Wayfinding with Maps and Verbal Directions

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Abstract

This experiment investigated the role of the source of information as well as the route complexity for wayfinding performance and wayfinding knowledge acquired. Participants had to find a complex and a simple route in an unknown city with figural instructions (map) and verbal instructions (directions). The participants reported transforming the map into verbal directions; therefore no general difference between the instructions was found. On oblique intersections which were difficult to code verbally participants recalling the map tended to perform better but built up worse route knowledge. Figural information from the map was only used for wayfinding or pointing if these tasks could not be solved otherwise.

Introduction

Imagine you are on your way to meet someone in a café in the city centre. You have just arrived at the station but your train was late so now you are in a rush. The café is nearby but you are not exactly sure where it is. What do you do? Use the big city-map on the station-wall or ask somebody for directions?

The goal of the present study is to answer this question and at the same time to explore how wayfinding knowledge is represented in memory. At least two forms of knowledge are distinguished: route and survey knowledge (e.g. Herrmann, Schweizer, Janzen & Katz, 1998; Montello, Waller, Hegarty & Richardson, 2004; Siegel & White, 1975). Route knowledge can be defined as a sequence of places or landmarks connected by direction information or locomotion patterns. It is one-dimensional or "string-like" and usually measured through errors in a wayfinding task. Survey knowledge can be defined as the knowledge of a layout of places or landmarks and their direct spatial interrelationships including distances and directions. It is two-dimensional or "map-like" and usually measured in shortcut behaviour, in a pointing task or in drawing a map.

The starting point of our present study is that the acquisition of route and survey knowledge is usually studied either by the direct experience of the actual environment that is by navigating through a real or virtual environment or it is studied by learning from maps or texts (e.g. Moeser, 1988; Richardson, Montello & Hegarty, 1999; Taylor & Tversky, 1992; Thorndyke & Hayes-Roth, 1982). However, what if individuals acquire their initial knowledge from maps or verbal description and then find their way through their environment? In daily life, this is very often the case. Before we start our journey we plan the route by studying a map, asking other people, or – more recently – use a route planner, for instance, from the web. Such route planning systems typically provide the information as a marked route on a map *and* as a "string-like" sentential description.

One obvious question is which source of information is more helpful for wayfinding? Some studies tackled this question: e.g. directions presented by tape during driving increased wayfinding performance compared to map usage during driving (Streeter, Vitello & Wonsiewicz, 1985). However, visual information such as from a map is known to interfere with the driving task more than verbal information (Liu, 2001; Vollrath & Totzke, 2001). This interference is specific for driving, e.g. when walking to a goal via two levels of a building, participants who had a map instruction showed shorter learning times and hesitated less during navigation but did not commit less errors and were not faster than participants with directions (Pazzaglia & De Beni, 2001). No differences between map and text instructions could also be found for navigating a virtual desktop environment (Schlender, Peters, & Wienhöfer, 2000). These results are somehow heterogeneous. Maybe the two information sources are not equally helpful on all sorts of routes? Probably one source of information is more helpful for simple routes and the other for highly complex routes.

A third question is whether route and survey knowledge are built up differently by means of verbal instruction or by maps. In fact, route and survey knowledge can both be expressed in a map as well as in directions. However, it seems to be easier to express survey knowledge in a map as survey knowledge is considered two-dimensional, and measured e.g. through map drawing. On the other hand, the linear structure of verbal directions parallels the one-dimensionality of route knowledge. From a map where each aspect is equally accessible this would have to be inferred first.

This subjective impression motivates the hypothesis that directions lead to better route knowledge whereas a map leads to better survey knowledge. One aim of the study is to test this hypothesis. The second aim is to investigate which *source of information* - verbal descriptions or maps - results in better wayfinding performance and how that is affected by the complexity of the route. We report a field-experiment in an urban environment in which participants learned different routes (varying in complexity) from sentential descriptions and from maps. We discuss our results in relation to other accounts of human wayfinding and draw some general conclusions about wayfinding, verbal descriptions, maps, and the representation of wayfinding knowledge in memory.

Method

Participants

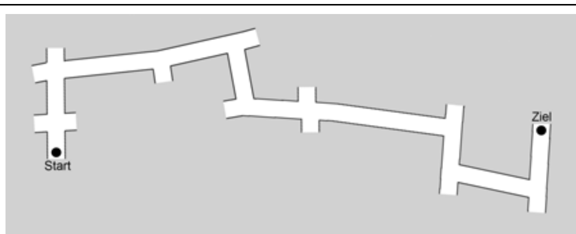
Six female and six male participants, mainly students between 20 and 31 (M=24; SD=3.3) participated in the experiment which took place in Tübingen. All participants were recruited in Freiburg a city about 200 km away from Tübingen. They received a list of different cities in the South of Germany and only those people who mentioned having never been to Tübingen before were selected for the study. The selected participants were German native speakers and they were paid for their participation. They all were transported by bus, from Freiburg to Tübingen, on the morning of the study.

The city and wayfinding materials

Tübingen is an old university city in the south of Germany first mentioned in 1078. Today 83000 citizens live in the city. The study took place in the mediaeval city centre where the participants had to find two different routes.

The complexity of the routes was systematically varied. The *simple route* had 9 almost orthogonal intersections with two or three possible choices of direction at each, summing up to 21 possible choices (see Figure 1).

The *complex route* had 10 intersections with two to four possible choices at each summing up to 23 possible choices. Most intersections were at oblique angles (see Figure 2).

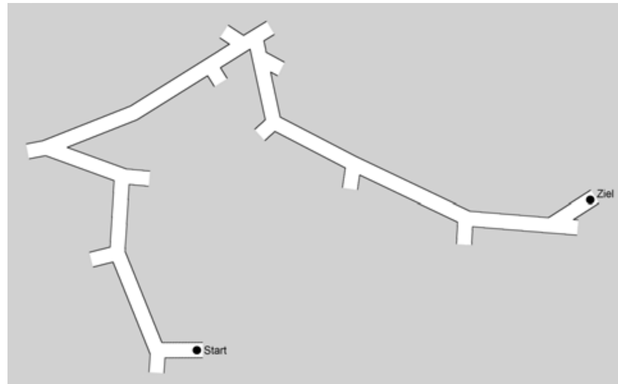


Go straight on. At the 2nd intersection turn right. Turn right again at the 2nd intersection.	Then left. Then the 2nd to the right. The 1st turn left. Left again. Here is your goal.

Figure 1: The map of the simple route and the corresponding verbal directions translated into English.

In the *map-condition*, the participants received a map that a professional geographer constructed on the basis of official maps. All streets on the maps had the same width and local features like house corners were not shown on the map.

In the *directions-condition*, participants received the instructions as written sentences on a paper. The verbal descriptions of the directions-condition were produced following the "skeletal description" procedure introduced by Denis (1997). On the basis of the two maps, prior to our main study six female and six male volunteers gave verbal directions. Then these verbal directions were analysed for common features, i.e. features that were mentioned by the majority of participants and were agreed on by two independent raters. The formulations mentioned most often were used for the directions.



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 2: The map of the complex route and the corresponding verbal directions translated into English.

Procedure

In the main experiment, each participant had to find the complex and the simple route. Half of the 12 participants got the map instructions on the complex route and the directions on the simple route. The other half of participants got the map instructions on the simple route and the directions on the complex route. The order of conditions was counterbalanced.

The participants were tested individually. They waited for their turn in a university room, were escorted to one of the starting points blindfolded and then turned around to minimize prior orientation. Then they had three minutes to study the maps or the verbal description presented on a sheet of paper. If they were not able to answer a control question they had two additional minutes study time. They could not look at the maps or the written descriptions again after this study period. Then the participants started to find the way to the destination point. The experimenter followed the participants and recorded (1) time to reach the goal, (2) stops for orientation including their duration if longer than five seconds, (3) getting lost, and (4) need for instructions. After the participant had reached the goal she or he was blindfolded again and then taken to the second starting point. Here the same procedure as described above was used.

After reaching the goals some additional measures for route and survey knowledge were gathered. To measure *survey knowledge*, the participants were asked to point from the goal to the starting point of the route. The exact direction was marked by the experimenter in a 360° picture. Then the participants estimated the Euclidian distance to the start on a scale with two visible objects as anchors for distances. Back in the waiting room, survey knowledge from a vertical perspective was tested by presenting the participants a map of the goal area of their first route and asking them to draw in the start with a cross.

To measure *route knowledge* a choice reaction task was used. Pictures of all intersections (as seen before crossing) were presented on the screen. The participants had to indicate the correct direction of the further route by pressing a joystick to the right, left or front as fast as possible (see Figure 3 on the left). They were told to pull the joystick, if they did not know the intersection. The distracters were pictures taken from the same area of intersections not previously seen by the participants. All pictures were presented in random order.

Finally, we also measured individual differences with a German translation of the *Santa Barbara Sense of Direction Scale* (Hegarty, Richardson, Montello, Lovelace & Subbiah, 2002).

Figure 3: The setting used for measuring route knowledge. A picture of an intersection was presented and a participant had to indicate the correct direction with a joystick as fast as possible.

Results and Discussion

Wayfinding Performance

The performance of the participants as a function of *route complexity* is presented in Table 1. On the complex route the participants walked longer (Wilcoxon Test, $Z = 3.06$, $p = .002$), made more stops per person ($Z = 2.99$, $p = .003$) 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 complex and the simple route.

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

The performance of the participants as a function of *source of information (map vs. description)* is presented in Table 2. Both groups took about the same time to walk the two routes together, they stopped, got lost and needed the instructions equally often no matter which instruction they got (four Wilcoxon Tests all $Z < .785$, $p > .433$).

Table 2: Wayfinding performance for map and verbal directions as instructions.

	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

However, visual inspection of Figure 4 suggests an *interaction between information source and route complexity*. On the simple route, participants got lost more often, when they used a map, whereas, on the complex route they lost their way more often with directions. Due to the small number of participants this observation did not reach statistical significance. (U-tests for instruction differences on simple route: $Z = 0.73$, $p = .465$; difficult route: $Z = 1.16$, $p = .246$).

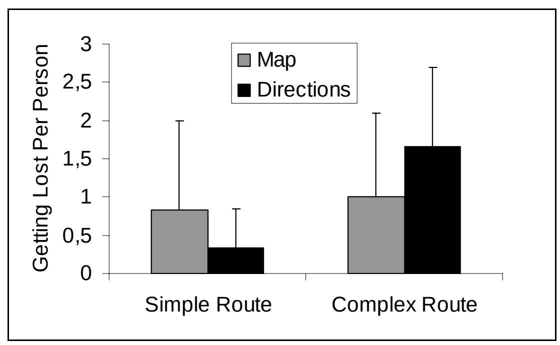


Figure 4: Interaction between complexity of the routes and source of information. Mean numbers of getting lost and standard deviations are shown.

For the source of information no mean differences in task performance could be found. This is in accordance with other studies which also did not find a difference between map and text instruction at least not in time or errors made (Schlender, Peters & Wienhöfer, 2000; Pazzaglia & De Beni, 2001). Why was there no difference? Schlender, Peters and Wienhöfer (2001) proposed this was due to rotating the map to align it with the environment which equals the assumed performance advantage of the map. Still, it would be surprising that in three independent studies advantages and disadvantages balanced each other. We propose a different explanation: In a questionnaire filled in after the study all twelve participants mentioned that they had translated the map into verbal directions. So it seems that both groups used directions to guide their way: either the ones self produced from the map or the ones given as instructions. Therefore no general performance difference according to instruction was found.

The starting point of our study was the conjecture that the usefulness of maps and verbal descriptions might depend on the complexity of the route. Visual inspection indicated an interaction between route complexity and source of information in getting lost. This was despite the fact that the chance for guessing the correct route was .5 at most intersections. This interaction was also present in the representational measures (see route knowledge section). How does this observation fit with the interpretation of translating the map into directions?

A closer look at the most difficult intersection (see Table 3 and Figure 2 the uppermost intersection with five arms) reveals that the participants stopped equally often with both instructions (U-test: Z = .365, p = .715). However, participants with a map instruction stopped more than five times longer than people with directions (U-test: Z = 2.46, p = .014). What did they do? Did they just recall the verbal directions they had constructed from the map and compare them with their surrounding? This does not seem plausible as participants instructed with verbal directions just stopped for ten seconds. So what else did they do? Maybe they tried to remember something else and that was the map. This might have been effortful and time consuming and was therefore not carried out at every intersection. However, if the intersection was difficult like here it might have been worth the effort: participants with verbal directions got lost and needed the instructions twice as often as participants with maps. Again, due to tests low in power and the small number of participants this effect is not reliable (got lost: Z = 1.04, p = .299; needed instructions Z = 1.17, p = .241). This potential explanation is in accordance with results showing that people associate the expressions “turn left” or “turn right” automatically with right angles as they draw the intersections like this (Klippel, 2003). Intersections not describable in this scheme might cause problems. This is the case for oblique intersections like those on the complex route. Comparing both routes this obliqueness is also the most plausible explanation for differences in difficulty: both routes do not differ substantially on other factors like number of intersections (9 vs. 10), possible choices (21 vs. 23) and number of turns required (six each).

In summary, our findings suggest that representing the routes verbally can explain, first, problems with oblique intersections, second, the lack of a main effect of source of information in this and other studies, third, a possible interaction between route complexity and source of information and, fourth, it can explain results showing a strong tendency in many subjects to recall intersections in right angles, even if the experienced intersection was e.g. 120° (Gillner & Mallot, 1998; Tversky, 1981).

Table 3: Wayfinding performance at the most difficult intersection on the complex route.

	Map		Directions	
	M	*SD*	*M*	*SD*
Stops	0.7	0.5	0.8	0.8
Stop time [s]	53	31	9	4
Got lost	0.5	0.5	1	0.9
Needed instructions	0.2	0.4	0.5	0.5

Route Knowledge

Our second assumption stated that the representation of route knowledge is supported by verbal descriptions. This is also illustrated by the fact that in constructing the verbal directions from the map (see also method section) not one of the twelve volunteers mentioned a single expression describing survey knowledge, so no survey knowledge was contained in the verbal directions at all. Contrary to our expectations, participants with different sources of information did not differ in their route knowledge, as measured through the choice reaction task (ANOVA with correct reactions, main effect source of information $F(1,135)$ = .27, p = .870)[1]. There was no main effect of route complexity ($F(1,135)$ = 0.36, p = .850), but there was an interaction between route complexity and source of information ($F(1,135)$ = 5.1, p = .025). Interestingly, this interaction was in the opposite direction to the one found in the navigation performance (see Figure 4). On the complex route participants reacted faster if they had verbal directions as instruction whereas on the simple route participants with a map reacted faster. So participants built up a better route knowledge under conditions where they got lost more often. As route knowledge and getting lost did not correlate highly, this was probably not due to individual differences but had to do with the experimental conditions (n = 12, r = .30 p = .337)[2]. This supports the interpretation that this interaction found in wayfinding performance is reliable.

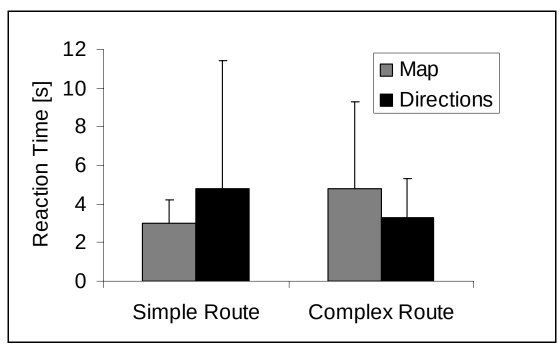


Figure 4: Average reaction time and standard deviations of correct reactions as a measure of route knowledge.

Why did the participants build up a better route knowledge under conditions where they also got lost more often? More learning time could not be the reason, as on the complex route, only participants in the map condition stopped longer (compare Table 3). These people built up worse instead of better route knowledge. Still, this fits with the interpretation

[1] The overall mean accuracy was 61%. No difference between experimental conditions was found.

[2] The performance measures on both routes were added together for overall performance per person independent of instruction. Correlations for each route separately show a very similar picture.

that participants with a map instruction did not look at their environment while stopping but tried to remember the map they had seen before. Therefore their attention was not focused on their surroundings, leading to a worse route knowledge and less getting lost on average but not necessarily on an individual level (compare Kane & Engle, 2000). Alternative explanations for the differences in route knowledge could focus on increased attention when getting lost or on more perspectives seen of an intersection (comp. Bülthoff & Edelman, 1992). However, they would predict a substantial correlation between getting lost and route knowledge.

Survey Knowledge

Our assumption that the representation of survey knowledge is eased by the map instruction was also not supported. Participants with map and verbal directions did not differ in their performance of pointing from the goal to the start (systematic error expressed by mean deviations: U-Test simple route: $Z = 0.481$, $p = .630$; complex route $Z = 1.04$, $p = .296$; unsystematic error expressed by standard deviations: simple route $F(5,5) = 2.67$, $p > .10$; complex route $F(5,5) = 2.43$, $p > .10$) and estimating the distance (deviation of drawn distance to correct distance in mm. U-Test simple route $Z = 0.641$, $p = .522$; complex route $Z = 0.641$, $p = .522$).

So participants with a map instruction were not better in pointing. Did they not remember any survey information from the map? As marking the starting point in a map of the goal area showed, this was not the case (see Table 4). For participants with verbal directions the estimates of the direction of the starting point were less accurate as shown in their higher standard deviation a measure for the unsystematic error ($F(5,5) = 8.31$, $p < 0.025$). On the other hand, they performed better in the distance estimation than participants with map instructions who overestimated the distance (Binomial Test: 2 underestimations vs. 10 overestimations $p = .039$). However, the map the participants had to draw in the starting point was 50% the size of the map they were instructed with. Therefore the overestimation in the map condition is plausible assuming the participants orientated themselves on the size of the original map. So the participants did remember survey knowledge from the map, but they did not use it in the pointing task. Possibly information from path integration was more accessible than figural information from the map. Just as self translated directions could be easier to access in finding a route compared to figural layout information from the map presumably only used at difficult intersections.

Table 4: Errors in distance and direction estimation of the starting point when drawing a map given the goal area.

	Map		Directions	
	M	*SD*	*M*	*SD*
Direction error [°]	+15	20	+7	49
Distance error [mm]	+12	15	-1	17

So the participants did not use survey knowledge from the map for the pointing task. Did they use it for navigation? Indeed three participants reported that they had tried to walk into the direction of a (sub)goal when using a map. Is this *least angle strategy* (Hochmair & Frank, 2002; Hölscher, Meilinger, Vrachliotis, Brösamle & Knauff (2005) more beneficial for finding a route than relying on route knowledge that is just orientating on the turning at intersections? It is not. Similar to Hölscher et al. (2005) the application of the least angle strategy was correlated with bad performance in navigation: participants got lost more often ($r = .84$, $p = .001$) and needed the instructions more often $r = .78$, $p = .003$)[2]. So for walking a specific unknown route relying on survey knowledge is not to be recommended. These participants also contributed substantially to the error frequency in the condition with map instruction. Excluding them, both groups showed no difference in getting lost on the easy route, but the difference on the difficult route was increased.

The greater importance of route knowledge compared to survey knowledge in this study might also explain results in *individual differences*: the performance in navigation was not significantly correlated with the sense of direction measured in the German version of the Santa Barbara Sense of Direction Scale (four correlations to performance measures, all $r < .32$, $p > .326$)[2]. Also contrary to other studies (e.g. Moffat, Hampson & Hatzipantelis, 1998; Lawton, 1996) no correlations of wayfinding performance and gender could be found (four correlations $r < .10$, $p > .763$). These results are intelligible if it is taken into account that the sense of direction is related to the usage of survey knowledge, not to route knowledge relevant here (Hegarty et al., 2002; Prestopnik & Roskos-Ewoldson, 2000) and that gender differences are often related to the usage of survey strategies (Lawton, 1994, 1996).

These results are limited to tasks in which a specific route to an unknown goal has to be found with the help of instructions. Finding a specific route does not involve searching for the shortest route. It is kind of unusual to search for shortcuts in given directions. In using a map to reach a goal, it seems more plausible to look for the shortest route first and then to try to memorise it, for example by translating it into directions. It seems less plausible to memorise the whole map and then to look for a shortcut

Conclusions

No global differences between map instruction and verbal directions were found. We suggested that this was because participants translated the map into directions. Oblique intersections were more difficult for wayfinding. On such intersections, which are not easily expressed in verbal directions, recalling the intersection layout from the map presumably helped finding the route. This led to worse route knowledge. It seems that participants did not use figural information from the map, if they could use directions for navigation instead or path integration for a pointing task. Maps or directions did not selectively enhance the construction of survey or route knowledge. For finding a specific unknown route, survey knowledge did not seem to have any advantage. Focusing on it could even lead to worse performance. Practically speaking, for cities with an orthogonal street layout, verbal directions are sufficient to reach your goal, in other cases it would be better to use a map.

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