When and Why Are Visual Landmarks Used in Giving Directions?*

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Abstract. Route directions describe the sequence of actions a moving person needs to take to reach a goal in an environment. When generating directions, speakers not only specify what to do. They also refer to landmarks located along the route. We report two studies intended to identify the cognitive functions of landmarks. In the first study, participants learned a route in an urban environment. They then generated route directions to help pedestrians unfamiliar with this environment to find their way. We found that landmarks were reported more frequently at specific points on the route, especially at reorientation points. The second study showed that pedestrians perceived landmarks as a useful part of route directions. We conclude that reference to landmarks is intended to help movers to construct a mental representation of an unfamiliar environment in advance and to prepare them cognitively to get through difficult or uncertain parts of that environment.

Keywords. Landmarks, spatial cognition, route directions, urban environment, navigation.

1. Introduction

In spatial cognition studies, considerable attention has been devoted to the processes involved in generating and comprehending route directions. This trend reflects the value attached by researchers to the investigation of the *dynamic aspects* of spatial cognition, rather than to approaches limited to processing static scenes or environments. It also illustrates the need for accounts of the cognitive processes on which most navigational aids are based. This is especially critical in the context of designing human-computer devices intended to provide pedestrians and drivers with navigational instructions (e.g., Chalmé et al., 2000; Chown, Kaplan, & Kortenkamp, 1995; Jackson, 1998; Werner et al., 1997).

Route directions belong to the broad category of *procedural discourse*, which is intended to assist an agent to carry out an action so that it has a measurable, adaptive effect (cf. Dixon, 1987; Glenberg & Robertson, 1999). In the situation of route directions, the desired effect is for a human agent (or a robot) eventually to reach a

* The experiments reported in this paper were conducted as part of a collaborative research program of LIMSI-CNRS with Bouygues Telecom.

new position in a three-dimensional world. Once the agent has successfully reached this new position, an observer can plot the course that has been followed**.** Route directions can be summarized as the set of instructions that prescribe the actions required in order to execute that course, step by step, in an appropriate manner (cf. Allen, 2000; Denis, 1997; Denis et al., 1999; Fontaine & Denis, 1999; Golding, Graesser, & Hauselt, 1996; Lovelace, Hegarty, & Montello, 1999; Schneider & Taylor, 1999).

The basic function of route directions is to prescribe actions. These actions succeed one another in a specific order. For the moves to lead an agent to a succession of specific locations along a route, reorientation procedures will be required. The default move, in the absence of any explicit instruction, is to move straight on, along the back-front axis of the moving agent. However, it is not only necessary to prescribe specific reorientations, but also to specify exactly *where* they take place.

While progressing along a route, movers collect direct perceptions of their environment, and this is important if they are to be able to relate their moves to this environment. Route directions actually rely on the fact that moving agents are also *perceptive agents*, and this is reflected by their ability to describe the environment when they are invited to do so, especially at points where reorientation is necessary.

The objective of a person generating route directions is thus to deliver a combined set of *procedures* and *descriptions* that allow someone using them to build an *advance model* of the environment to be traversed. The discourse will therefore include information that makes it possible for the user to create such an internal representation. The representation is created in such a way that it reflects frontal views of the environment, as it will be viewed along the route (rather than survey views) (cf. Schweizer et al., 1998; Taylor & Tversky, 1992, 1996). Most route directions can therefore be expected to include a rich set of descriptive components (descriptions of scenes, objects, topological relationships between objects, relationships between objects and the moving agent).

In order to generate route directions, a speaker will have to refer to three types of entities. The first entities to be referred to are those on which the moves are executed, such as streets or roads. These entities have a two-dimensional extension. They can be described in terms of strips having both a length and a width. They are usually assimilated to a linear entity, or *vector*. This vector can be specified by its type ("*street*", "*path*", "*avenue*", etc.) and, optionally, by its proper name ("*rue de Rivoli*"). Width is neglected as long as it remains within certain limits, but it may be taken into account in some situations. For instance, it may be useful to specify which sidewalk (left or right) of the Champs-Elysées to walk on, whereas this will not be crucial in a narrow street.

The second set of entities to be referred to are *points* on these vectors, used to signal the position of a landmark, or the place where reorientation should occur. A variety of linguistic expressions can be used to signal these points, or small regions assimilated to points. Examples include "*at the end of the street*", "*at the top of the stairs*", "*by the*

middle of the street", "*halfway*", "*at 200 meters*", "*at number 28*". Such points have a metric value in a system of coordinates. They are conceptually distinct from objects that may be located at those points.

The third set of entities to be described are precisely the *objects* that are found along the vectors. They correspond to points or regions of limited size. Even if they are not strictly speaking point-like, they can be assimilated to points. They are two- or three-dimensional entities. When used in route directions, they may serve a variety of functions. The first, and probably most crucial function is to signal sites where actions, and particularly reorientations, are to be accomplished. The second function of landmarks is to help locate other landmarks, which are supposed to trigger a specific action. The third function is that of confirmation; the speaker mentions landmarks situated along the route in a context of lengthy actions, to confirm that the moving person is indeed on the right route.

There are good reasons to assume that landmarks play an important role in route directions. This is a general feature, although some individual differences have been consistently observed. For instance, it has been shown that women refer to and make use of landmarks more readily than men do (cf. Denis, 1997; Galea & Kimura, 1993). However, despite such differences, landmarks are generally considered to be key components for constructing the representations used during navigation. The two studies reported below investigated the role of landmarks as components of navigational aids in urban environments.

2. Study 1: Collecting route directions

This study involved collecting a corpus of route directions in the city of Paris. We paid special attention to the spatial distribution of the landmarks mentioned in route directions and to how often they were mentioned.

2.1. Method

After having learned a route by navigating it, the participants were invited to generate route directions. They were told that these directions should successfully guide someone who was totally unfamiliar with the environment. The same procedure was repeated for two different routes.

Routes. The two routes were located in two districts of Paris. Route 1 started from the fountain at the place Saint-Michel and ended at the Medical School, which is located in the rue des Saints-Pères. It was 1200 meters long, and included three segments (a short one, a long one, and then another short one) and it took in three streets. Two reorientations were required, at the end of the first and second segments, respectively. In the middle of the longest segment (850 meters), the route crossed a wide-open space consisting of two contiguous squares. Route 2 started from the Opera House, located in the place de la Bastille, and it ended at Victor Hugo's House, located in the place des Vosges. It was 700 meters long, and consisted of four segments. The first segment involved walking round the place de la Bastille, and the next three segments

involved three streets. Thus, three reorientations were necessary, one at the end of each of the first three segments. In a pilot study, these two routes had been generated by people living in these districts as the best routes between the starting points and destinations.

Participants. The participants were 10 women and 10 men, 18-50 years in age. They were recruited from amongst the general population, and were paid for taking part. We confirmed that they were unfamiliar with the environments studied.

Procedure. The participants were tested individually. For each route, the learning phase consisted of two stages. First, the participant was guided by the investigator along the route to be learned, and was instructed to pay attention to all aspects that would allow him/her to give adequate route directions later to someone else. After reaching the destination point, the participant was brought back to the starting point by another route, without walking back along any section of the original route. Back at the starting point, the participant was asked to follow the same route to the destination point again, while being monitored by the investigator. At the destination point, the participant was required to give directions for the route he/she had just learned. These directions were tape-recorded. The procedure was the same for the second route. The order in which the two routes were learned was balanced amongst the participants.

Elaboration of data. The route directions collected were transcribed, and revealed considerable variability in terms of length and content. Each individual set of instructions, or protocol, was formatted as a set of minimal units of information, according to the method developed by Denis (1997). For example, the sentence "*You come to a boulevard lined by plane trees that you have to cross*" was considered to be composed of three units: "*You come to a boulevard*", "*The boulevard is lined by plane trees*", and "*You have to cross the boulevard*". The list of landmarks mentioned by each participant for each route was established. We classified the landmarks into two broad categories: on the one hand, public thoroughfares, such as streets, boulevards, and squares, which we called 2D landmarks since they are essentially two-dimensional, and, on the other hand, the buildings, shops, statues, public gardens, etc., which we characterized as 3D landmarks.

2.2. Results

Number of landmarks. Although the two routes differed in terms of layout, length, and landmarks, a correlation of $r\ (18) = 0.61$, $p < .005$, was found between the number of landmarks (both types considered) mentioned for the two routes. For the 2D landmarks, this correlation was $r\ (18) = 0.42$, $p < .07$, and for the 3D landmarks it was $r\ (18) = 0.56$, $p < .02$. The participants who mentioned more landmarks for one route also seemed likely to mention more landmarks for the other route. No significant correlation was found between the numbers of 2D and 3D landmarks mentioned for Route 1, $r\ (18) = 0.29$, or Route 2, $r\ (18) = 0.11$. This supported the view that the two categories of landmarks serve distinct functions in route directions. The mean number and standard deviation of both types of landmarks mentioned in route directions are shown in Table 1.

Directions for the two routes included fairly similar numbers of each type of landmarks. This was to be expected for the 2D landmarks. The two routes did differ from each other, but both included roughly similar numbers of streets and squares. This finding was more surprising for the 3D landmarks, as the series of buildings, shops, public gardens, and other items encountered along the two routes was unique to each route. This finding supports the idea that the similarities of route structures elicited similar needs for detailed explanations. Similar numbers of difficulties along the two routes (mainly changes in direction) may have induced this recourse to similar numbers of clues (mainly landmarks) when giving directions. An alternative hypothesis, although not one directly tested here, is that there is an optimum amount of information to be included in any route directions, irrespective of their length or complexity, which is essentially constrained by the limits of the processing capacities of people listening to directions (cf. Denis et al., 2001).

Table 1. Mean numbers of 2D and 3D landmarks for each route.

	2D landmarks	3D landmarks
Route 1	4.5 (1.70)	6.8 (3.04)
Route 2	5.0 (2.19)	6.7 (2.89)
Both routes	4.7 (1.95)	6.8 (2.92)

We calculated how many landmarks were reported by women and men respectively. Overall, women tended to mention more 2D landmarks than men, whereas there was no difference between the genders in referring to 3D landmarks.

Distribution of the landmarks. The spatial distributions of the landmarks mentioned by the participants for Routes 1 and 2 are shown in Figures 1 and 2, respectively. The figures show all the landmarks reported by the participants as a whole.

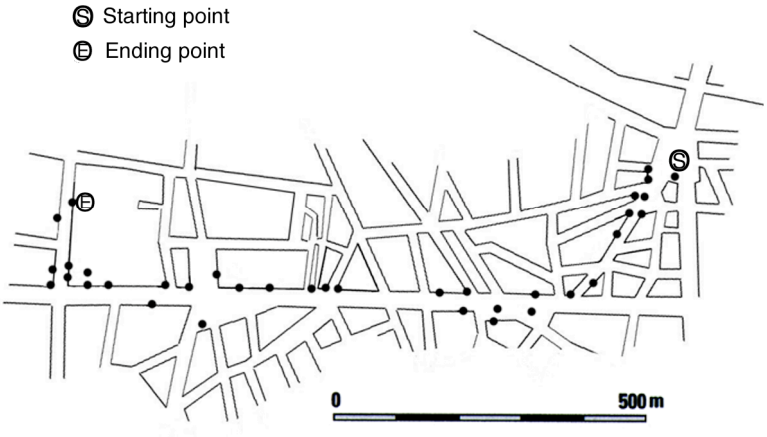

Figure 1. Spatial distribution of landmarks on Route 1.

A total of 34 different landmarks were mentioned on Route 1, and 28 on Route 2. These numbers are quite low if one considers the virtually infinite number of potential landmarks that can be seen along these routes, as in any downtown urban environment.

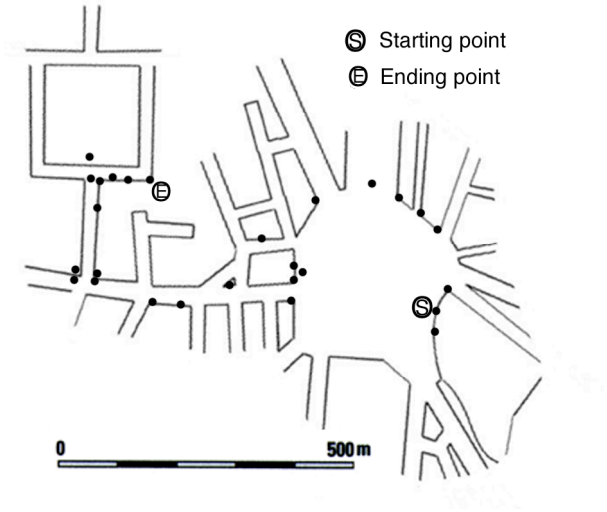

Figure 2. Spatial distribution of landmarks on Route 2.

On each route, the landmarks seemed to be spread along the whole route. This apparently random spatial distribution is compatible with the assumption that landmarks are simply used as beacons along the routes. According to this view, pedestrians simply progress along a route by directing themselves towards a landmark. When they reach that landmark, they then direct themselves towards the next one they can see, and so on until they reach their destination. In short, landmarks are essentially used in directions as sub-goals along the route (cf. Allen, 2000). However, the frequencies with which landmarks are mentioned reveals differences that forces us to consider another interpretation of their role.

Frequency with which landmarks were mentioned. Figures 3 and 4 show the same data as the previous figures, but the frequency with which the landmarks were mentioned is reflected by the size of the corresponding circles. This presentation reveals major differences in the frequency with which landmarks were mentioned at different points along the routes.

Higher density references to landmarks correspond to locations of several types. Firstly, and unsurprisingly, large numbers of landmarks were mentioned around the starting point. Similarly, at the other end of the route, the frequency with which landmarks were mentioned increased in the vicinity of the arrival point. In between, points where a change in direction was called for elicited numerous mentions of landmarks. This was also the case for some points, especially along long segments,

where wide-open spaces resulting from major street intersections or squares may have been identified by describers as places where errors were likely to occur. This elicited increased reference to landmarks, even though no change in direction was called for at this intersection. Points where a change in direction was required or could be made by accident were also treated by describers as critical nodes calling for a more elaborate description.

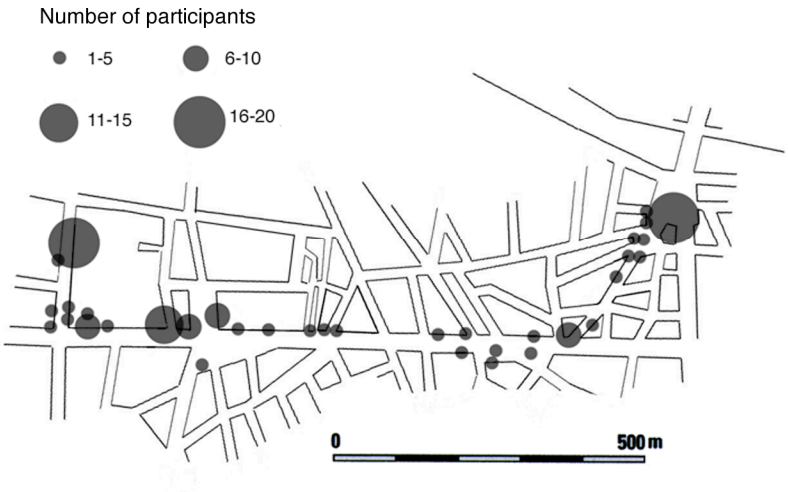

Figure 3. Frequency of landmarks mentioned along Route 1.

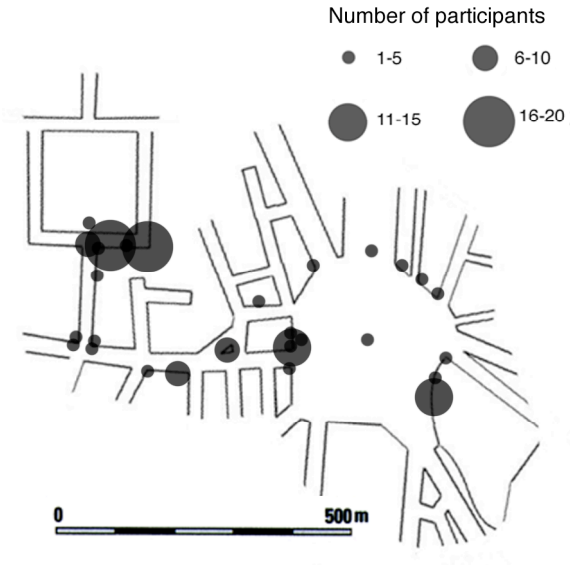

Figure 4. Frequency of landmarks mentioned along Route 2.

In order to test the relationship between the mentioning of a landmark and its location relative to crucial nodes, we computed the correlations between the frequency with which landmarks were mentioned and the distance separating them from the nearest node. For the 34 landmarks on Route 1, a correlation coefficient of $r(32) = -.40$, $p < .01$, was found. When the analysis was limited to the 21 landmarks along the second segment (boulevard Saint-Germain), the coefficient was $r(19) = -.47$, $p < .05$. A similar pattern was found for the 28 landmarks on Route 2, although the resulting correlation coefficient remained below the level of significance, $r(26) = -.35$. Landmarks were therefore more likely to be mentioned when they were closer to a node. This implies that the participants describing the routes were sensitive to the need for information people experience when they approach critical nodes along a route (cf. Golding, Graesser, & Hauselt, 1996).

2.3. Discussion

This study reveals a major function of landmarks in route directions. The spatial distribution of landmarks and the frequency with which they are mentioned are closely related to specific regions along a route. In particular, landmarks are more likely to be mentioned when they are close to critical nodes. This finding supports the idea that people giving directions spontaneously stress those parts of their discourse that are related to segments of routes where special difficulty will be encountered. They anticipate the potential difficulty pedestrians will experience in trying to find their way by introducing local descriptions of the route, which are expected to help them construct a detailed representation of the environment. Our study also supports the assumption that information is needed by a pedestrian not only at points where actual changes in direction must occur, but also at points where several possible directions could be followed (cf. Allen, 2000).

3. Study 2: Collecting suggestions of how to improve route directions

Study 1 provided clear evidence that landmarks play a special role in route directions by signaling the portions of a route to which people following them should pay special attention. However, this evidence is rather indirect, since it is inferred from an analysis of the verbal directions produced. More direct evidence was expected from the next study, involving the collection of explicit statements from people attempting to follow the route about what information they felt to be of primary importance in route directions.

3.1. Method

People were invited to walk along routes with the help of quite minimal navigational instructions. The instructions only contained procedural statements referring to the names of the ways to walk along and the directions to take (such as "*Take the rue Saint-Antoine on your right*"). Participants were invited to express their perceived difficulties as they followed the route, and in particular to identify any gaps in the

directions they had received. They were also invited to reformulate the directions by introducing their own corrections or revisions.

Routes. The two routes were the same as those used in Study 1.

Participants. The participants were 10 women and 10 men, between 18-50 years of age. None of them had participated in Study 1. They were recruited from amongst the general population, and were paid for taking part. They were unfamiliar with the two routes.

Procedure. The participants were tested individually on each route. They were equipped with small microphone and tape recorder. Before they set out to follow the route, they were given a minimal set of written instructions, consisting of a simple series of instructions of the type "*Take Street X on the left/right*", and ending with "*Arrival point at Number Y of Street Z*". The participants were invited to provide their comments and suggestions *in situ*, as they followed the route. What they said was tape-recorded as they progressed, and the investigator invited them to reformulate any instruction they found inadequate.

Elaboration of data. After transcribing the individual protocols, we listed the problems reported by the participants, as well as the solutions they proposed (involving correcting the original instructions or adding new ones). Some participants recommended solutions without necessarily making explicit the problem they had identified. There were also some participants who proposed several solutions for the same problem.

3.2. Results

On both routes, participants reported experiencing problems due to the extremely concise directions they were given. Table 2 lists the problems mentioned by the participants while they were proceeding along Route 1, and the solutions they proposed to improve the directions. For each problem mentioned, the number of participants who suggested a solution referring to a 3D landmark is shown in bold type.

The beginning of the route appeared to be the most challenging part of the route, as it was mentioned as a problem by all but one of the participants. This was to be expected as to set out requires that the first direction to be followed must be specified, and this cannot be done in terms of any previous orientation. Thus, the first segment cannot be located in terms of "*to your right/left*", since the pedestrian is not yet facing in any specific direction. The solution preferred by the majority of participants was to use a landmark located near to the street they were to take. Participants varied quite a lot in the specific landmark that they referred to, but all of them used a 3D landmark located at one corner of the street, thus clearly marking the beginning of the segment. Some 2D entities (a square or the Seine river) were also used to help locate the first segment, but fewer participants used them.

Table 2. Problems and solutions verbalized by participants along Route 1.

Starting Point		
Problem		
Locating the first segment	19	
Recommended solutions		
Locate the first segment relative to a fountain/bookshop/café		**16**
Locate the first segment relative to a nearby square		5
Locate the first segment relative to the Seine river		2
Describe the configuration of the square		1
First Segment		
(No problem mentioned)		
Second Segment		
Problem		
Locating the beginning of the third segment	18	
Recommended solutions		
Indicate the length of the second segment (in distance or time)		13
Indicate that one has to pass a church/café/subway station/bank		**10**
Indicate how many streets to go past		5
Indicate that the third segment is located just after a public garden		**2**
Indicate that one has to pass a square		1
Indicate the names of the streets to be crossed		1
Indicate street numbers at reorientation points		1
Third Segment		
Problem		
Locating the end point	1	
Recommended solution		
Indicate that the street numbers on the two sides do not match		1
Whole Route		
Problem		
Locating the reorientation points	3	
Recommended solutions		
Indicate the total length of the route		2
Indicate the length of each segment		1
Use landmarks instead of street names		**1**
Locate streets relative to conspicuous permanent points		**1**

The next major problem was related to the second segment, a long segment containing a critical point. Many of the participants said that the directions should have described the spatial extension of this segment, either by making its length explicit (in terms of distance or time), or by mentioning a 3D landmark to be passed or to be located just before the reorientation point. Some instructions using 2D landmarks were also introduced, referring to the names or numbers of streets to go past.

Table 3 shows the problems and solutions verbalized by the participants while proceeding along Route 2. Inspection of the data confirms the special informational value the participants attributed to visual landmarks.

Table 3. Problems and solutions verbalized by participants along Route 2.

Starting Point		
Problem		
Proceeding towards the second segment	11	
Recommended solutions		
Locate the second segment relative to a monument at the center of the square		**7**
Locate the second segment relative to the starting point (Opera House)		**5**
First Segment		
Problem		
Locating the beginning of the second segment	13	
Recommended solutions		
Locate the second segment relative to a monument/restaurant/ bank/café/kiosk		**11**
Locate the second segment relative to the starting point (Opera House on the opposite side of the square)		**10**
Indicate the number or names of the streets to be passed		7
Indicate that one has to walk past a restaurant		**2**
Locate the second segment relative to a landmark at a street corner		**1**
Second Segment		
Problem		
Locating the beginning of the third segment	6	
Recommended solutions		
Indicate the length of the second segment		4
Indicate the number of streets to be passed		4
Indicate that one has to pass a monument		**1**
Third Segment		
(No problem mentioned)		
Fourth Segment		
(No problem mentioned)		
Recommended solution		
Indicate the length of the segment		1
Whole Route		
(No problem mentioned)		
Recommended solution		
Indicate the total length of the route		1

Initiating progression and proceeding along the first segment were reported as difficult by participants, and most of them mentioned that the directions were not detailed enough at the starting point and along the first segment. Participants mentioned the difficulty of locating the beginning of the second segment, a street

leading off from the square. Although this street would have been encountered eventually by simply walking around the square, participants mentioned it would have been easier if they could have identified this street with the help of a visible landmark before starting to move. For the wide-open space that offered many possible directions to take, most solutions referred to 3D landmarks. Despite the large number of streets surrounding the square, only a few of the recommended solutions referred to streets.

The second major problem concerned the change in direction to be made between the second and the third segments. Here, the participants generally favored a reference to the length of the segment or to the number of streets to be passed. The virtual absence of reference to landmarks is interpreted as resulting from the fact that there were no clearly distinctive landmarks and this may have induced the describers to prefer other strategies to any reference to landmarks in giving directions.

3.3. Discussion

The results of Study 2 confirmed the importance of descriptive components, namely landmarks, in route directions to allow a pedestrian to anticipate local difficulties when finding his/her way. These descriptive components are introduced to allow the users of directions to construct an anticipatory visual representation — albeit a very sketchy one — of the places where difficulties are likely to occur. The visual content of this representation is substantiated by the landmarks mentioned, buildings and monuments, that are immediately perceptible to a pedestrian looking around the environment. Streets are also sometimes referred to in these descriptive parts of directions. But they are less distinctive, and their names can only be seen by moving and looking for signs. Consequently, streets are often cited in terms of roads to cross or go past, with rank order being given relative to the street eventually to be taken. This type of description requires maintaining a global representation of the route throughout and sustained attention to what has been passed and what remains to be passed. Such a strategy may not be ideally suited to a prolonged and complex type of behavior, such as following a route.

4. Conclusions

Our findings confirm that route directions spontaneously tend to include numerous references to landmarks. Furthermore, when confronted by directions restricted to a list of street names and left/right turns, people react to the absence of landmarks. Their suggestions for improving the directions call for the inclusion of landmarks. Landmarks may serve several distinct functions, such as signaling where a crucial action should take place, helping to locate another less visible landmark, or confirming to a pedestrian that he/she is still on the right way. In any case, the general function of landmarks is to provide information about important maneuvers to perform (or not to perform) at points in a route where changes in direction are likely to occur. Landmarks also contribute to creating a visual model of critical parts of an environment, as seen from a route perspective, which prepares the moving agent to react appropriately to situations involving a decision.

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