Some subjects may have been very familiar with all three routes, but able to identify critical elements only for some of them. Or a subject may have tended to use short descriptions, which may have been perfectly adequate for some routes, but not for others.

To summarize, the main information provided by Study 3 is the substantial agreement between familiar and unfamiliar judges as to the communicative value of route directions. These conclusions are in line with those of the previous study, which indicated that the perception of which items are important and which are not in a protocol and is substantially affected by knowledge of the environment described. Finally, the main features of descriptions recognized as good were their clarity and completeness, and their capacity to provide sufficient, and not redundant, information to the user. The similarities of ratings strongly suggest that these features are recognizable even when a judge is not familiar with the environment. This is not surprising, given that the first judge of the quality of a spatial description is generally the person who is about to use it and is, by definition, ignorant of the described environment.

STUDY 4

The judges agreed on the communicative value of the route descriptions. But the above studies provided no objective criteria for assessing the quality of descriptions. In the Denis (1997) study, the judges' ratings were validated by showing that the descriptions which received the highest ratings were most similar to the corresponding skeletal descriptions. Although this validation was based on independently collected measures, it was limited by the fact that the measures relied on subjective judgements. Even though the judges' responses were based on explicitly stated criteria, it seemed desirable to look for more objective criteria to support the classifications provided by the judges.

We therefore collected behavioural indices likely to reflect the qualities of descriptions designated as good or poor on the basis of the judges' ratings. In Study 4, the best and poorest descriptions of each route were selected, and new subjects were asked to follow the routes using these descriptions. If the purportedly good descriptions were really effective, they should elicit more efficient navigational behaviour than poor ones. In addition to assessing the behaviour of subjects given good or poor descriptions, we tested the efficiency of the skeletal descriptions as navigational aids. If, as expected, skeletal descriptions were close to the essentials of route directions, they should produce behavioural indices reflecting adequate navigational performance, since they contained all the essential information. We expected good descriptions to guide navigation better than poor descriptions, whereas the good and skeletal descriptions should produce similar results.

Study 4 also provided an opportunity to examine the effects of individual differences on the use of route directions. Subjects responded to a questionnaire that allowed us to compare those inclined to survey perspective and those relying more on visual memories of the environment. This contrast was thought to be relevant for comparing navigational performance. In particular, survey perspective typically generates map-like representations. These representations differ from those constructed from a route perspective, which essentially offers ego-centred frontal views of the environment. This latter perspective is structurally compatible with the representations generated by the ambulatory experience involved in navigation. Subjects who spontaneously adopt this perspective should be better prepared than the others to process route information and use it during navigation.

Method

Subjects

The 18 subjects recruited agreed to spend one day in Venice taking part in the study. They were undergraduate students in psychology, living in Padua, but they came from various cities in Italy. They were aged 20–27 and declared that they had little or no experience in the city of Venice. At most, they had visited the city once many years ago.

Materials

The materials were printed versions of a good description, a poor description, and the skeletal description of each route. The descriptions considered to be good for each route were those that had received the highest mean ratings from the familiar judges in Study 3. These were descriptions provided by Subject 14 for Route 1 (97 words; average rating: 6.4), Subject 11 for Route 2 (103 words; average rating: 6.2), and Subject 13 for Route 3 (94 words; average rating: 7.0). The descriptions given the lowest ratings for the three routes were all produced by the same subject (Subject 17). They were long, highly redundant descriptions, which differed markedly from all the others. We therefore selected as poor descriptions those which obtained the lowest ratings, excluding the descriptions by Subject 17. These were descriptions produced by Subject 18 for Route 1 (88 words; average rating: 1.6) and Route 2 (35 words; average rating: 1.2) and Subject 5 for Route 3 (117 words; average rating: 1.8). The skeletal descriptions were those based on the selections made by the subjects who were familiar with Venice.

Procedure

Subjects were randomly assigned to one of three groups who were tested in different orders for the three routes. Group 1 was tested for Routes 1, 2, and 3 successively, while Group 2 was tested for Routes 2, 3, and 1, and Group 3 was tested for Routes 3, 1, and 2. Two subjects in each group were given the good description of the first route tested, the poor description of the second route, and the skeletal description of the last route; two subjects were given descriptions in the order: poor, skeletal, good; and two subjects were given them in the order: skeletal, good, poor. Subjects were tested individually. They were given the printed version of a description at the starting point of the corresponding route and were invited to study it for 2 minutes. They then returned the description to the experimenter and immediately started to follow the route, followed by the experimenter a few metres behind. Subjects were asked to walk in a relaxed manner while avoiding pauses and to ask for assistance form the experimenter if necessary. They were told that the experimenter would follow them to record their progress and provide help if required. When subjects took a wrong turning (for instance, when they had gone down the wrong street for more than 5 metres), the experimenter called them back and repositioned them at the intersection, informing them that the direction they had followed was not correct. Once the subjects had reached the end of one route, they were taken to the start of the next. The experimenter was careful to avoid passing through parts of the city which were parts of another tested route.

Results and Discussion

Most subjects produced few errors. The number of directional errors and number of requests for assistance were recorded for each subject and each route. Hesitations were scored as 1 every time subjects stopped for more than 5 seconds, and 0.5 for shorter stops.[2] Table 13 shows the average numbers of directional errors, hesitations, and requests for assistance from the experimenter, per route, for each type of description. The data from two subjects were not included in the analyses. For reasons not related to the experiment proper, they were not able to execute the last navigation task.

Since the overall scores were very low, the total error score, obtained by summing the three individual error scores, was analysed. Analysis of variance revealed that the total error scores for the three kinds of descriptions was significantly different, $F(2,30) = 11.52$, $p < 0.001$. *Post hoc* analyses revealed that the poor descriptions produced significantly higher total error scores than the good and skeletal descriptions ($p < 0.001$). There was no difference between the error scores for the good and skeletal descriptions.

These findings show that good descriptions result in better navigation than poor descriptions. The similarity of the performances for good and skeletal descriptions also suggests that the latter captured some of the essential features of the best original descriptions. These results thus provide behaviour-based support for the ratings given by the judges in Study 3. Those descriptions assessed as the best for their navigational assistance were indeed those which guided navigation the most efficiently. They probably did so because they possessed the essential features of good descriptions. They were clear, complete, unambiguous, precise, and concise, as stated by the subjects and judges of the previous studies. These characteristics were also true of skeletal descriptions. In spite of their different surface features (they were crude lists of landmarks and prescriptions), skeletal descriptions had the same communicative value as the best natural descriptions. In contrast, poor descriptions made navigation

Table 13. Average error scores during navigation per route for each type of description

	Good description	Poor description	Skeletal description
Directional errors	0.25	0.69	0.12
Hesitations	0.06	1.31	0.56
Requests for assistance	0.51	0.94	0.31
Total error score	0.82	2.94	0.99

[2]In the analysis of results, the coding of hesitations as 'errors' should not be taken literally. As the other measures used, hesitations should be considered as behavioural indices of the difficulty experienced by the movers after reading a description.

much more difficult. They were generally slightly shorter than good descriptions (80 versus 98 words, on average), and so may have failed to provide all the essential information. This could have led subjects to make more directional errors and be more uncertain, as indicated by the frequent hesitations. In contrast, subjects using good descriptions almost never hesitated.

Our data clearly indicate that the quality of directional instructions affects navigational performance. However, the nature of the representations actually used by subjects during the navigation task remains an open issue. The literature on spatial mental representations has established a contrast between survey and route perspectives in the comprehension of spatial language and the construction of spatial knowledge (cf. Taylor and Tversky, 1996). People who are inclined to use survey perspective are thought to adopt a bird's-eye view of an environment, whether the environment is a familiar one reconstructed later from memory or a new one conveyed by a spatial description. The survey perspective relies on an extrinsic frame of reference and typically uses canonical spatial terminology ('north', 'south', 'east', and 'west'), resulting in a map-like mental representation. People who are biased towards a route perspective generally adopt the successive points of view of a person navigating in the environment. They consequently rely on an intrinsic frame of reference, and are more likely to encode spatial relations in egocentric terms ('right', 'left', 'front', 'back'). Route-oriented people may differ in their emphasis on encoding the kinaesthetic aspects of navigational experience (by recording a succession of moves and turns) or the visual experience associated with navigation (encoding a succession of visual memories of scenes and landmarks).

Although the objective of the present research was not to investigate individual differences *per se*, the subjects who participated in Study 4 had also been tested in an independent study for their cognitive preference for different modes of spatial representation. They had filled in a Questionnaire on Sense of Direction and Spatial Representation (Pazzaglia, 1996), which included items that required reports of their preference for survey, route, and more particularly visual aspects of environment knowledge. Correlational analysis of the questionnaire based on data collected from 50 subjects revealed that the scores describing preference for a survey perspective and those for visual memories were negatively correlated, whereas a preference for a route perspective was correlated negatively, but non-significantly, with the other two scores. Analysis of the survey and the visual items in the questionnaire, which were the most clearly contrasted, was used to divide the subjects who took part in Study 4 into two groups. One group included the subjects who had described themselves as inclined towards a survey (map) perspective rather than a visual (landmark) memory (the Survey group). The second group of subjects had reported the opposite tendency (the Visual group).[3]

Table 14 shows the total error scores of the Survey and Visual subjects for each type of description. Despite the small number of measures involved, there was a significant difference between performances of the Survey and Visual subjects when following poor descriptions. Both groups performed equally well when given good and skeletal

[3]Additional psychometric investigations looked for the relationships between survey perspective and performance in tasks calling for visuo-spatial working memory. A battery of visuo-spatial tests was used in a stepwise regression analysis, which showed that measures of preference of survey perspective were significantly predicted by performance on a spatial span test, the Corsi test (cf. Pazzaglia, 1996; Pazzaglia and De Beni, 1997).

Table 14. Average total error scores during navigation per route for each type of description, for the Survey and Visual groups*

	Good description	Poor description	Skeletal description
Survey ($N = 7$)	0.60	4.42	1.21
Visual ($N = 11$)	0.86	2.23	0.68

*Two subjects did not complete the last task, hence the means of the Survey group for the good and poor descriptions are based on six values instead of seven.

descriptions, but the poor descriptions caused the Survey subjects to make more errors than the Visual subjects, $t(15) = 3.06$, $p < 0.01$. Thus, Survey subjects had special navigational difficulties with materials having poor communicative value.

The survey perspective is generally considered to be a rather sophisticated mode of representation, involving the recoding of ego-centred visual and/or kinaesthetic experience as map-like mental representations. The construction of a survey representation from material privileging a route perspective, as in route directions, probably involves substantial cognitive cost, while ultimately making a coherent representation which provides a global view of the memorized environment. In fact, the subjects who were most expected to build such representations had particular difficulty in the subsequent navigation task. This may be because these subjects abandoned their preferred strategy for an alternate one, at which they were not at all proficient, when they realized the difficulty of converting a confusing route description into a survey representation. Alternatively, these subjects may have continued to construct their preferred representations, but the poor descriptions resulted in confused survey representations, with missing or fuzzy portions, which caused subsequent poor navigation. These difficulties were probably increased by the specific characteristics of the topography of Venice, which make it especially difficult to construct a global survey representation of the environment traversed by the routes. In contrast, the subjects who relied more on the encoding of visual scenes and landmarks that were to be encountered suffered less from poorly organized spatial discourse. They made use of the many landmarks, even if these were not always coherently introduced in the descriptions. The data reported here clearly suggest that the navigational performance based on spatial discourse depends to a large extent on interactions between individual cognitive characteristics or preferences, properties of the environment, and intrinsic characteristics of the linguistic material.

GENERAL DISCUSSION

The above studies were intended to shed light on a special type of spatial discourse, route directions. We collected a corpus of descriptions in a natural context, and extracted from it the most characteristic features of route directions, thus extending previous analyses of spatial discourse (Denis, 1996; Golding *et al.*, 1996; Klein, 1982). The specific environment of Venice was chosen as it was likely to generate descriptions containing specific features in addition to those that have been found to occur in the descriptions of more frequently considered environments.

One of the previously reported features of route directions was confirmed. We found that their content was composite, involving a combination of descriptive and instructional discourse. The protocols specified the steps needed to go from starting point to destination, together with the actions to be performed at critical points that were essentially described as configurations of landmarks. The protocols confirmed the role of landmarks at the approach of such critical nodes, where an orientation problem was to be solved. In the specific environment investigated here, route directions were expressed as successions of ways supporting navigation (streets, bridges, and squares). The protocols also included references to three-dimensional landmarks, such as buildings or monuments. As was found in studies conducted on university campuses or in ordinary urban environments, the landmarks were more frequently mentioned at points requiring reorientation or choice among alternative streets than when the route went along segments involving no reorientation. Landmarks thus appear to be included in route directions for their intrinsic information value for navigation (cf. Galea and Kimura, 1993; Lloyd, 1991).

Another remarkable feature was the great difference among the descriptions produced by individuals, in particular the variety of the information units included by speakers in their route directions. This had also been found in research conducted in more standard environments, and it was confirmed here, although the routes selected for this research were highly constrained and offered quite a limited set of variants, if any. Only a subset of the many landmarks punctuating routes were actually used in descriptions. Our findings also confirm the large differences among speakers in terms of protocol length, number of information units, and number of landmarks mentioned.

The assumption that descriptions are variants of a core structure was formalized by constructing skeletal descriptions of the routes. The concept of a skeletal description was forged to capture the idea that some pieces of information in route directions are more important or more central for navigation than others. The main thread of each route was extracted from the whole set of descriptions, by relying on the selections of people having a thorough knowledge of the Venice environment (rather than selecting items that fitted the experimenters' intuitions). The resulting reduced versions of route descriptions incorporated all the essentials for following each route. More importantly, the contents of the skeletal descriptions were virtually the same, whether they were built from the responses provided by subjects familiar with Venice or from those produced by subjects who were totally ignorant of it. Deciding what is important in a description probably involves specific knowledge of the environment, but knowledge of which among the many pieces of information available should be included in useful route directions is at least as important. The relative independence of item selection from knowledge of the environment is particularly remarkable in a city like Venice, where familiarity with the environment and specific local terminology may well have been thought to be crucial. The agreement between the subjects who were familiar with Venice and those who were not suggests that they all had, and made use of, metacognitive knowledge that was independent of their familiarity with the environment.

The availability of knowledge about what is relevant in route directions, which pieces of information to include and which to exclude, is also illustrated by the similarity between ratings of protocols made by judges who were familiar with Venice and those who were not. If such metacognitive knowledge is available to monitor spatial discourse, then the judges must have taken into account the cognitive capacities of the potential addresses, giving the highest scores to descriptions which best matched their implicit criteria. Our study in fact shows that descriptions rated as good by judges were used more efficiently by people travelling in Venice (with fewer directional errors, fewer hesitations, and fewer requests for assistance) than poor descriptions. The skeletal descriptions were as effective as the best descriptions, and must therefore have included the essential components and structural features of good descriptions. The impact of good and poor descriptions on behaviour also means that the ratings provided by judges were not just about some superficial qualities of discourse but assessed the effective use of a description in context. Several indicators have thus been cross-checked, and this was especially informative when subjective ratings predicted the effectiveness of descriptions in assisting navigational behaviour. The descriptions evaluated as good all had several features likely to facilitate navigation, and these features were explicitly stated by judges in terms of clarity, completeness, lack of ambiguity, and brevity.

Finally, the study shows that a cognitive preference for a spatial perspective may influence a subject's capacity to use descriptions for navigational purpose. Subjects biased towards survey representations were particularly disadvantaged when they had to process poor descriptions in a real environment. This may seem counterintuitive. Subjects preferring survey representations generally perform well in visuo-spatial tasks, such as those requiring pointing to non-visible remote landmarks (cf. Lawton, 1996; Pazzaglia, 1996). The present findings may result from a number of interacting factors. Venice is a city of narrow streets, which restricts distant views of important landmarks. The intricate spatial structure of the city makes it difficult to construct a survey (map-like) representation of the environment. This is probably why navigation anchored to salient visual landmarks resulted in better performance than attempts to build comprehensive survey representations. Because route directions typically impose a route perspective (unless costly recoding is performed by users), survey representations may be of limited assistance for navigation based on this type of discourse. This should be especially true if a route description is poor or omits critical pieces of information.

To summarise, the research reported here aimed at documenting an emerging issue in the domain of spatial cognition, namely, people's use of language to convey spatial information and, more particularly, provide navigational assistance to other people unfamiliar with an environment. Route directions are a form of procedural discourse that exploits a vast domain of human knowledge, spatial knowledge, and intends to have other people construct new knowledge to guide their action in the environment. By articulating the concept of internal spatial representations and the concept of their externalization through language, this field of research offers new opportunities to demonstrate the value of a basic cognitive approach for resolving concrete spatial problems.

AUTHORS' NOTE

This research was conducted as part of a project supported by a Human Capital and Mobility grant (#CHRXCT940509) from the Commission of the European Communities. Requests for reprints should be sent to either Michel Denis, Groupe Cognition Humaine, LIMSI-CNRS, Université de Paris-Sud, BP 133, 91403 Orsay Cedex, France (e-mail: denis@limsi.fr), Francesca Pazzaglia or Cesare Cornoldi, Dipartimento di Psicologia Generale, Università degli Studi di Padova, Via Venezia, 8, 35131 Padova, Italy (e-mail: pazzagl@psy.unipd.it, cornoldi@psico.unipd.it).

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