Ask for directions or use a map: A field experiment on spatial orientation and wayfinding in an urban environment

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ABSTRACT

When planning a route we usually study a map, ask other people for verbal directions, or use a route planner. Which source of information is most helpful? This experiment investigated human wayfinding and knowledge acquisition in urban environments. Participants were required to retrace two different routes learned either from route maps, or from verbal directions. We show that both maps and verbal directions are equally useful tools for conveying wayfinding knowledge. Even the survey knowledge of map-learners was not better. We argue that both verbal directions and maps are memorized in a language-based format, which is mainly used for wayfinding.

Keywords: wayfinding, map, verbal direction, route knowledge, survey knowledge, field experiment

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INTRODUCTION

Imagine walking through a foreign city. The crowd carries you until it starts getting dark. Then you are planning to go back to the hotel and you immediately notice that you do not remember at all which way you came. You are lost! There are basically two possibilities for how to find the way back to your hotel: by asking somebody for the way or by using a map. But which is better? The goal of the present study is to answer this question and at the same time to explore how wayfinding knowledge is represented in human memory.

The starting point of our study was that the acquisition and representation of wayfinding knowledge is usually studied either by the direct experience of the actual environment or it is studied by learning from maps or texts (e.g. Moeser, 1988; Richardson *et al*., 1999; Taylor and Tversky, 1992; Thorndyke and Hayes-Roth, 1982). In such studies, the individuals navigate through a real or virtual environment and then different performance measures are analysed. In daily life, however, before we start our journey we usually plan the route by studying a map, asking other people, or – more recently – using a route planner, for instance, from the web. What happens if individuals acquire their initial knowledge from such *indirect* sources of information and then have to find their way through the real environment? Which source of information is more helpful when finding our way? And if one of the information sources is considered to be more helpful, does that apply to all sorts of routes?

In the following, we report a field-experiment in an urban environment in which participants learned two different routes, either from route maps, or from verbal directions, before walking a route. In a number of post-tests, we then investigated how the routes were represented in memory. Here we refer to the distinction between route knowledge and survey knowledge. Route knowledge describes the path that one must walk to reach the goal by telling the individual what to do at the decision points on the route, e.g. turn right at the church, then the second street to the left. It is one-dimensional or *string-like* and it does not necessarily involve the knowledge of the exact location of the goal. Survey knowledge, on the other hand, tells you in which direction and distance a location is to be found independent from knowing a path which leads you there, e.g. the train station is about 300 metres east from here. It is two-dimensional or *map-like*. (e.g. Golledge, 1990, 1999; Herrmann *et al*., 1998; Kitchin and Freundschuh, 2000; Montello *et al*., 2004; Siegel and White, 1975). We discuss our results in relation to other accounts of human wayfinding and draw some general conclusions about wayfinding, verbal directions, maps, and the representation of wayfinding knowledge in memory.

METHOD

Participants

The experiment took place in Tübingen and the participants were recruited in Freiburg. The cities are about 200 kilometres away from each other. To ensure participants had never been to Tübingen before, we presented 35 volunteers with a list of four cities in the south of Germany. They had to mark all cities to which they had been before. From this sample we selected twelve participants who never had been to Tübingen before. Half of the participants were female and half were male. They were students from the University of Freiburg between 20 and 31 (M = 24; SD = 3.3). They were all German native speakers and they were paid €50 for their participation. They were transported by bus, from Freiburg to Tübingen, on the morning of the study and were taken back to Freiburg in the evening.

Material and Design

A map of the city centre of Tübingen in which the experiment took place is presented in Figure 1. We systematically varied *route length* (short vs. long) and *source of information* (map vs. directions).

The *route length* was varied in order to test the memory components of wayfinding with maps and verbal directions. The short route was 320 metres long and had 9, almost orthogonal, intersections with 21 alternatives. The long route was 480 metres long, had 10 intersections, 23 alternatives, and most intersections were at oblique angles. We had the intuition that the visual input from the environment might interfere more strongly with knowledge acquired from maps than with knowledge acquired from verbal directions. If so, then the interference on the longer route should be more prolonged than on the short route and thus navigation performance on the long route should be worse. Under the verbal directions condition no such difference should be found.

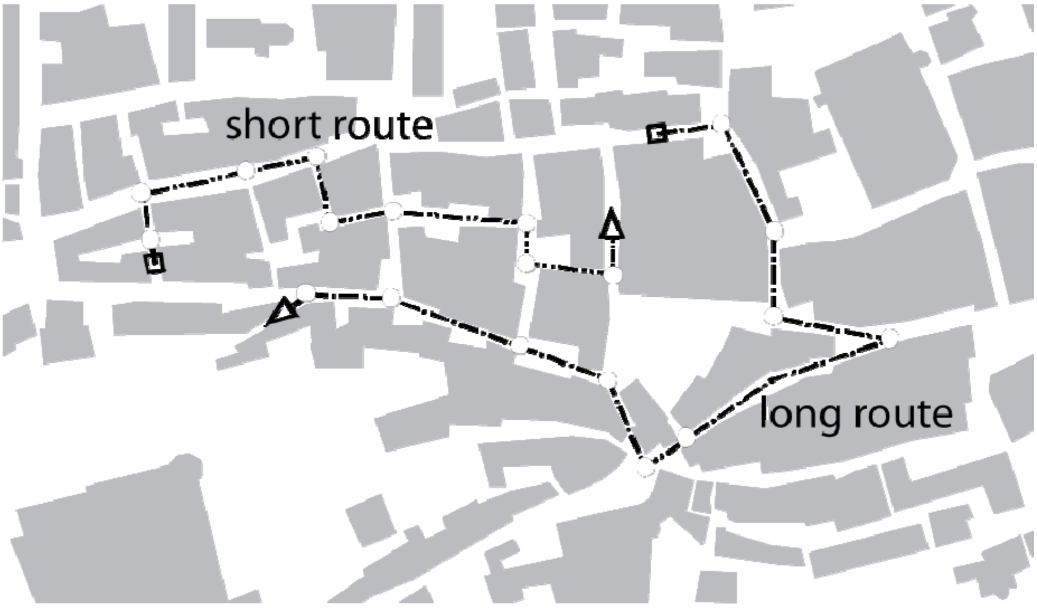
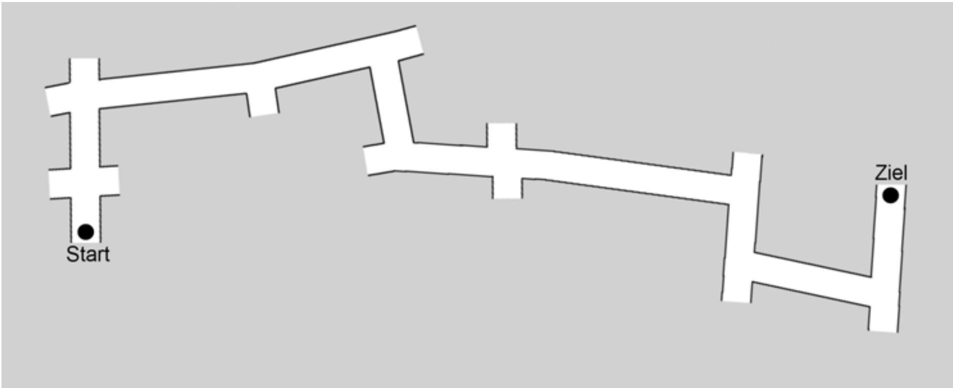


Figure 1. *A map of the area the experiment took place and the two routes. Circles correspond to intersections.*

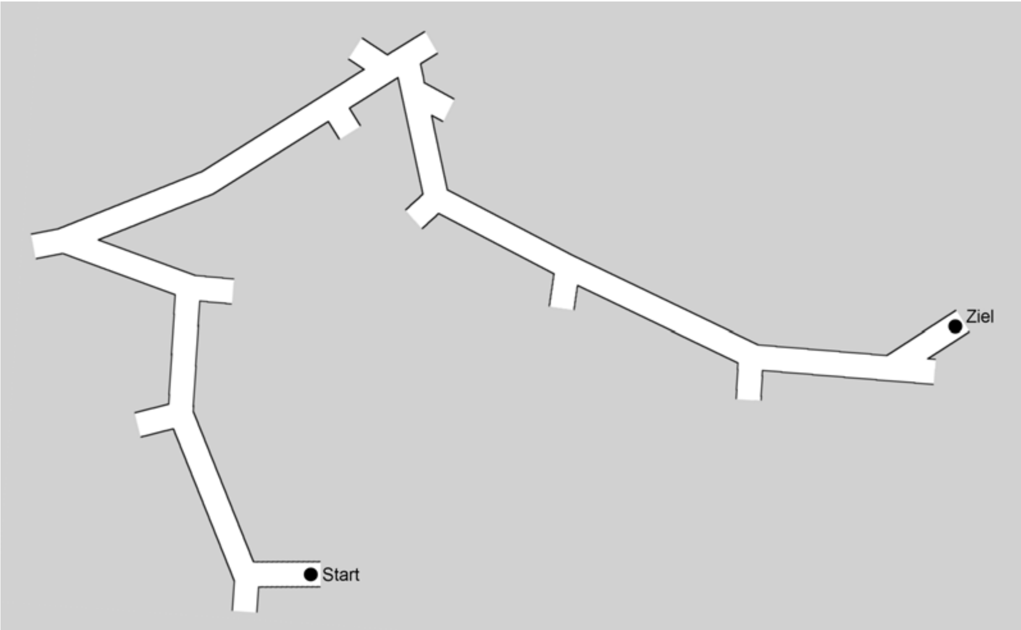
In the *map-condition*, the participants received a route map that a professional geographer constructed on the basis of official maps (Figure 2). This route map exclusively communicated the topographically correct layout of this specific route without other geographical (e.g. house corners) or further features (e.g. landmarks, street names, surrounding environment). Accordingly, all streets on the maps were drawn with the same width. In this way the information provided by the map was maximally concordant with the information from the verbal directions. The size of the paper sheet with the map was A4.

In the *directions-condition*, participants received the instructions as written sentences on a paper of the same size. Again our goal was to provide the same information with the direction and the maps. Thus, the sentential directions were determined in a pilot study following a shortened version of the *skeletal description* introduced by Denis (1997). A different sample of six female and six male volunteers generated verbal directions based on the maps. The persons were not familiar with Tübingen. These verbal directions were recorded and typed on paper. Descriptions were analysed for how often units of information were mentioned. If a unit of information was mentioned by at least seven out of twelve participants then this was used in the directions. This criterion was agreed on by two independent raters. To ensure unambiguity three further units of information also mentioned in the descriptions were added on the long route (e.g. turn *sharp* right). Two examples of an original direction are presented in the Appendix. The maps for the short and the long route and the corresponding directions are shown in Figure 2a and Figure 2b, respectively.



Go straight on.
Turn right at the 2nd intersection.
Turn right again at the 2nd intersection.
Then left.
Then the 2nd to the right.
Turn left the 1st.
Left again.
Here is your goal.

Figure 2a. *The map of the short route and the corresponding verbal directions translated into English.*



Go straight on.
Take the first right.
Straight on until it is not possible to do so any more.
Then turn left.
Then turn sharp right at the next opportunity.
Go straight on.
There is a crossroad to the right.
Do not take this one, but the 2nd intersection sharp right.
Go straight on and turn half left.
Go straight past 2 streets on the right.
On the 1st intersection turn half left.
Here is your goal.

Figure 2b. *The map of the long route and the corresponding verbal directions translated into English.*

Procedure

The experiment followed a mixed 2 (routes) x 2 (group) design. Half of the participants got the map on the short route and the directions on the long route. The other half of participants got the map on the long route and the directions on the short. This particular design was chosen to provide higher power in the direct comparison between map and directions as this is a within subjects comparison in our design. This comparison is indicated in the interaction between the factors route and group, whereas a main effect group would indicate that maps and verbal directions work differently on the two routes. The order of routes was controlled. However, due to the number of participants and the mixed design, no interactions between order and the other factors could be analyzed.

Each participant was tested individually. They waited for the experiment in a university room, were escorted to one of the starting points blindfolded, and then turned around to minimize prior orientation. Then the participants were given three minutes to study the maps or the verbal descriptions. After the three minutes they had to answer a control question. If they were not able to answer this question they had two additional minutes study time. It is important to notice that the maps or the directions were taken away after the study phase so that the participants had to keep in mind and to maintain the acquired information in memory.

Then the participants were requested to walk from the start to the destination point (Figure 2). The performance measures were recorded by the experimenter or one of the two assistants. The recorder followed the participant with a distance of about five metres and recorded:

- the time to reach the goal,
- the number of stops,
- how often the participant got lost, i.e. entered a wrong street for five meters, and
- how often the participant asked the experimenter for help (the participants were not allowed to ask other people on the street)

During learning the map participants were instructed that they were not allowed to use the maps or instructions again.. When the participants had reached the goal they were blindfolded again and then taken to the second starting point. Here the same procedure was used. To avoid learning- or ordering effects, the order of conditions and routes was counterbalanced, as were the experimenters and the gender of the participants. A snapshot of one experimental situation is presented in Figure 3.

Figure 3. *A participant walking the route followed by an experimenter recording the dependant measures.*

After the main experiment, the participants were asked to perform a series of post-tests. First, a set of tests was used to measure if the participants had acquired *survey knowledge.* A second set to measure their *route knowledge*. At last, they filled in a questionnaire about the strategies they applied to solve the navigation tasks e.g. *During memorising the map, did you memorise it as directions e.g. 'the 2nd street to the right'?* or *Did you try to walk directly into the direction you assumed the goal or a subgoal?*

To measure *survey knowledge* three different tests were conducted.

In a *pointing task*, the participants stood at the goal. Here they were asked to point with the index finger in the direction of the starting point and mention an object in this direction e.g. the left end of the 2nd window. The experimenter marked the direction in a 360° picture (Figure 4) and then the angle between where the participants pointed to and the target location was calculated.

The *distance estimation task* also was conducted at the goal. The participants were asked to mark the straight-line distance to the starting point on a visual analogues scale (Figure 4). In order to get an idea of distances on the scale two anchor distances were indicated. The anchors were two objects in the visible environment e.g. a corner of a house. This anchor was marked on a photograph and the corresponding distance indicated on the scale. So the participants saw the distance to this corner of the house and they could see how this related to the distance marked on the scale. Two objects in opposite directions from the goal point at distances of 22 and 48 metres were used for each of the two routes.

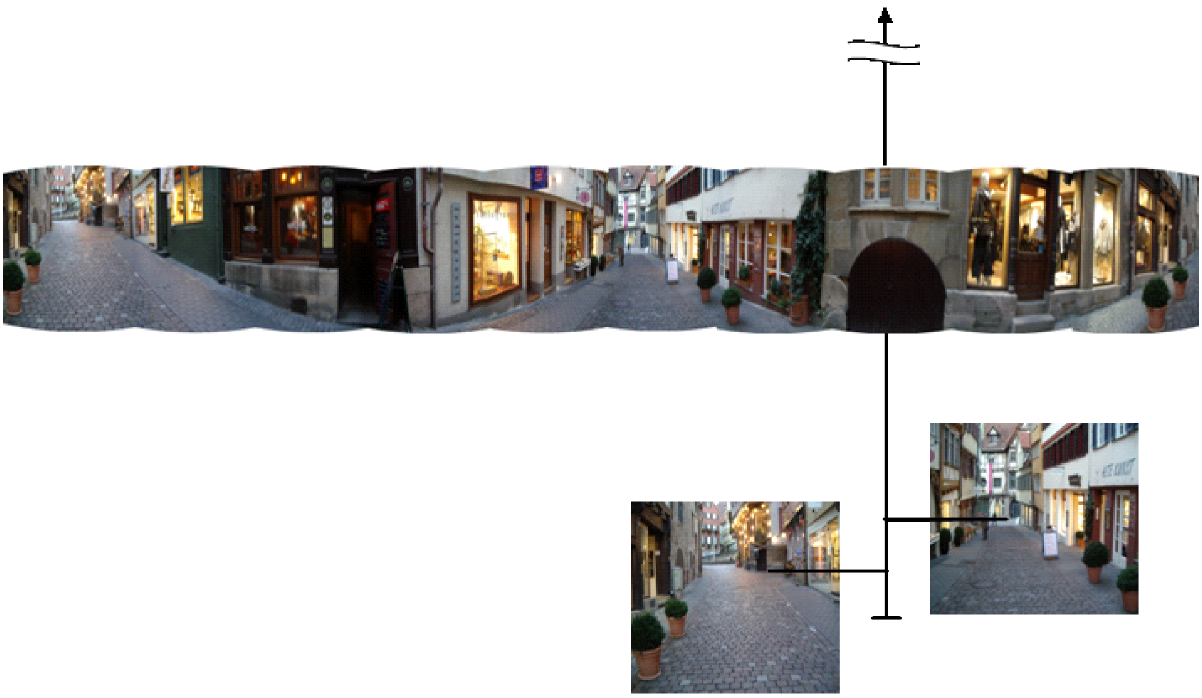


Figure 4. *Material used for the pointing task to measure survey knowledge from a horizontal perspective. In front the 360°-picture was used for marking the direction of the start from the goal. In the background the scale was used for estimating the straight-line distance of the start with two visible anchors.*

In a *marking task,* the participants were back in the waiting room and had to mark the starting points of a route on a map only showing the goal area of the route (Figure 5). From this, first, the angle between the direction where the participants marked the starting point and the actual direction of the starting was calculated. Second, the marked distance between start and goal point was measured and compared to the correct distance. Contrary to the pointing and distance estimation task, the marking task could not be solved based on path integration only.

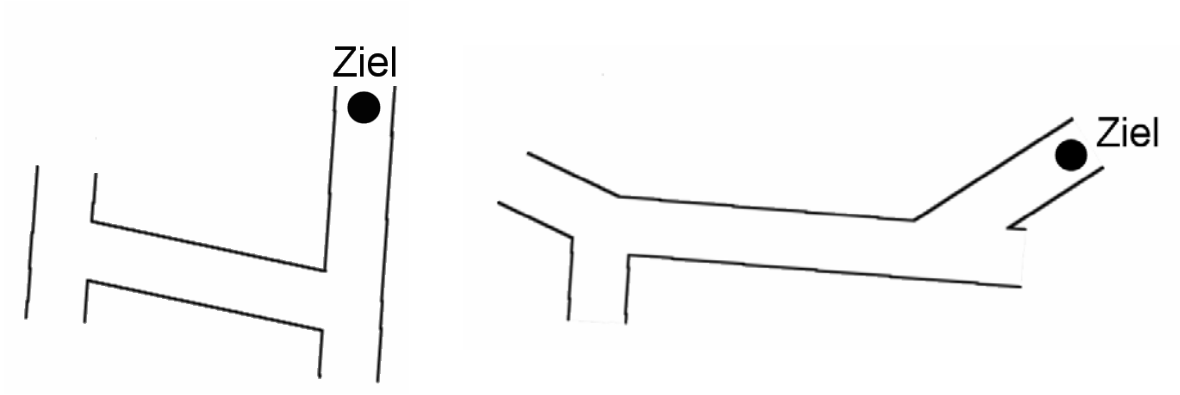


Figure 5. *The goal areas of the short (left) and long route (right) the participants used to mark the start points.*

To measure *route knowledge* two different tasks were used.

In a *drawing task*, the participants had to draw the routes. This was done after marking the start point in a map of the goal region. The participants had to draw the missing route and the drawn turning points were counted. The number of deviations from the six required turns was counted as errors.

Additionally the participants were asked to give *verbal directions*. Like in the drawing task errors in number of turns mentioned were taken as the dependent variable.

RESULTS

Wayfinding Performance

The findings reported in this section are mainly based on nonparametric statistical tests. Such tests are appropriate for assessing the significance of differences in data when the assumptions of normal distribution and homogeneity of variances are violated (Siegel and Castellan, 1988). For statistical decisions, an alpha level of 0.05 was adopted.

The performance of the participants as a function of route length is presented in Table 1. On the long route the participants walked longer (Wilcoxon Test, $Z = 3.06$, $p = .002$), made more stops ($Z = 2.99$, $p = .003$), got lost more often ($Z = 2.17$, $p = .030$) and needed further instructions more often ($Z = 2.12$, $p = .034$).

Table 1. *Wayfinding Performance on the Short and the Long Route*

	Short route		Long route	
	M	*SD*	*M*	*SD*
Time [min]	3	0.5	6.5	0.9
Stops	0.3	0.5	1.8	1
Got lost	0.6	0.9	1.3	1
Needed instructions	0.1	0.3	0.6	0.7

The performance as a function of map-learning and direction-learning is presented in Table 2. The data show that under both conditions the performance was almost identical. Map-learners and direction-learners needed about the same time to walk the two routes ($Z = 0.78$, $p = 0.433$), they stopped equally often ($Z = 0.59$, $p = 0.555$), they got lost equally often ($Z = 0.29$, $p = 0.773$), and they asked the experimenter for help equally often ($Z = 0.0$, $p = 1$). The performance with maps and directions was not significantly different on the two routes (four U-tests on two routes; all eight $Z < 1.64$, $p > .10$).

Table 2. *Wayfinding Performance for Map and Verbal Directions*

	Map		Directions	
	M	*SD*	*M*	*SD*
Time [min]	5.3	1.8	4.9	1.6
Stops	1.3	1.4	0.9	0.8
Got lost	0.9	1,1	1	1
Needed instructions	0.3	0.7	0.3	0.5

Route and Survey Knowledge

In the post test the variability in direction estimation was compared with F-Tests. Values deviating more than two standard deviations from the overall mean were replaced by the most extreme value within two standard deviations. The rest of the data were analysed with non-parametric tests.

The pointing task, the distance estimation task, and the marking task, measured survey knowledge.

Pointing task. Participants with maps and verbal directions did not differ in their performance of pointing from the goal to the start (Table 3; systematic error expressed by mean deviations: U-Test short route: $Z = 0.481$, $p = 0.630$; long route $Z = 1.04$, $p = 0.296$; unsystematic error expressed by standard deviations: $F(11, 11) = 1.02$, $p > .25$).

Distance estimation task. There was also no difference in the distance errors between map-learners and direction-learners (Table 3; deviation of estimated distance to correct distance. U-Test short route $Z = 0.641$, $p = 0.522$; long route $Z = 0.641$, $p = 0.522$).

Marking task. There was no difference in the systematic error expressed by mean deviations (U-Test short route $Z = 1.20$, $p = 0.229$; long route $Z = 1.69$, $p = 0.091$). However, map-learners were more accurate in estimating the direction of the starting point which is shown by their lower standard deviation, a measure for the unsystematic error (Table 3; $F(11, 11) =$

3.80, $p < 0.05$). Map-learners overestimated the distance (Binomial Test: 2 underestimations vs. 10 overestimations $p = 0.039$) which was not the case in direction-learners (Binomial Test: 5 underestimations vs. 7 overestimations $p = 0.774$).

Table 3. *Errors in Pointing, Direction Estimation and Marking*

	Map		Directions	
	M	*SD*	*M*	*SD*
Pointing and distance estimation				
Direction error [°]	12	35	13	48
Distance error [m]	76	81	76	78
Marking task				
Direction error [°]	15	20	5	49
Distance error [m]	48	57	-4	64

Note. For pointing and distance estimation the participants stood at the goal point. For the marking task the participants marked the start point in a map which displayed the goal area. Positive numbers indicate pointing to the left in direction error and an overestimation in distance error.

Route knowledge was measured in a drawing task and in giving directions.

Drawing task. There was no main effect of route length on errors in drawing turns ($\chi^2(1, N = 17) = 2.88$, $p = 0.089$), and no difference between map-learners and direction-learners (Table 4; $\chi^2(1, N = 17) = 0.059$, $p = 0.808$). No interaction was revealed ($\chi^2(1, N = 17) = 0.142$, $p = 0.707$).

Giving directions. The participants were very precise in giving directions. In the number of required turns just seven errors were committed altogether (Table 4). Due to the small number, the errors were not analysed further with regard to source of information or route. Comparing them to the drawing task the participants made less errors in giving verbal directions compared to drawing a route with respect to necessary intersections to turn at ($\chi^2(1, N = 24) = 4.17$, $p = 0.041$).

Table 4. *Errors in Drawing Turns and in Mentioning Turns when Giving Directions*

	Map	Directions	Sum
Drawing Turns	9	8	17
Giving Directions	5	2	7

Questionnaire

Although asking participants for their strategies has severe limitations, it can provide some clues as to how the participants used the maps and directions in navigation (or at least think that they did). Two aspects were important here. First, all participants reported having translated the map into directions during memorising the map. Second, when using the map three participants reported orienting on the direction they assumed the goal or a subgoal was and trying to walk in this direction rather than orientating on the course of the route. The latter navigation strategy was correlated with bad performance: participants got lost more often ($N = 12$; $r = 0.84$, $p = 0.001$) and needed the instructions more often ($N = 12$; $r = .78$, $p = 0.003$).

DISCUSSION

We conducted a field experiment on human navigation under highly realistic conditions. Our starting point was that in many related studies the acquisition and representation of spatial knowledge has been studied via direct experience of an environment. Still, in daily life, we first ask someone for directions, search for an appropriate route in a map or more recently, look for route-maps and directions in the WWW. So the knowledge we acquire by that, originates from the *indirect* instructions *and* from the *direct* experience of the environment. The present study was designed to resemble this *natural* wayfinding situation.

The most important finding was that maps and verbal directions seem to be equally useful tools for conveying wayfinding knowledge. There was no main effect of the source of information. Many theorists would have predicted such a difference because there might be a general advantage for depictions (Larkin and Simon, 1987; Freksa, 1999; Paivio, 1971; 1986). The obvious explanation is that the null-difference is simply due to the small sample size. In fact, for the effect sizes observed in our experiment we would have needed more than ten times as many participants to obtain significant results in an independent t-test, for getting lost even more than 100 times as many. We do not think that the lack of power explains our null-effect. In fact, our finding is in accordance with other studies which also did not find a difference between maps and directions in terms of time and errors (Schlender *et al*., 2000; Pazzaglia and De Beni, 2001). According to Schlender *et al.* (2000) equal performance levels indicate that wayfinders waive the advantages of a map by mentally rotating the map to align it with the environment that is ensuring that *up* in the map matches *forward* in the environment (e.g. Klippel *et al*., 2006; Levine *et al*., 1982; Rossano and Warren, 1989). Another possible reason is that depictions force the participants to store spatial information that might be irrelevant if they reach the corresponding location during navigation. The need of maintaining all spatial relations from the map in memory might waste cognitive resources and, thus, waive advantages of maps. Verbal directions, in contrast, are certainly useful, but their convenience highly depends on their quality. As everybody knows some verbal directions are not helpful at all. However, in our study we used a shortened version of the method of *skeletal description* to generate an *optimal* description of the route. In several publications, Denis and colleagues have demonstrated that such skeletal descriptions are a very efficient way to describe a route (Denis, 1997; Denis and Briffault, 1997; Denis *et al*., 1999).

A third explanation might be that our maps and verbal directions differed from the one that we typically encounter in daily life. For example, verbal directions usually refer to landmarks visible in an environment (Denis, 1997) and “normal” maps usually provide much more configurational information about other streets. In our maps, the metric relations in the city were displayed correctly, but normal city maps also provide alternative routes and display side streets which could be used, e.g., to reorient after getting lost which is hardly possible with verbal directions only. As a consequence map users with more natural maps might act differently than participants in the present experiment. We cannot completely rule out this view, but overall we believe that the way we constructed the maps and formulated the directions had many advantages. In particular, an important advantage of our study is that our maps and the verbal directions provided exactly the same information. In fact, both learning conditions were “informationally equivalent” and thus fulfilled an important experimental criterion introduced by Larkin and Simon (1987).

Our explanation for the null-difference between maps and directions is that map learners might have translated the maps into verbal directions. During the learning phase they generated a string of verbal expressions, e.g. *2nd right, 2nd right, left, 2nd right, left, left* for the short route. In this way they basically had the same mental representation as the direction-learners: a description. When both groups rely on this descriptive representation for wayfinding, this explains why no difference between map and directions could be found.

Initial support for this account comes from the questionnaires in which all of our participants reported having translated the map into directions during memorising the map. However, there is also evidence for this account in our performance measures and in other experimental studies. First, in our study the participants made fewer errors in giving directions than in drawing the routes. This speaks for a language-based recoding of the maps.

Second, participants performed better on the short route. We ensured that both routes were comparable in number of turns, intersections and alternatives (cf. Best, 1970; O'Neil, 1991). Participants on the long route performed worse within the mean time needed for navigating the short route. This excludes the time for maintaining instructions in memory as an explanation. The long route, however, contained mainly oblique intersections. Oblique intersections are more difficult to express verbally than the orthogonal intersections of the short route (cf. Klippel, 2003). Therefore, our verbal description of the long route consisted of 75 words, the description for the short route of 35. Memorising more words from these directions or memorising more words from verbal re-coding of the maps, should be more error prone and, therefore, lead to worse wayfinding performance on the long route – this was exactly what we observed.

Support for the idea of language-based recoding of the maps also comes from other experimental investigations which found no differences between maps and directions (Schlender *et al*., 2000; Pazzaglia and De Beni, 2001) and from dual-task experiments. Garden *et al.* (2002) showed that a concurrent verbal task interferes with walking an unknown route and finding it immediately afterwards. Moreover, in this study the participants also reported to have relied heavily on verbal cues generated whilst learning the route. The second dual task experiment on wayfinding that supports our *verbal re-coding theory* comes from our own group. In Meilinger *et al.* (in press) we examined the working memory systems involved in human wayfinding. In a learning phase the participants learned the same routes as in the present study, now not in *real Tübingen* but in a photorealistic virtual environment simulation of Tübingen displayed on a 220° panoramic screen. While they learned the two routes they were occupied with a visual, a spatial, or a verbal secondary task. In the following wayfinding phase the participants had to find and to *virtually walk* the two routes again. In this study we showed that encoding wayfinding knowledge most strongly interfered with the verbal and the spatial secondary task, but only moderately with the visual secondary task. These results also speak against an alternative explanation in which the no-difference is due to the fact that the verbal directions are translated into a pictorial representation and so both directions and map users would rely on a pictorial representation. Obviously, this would not explain the pattern of interference in Meilinger *et al.* (in press) and it also does not explain the better performance in giving directions compared to drawing a map in the present experiment. It does not explain the introspective importance of verbal strategies in our present studies and in other related experiments (Garden *et al*., 2002; Meilinger *et al*., in press) and it also does not explain why our participants acquired almost the same route and survey knowledge under the two learning conditions. A theory of verbal re-coding can explain these findings and might provide a good starting point for additional studies on the role of language and space in human wayfinding.

Maps and verbal directions enable us to find locations never visited before – a capacity only rarely encountered in the animal kingdom. Although language probably evolved as a solution for other problems than wayfinding, this could very well be one of language's manifold applications, enabling our astonishing performances not only in finding our way through the world.

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APPENDIX

Two examples of verbal directions used to construct the directions of the main experiment (translated from German)

Participant L.K.

Long Route. Go straight on until you reach the next crossroad. Turn this road to the right. Straight on until there is another road on the left. Ignore this one and walk straight on until the next crossroad. There turn left until the next crossroad. There turn right in a sharp angle. Again, straight on quite a while until there is a road on the right. Ignore this one. Turn right at the next possibility. Turn left the next but one. Then straight on ignoring two roads on the right. Then turn left the next possibility. There is your goal.

Short Route. Straight on. Turn right the 2nd possibility. Again turn right the 2nd possibility. Then turn left the 1st possibility. Then again turn right the 2nd possibility. Then turn left the first possibility and again turn left the 1st one.

Participant W.B.

Long Route. Straight on, then turn right. 2nd intersection where you can't go any further. Then turn left. Then turn right. Again turn right the 2nd street. Turn left at the 2nd fork. Then turn left at the 1st street on the left.

Short Route. Straight on to the 2nd intersection. Then turn right. Again to the 2nd intersection. Then turn right until you can't go on any further. Turn left until you can't go any further. Turn right. Again turn left until you can't go any further. Turn left.