Finding the return path: allo- versus egocentric perspective

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Abstract

In a series of two experiments we investigated the influence of an allocentric and egocentric perspective on landmark-based wayfinding and finding the according return path. Participants had to learn a route consisting of twelve intersections with four different verbal landmarks at each intersection. They were asked to memorize at least one of the landmarks for providing a route description after the learning phase, either in the learning direction (initial path) or in the opposite direction (return path). In the allocentric experiment, a clear preference and higher performance was demonstrated for landmarks located at the position before the intersection and in the direction of turn, while in the egocentric perspective landmarks in the direction of turn were better remembered and used more frequently, independent of the position before or behind the intersection. These results will be discussed with respect to current research on structural salience in landmark-based wayfinding.

Keywords: spatial cognition; return path; structural salience; landmarks; allocentric perspective; egocentric perspective

Introduction

At the past two CogSci conferences we introduced ideas and empirical research on finding a return path (Hamburger, Dienelt, Strickrodt, & Röser, 2013; Hinterecker, Strickrodt, Röser, & Hamburger, 2014). Now, we want to focus on a new aspect: the perspective of the wayfinder, allocentric versus egocentric.

Let us start with an example from the fiction literature (*Inheritance*) as a very good everyday example:

> "Which path should we pick?" asked Wyrden. "Isn't it obvious?" asked the herbalist. "The left one. It's always the left one." […] Eragon could not help himself. "Left according to which direction? If you were starting from the other side, left–" "Left would be right and right would be left, yes, yes," said the herbalist. Her eyes narrowed. "Sometimes you are too clever for your own good, …" (Paolini, 2011; p. 338)

If we take this example of a perspective change seriously, which we should, as we need to find our ways each and every day of our life, we need to think about wayfinding strategies and how people manage to avoid getting lost (e.g., Dudchenko, 2010). Finding back to the point of departure is a typical wayfinding problem. Humans, like many animals, show capabilities such as path integration (e.g., Mallot, 2012; Wiener, Berthoz, & Wolbers, 2011) and finding shortcuts (e.g., Golledge, 1997, 1999). However, imagine being in an unknown city. You walk from the train station to the university, where you are about to give a presentation. After your presentation you need to go back to the train station in order to catch your train. You are in a hurry. What are you going to do? Reproducing the initial path should be the perceptually and cognitively easiest solution in this case (and most promising with respect to avoid getting lost). Golledge (1995) stated the following: "… a pure retrace strategy may have been used, thus precluding any ´longest leg first´ strategies […] indicate that exact route retracing was a possible option as a route selection strategy." (p. 18).

The general literature on landmark-based wayfinding provides different approaches to landmark salience, i.e. the importance of an object at certain locations in order to aid successful navigation (e.g., Lynch, 1960; Presson & Montello, 1988; Raubal & Winter, 2002). The majority of landmark models define landmark salience as inherent features of an object or intersection (e.g., Sorrows & Hirtle, 1999). In contrast Caduff and Timpf (2008) focus on the observer with her cognitive abilities and limitations in order to provide a more observer-based landmark salience approach.

A central concept in all these models is the position of a landmark at an intersection (e.g., Klippel & Winter, 2005; Raubal & Winter, 2002; Röser, Hamburger, Krumnack, & Knauff, in revision). The ideal position at a four-way intersection is the position before the intersection in the direction of turn (position D in Figure 1; Röser, Hamburger, Krumnack, & Knauff, 2012). This position preference is dependent on the observer's perspective (allo- vs. egocentric) and on their viewing point (Röser et al., in revision). In the literature, many researchers differentiate between an egocentric (self-to-object) and allocentric (object-to-object) perspective (Bryant, 1997; Coluccia, Mammarella, De Beni, Ittyerah, & Cornoldi, 2007; Klatzky, 1998; Nadel & Hardt, 2004).

We here define allocentric as a birds-eye or map perspective, so that the information is seen from above (survey information) and has the same visibility for all parts of an intersection. Egocentric is here defined as the body-centered view of the participant standing in the environment, including different visibilities at an intersection (e.g., Winter, 2003; Röser et al., in revision; see Figure 1).

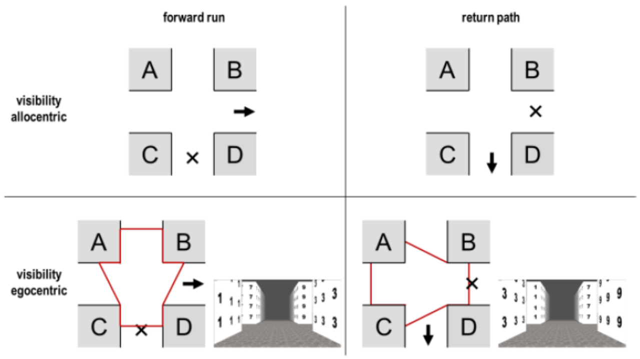

Figure 1: Visibility from two different positions: initial path (left) and return path (right). X = position of individual; → = walking direction. In the allocentric perspective each position is equally visible for both directions, unlike in the egocentric perspective. The small images on the bottom visualize the different points of view in the egocentric perspective. *(image taken from Hamburger et al., 2013; p. 540)*

In the current study the task will be to gather empirical evidence for the ideal landmark position for providing a *route description* in the different conditions: allocentric and egocentric in combination with initial path and return path. This will be systematically investigated in two experiments with an allocentric and egocentric perspective, which results in the following three hypotheses:

Hypothesis 1: Describing the initial path will result in higher landmark accuracy than describing the return path.

Hypothesis 2: The position preference depends on the wayfinder's task (describing initial vs. return path).

Hypothesis 3: The described landmark positions differ between allocentric and egocentric perspective.

Experiment 1 – Initial and return path allocentric perspective

Method

Participants

A total of 127 individuals (79♀, 44♂, four did not provide gender information) participated in the online-experiment. They were recruited via an email distributed among all students of the Justus Liebig University Giessen. The mean age was 23.96 years (*range* = 18–46). Sixty-seven percent (85 participants) indicated to have a high-school diploma or similar, while 15 participants already had a Bachelor's and eight a Master's degree. For the analysis a total of 62 could be included, since the others dropped out during the experiment and did not complete it. The remaining sample consisted of 44♀ and 18♂ with a mean age of 23.61 (*range* = 18–32). The percentage of high-school diploma or similar increased to 74%, while six had a Bachelor's and four a Master's degree. All participants provided informed consent and participation was voluntary.

Material

Common German nouns with the first letter ranging from A to L, consisting of six letters and two syllables each served as material. This resulted in a total of twelve intersections (48 different words). At each intersection every word contained the same initial letter. Each landmark word had to occur at every position at an intersection (four different routes) and had to be combined with each turning direction (left, right; resulting in eight different routes). Since initial and return path were tested, the eight different versions had to be combined with the two different tasks, making up for a total of 16 different routes. An exemplary intersection in the allocentric condition is visualized in Figure 2. The experiment was run online via LimeSurvey2.05+ (Schmitz, 2012).

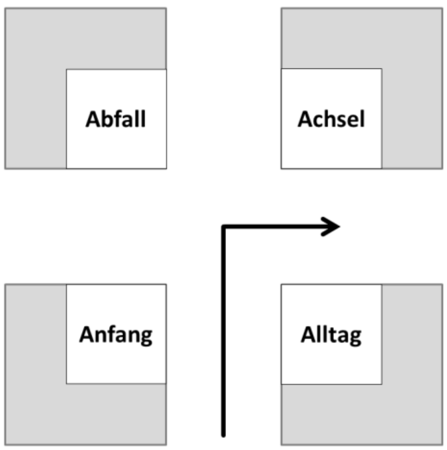

Figure 2: Exemplary intersection in the allocentric perspective; shown are the four words starting with the letter A in German language (Abfall = trash; Achsel = armpit; Anfang = beginning; Alltag = everyday life).

Procedure

Before the main task's first instruction was presented, participants had to answer some demographic and exploratory questions.

Instruction 1: Participants were asked to memorize the following path, which will be presented in form of screenshots, presenting an intersection with four different landmark words. For each intersection they were asked to memorize at least one landmark and the associated turning direction. Depending on the condition assignment, participants received one of the following instructions:

Instruction 2a: The task was not only to remember the path (*recognition*) but also to provide a route description of the learned path for another person also unfamiliar with this environment (*free recall*).

Instruction 2b: The task was not only to remember the path (*recognition*) but also to provide a route description of the return path (reverse learning order) for another person also unfamiliar with this environment (*free recall*).

After Instruction 2 the learning phase started, where the full route of twelve screenshots had to be learned one after another; self-paced. The sequence of screenshots was randomized for each participant to control for sequential effects across participants. When the learning phase was over, participants again received the related instructions to provide an exact route description of the learned path (Instruction 2a) or of the appropriate return path (Instruction 2b) for the testing phase. They had to fill in the landmarks and according turning direction into a list consisting of 16 rows and two columns; the first column for the direction and the second for the corresponding landmark object.

Results

The descriptive results show that participants described a total of 411 landmarks correctly. The different landmark words were used equally often ($\chi^2(47)=31.511$, $p=.960$). A total of 283 correct combinations of landmarks and direction were provided. For the initial path 84.81% of all described landmarks were correctly combined with the correct direction. For the return path this occurred only in 58.89% of the cases. This difference is statistically insignificant ($t(60)=.886$, $p=.379$). Figure 3 shows the chosen positions of the correctly described landmarks in combination with the correct directional information.

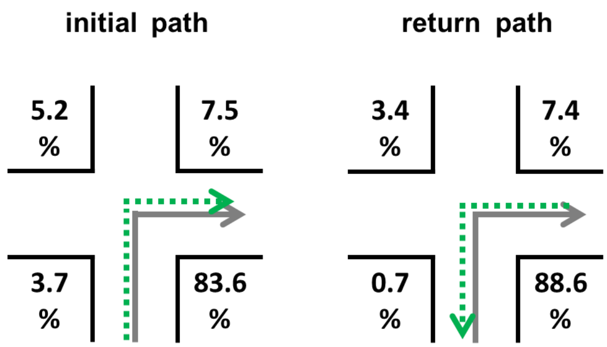

Figure 3: Distribution of landmark descriptions for the initial path (left) and return path (right) in combination with correct route directions (left/right) in the allocentric perspective. The gray solid arrows indicate the learning condition, while the green dotted arrows indicate the direction at retrieval. Please note that numbers do not necessarily add up to 100 due to rounding.

Taken together a significant landmark position preference is visible ($\chi^2(3)=197.675$, $p<.001$; deviation from an equal distribution); these position preferences differ significantly ($\chi^2(3)=15.277$, $p<.001$) for the initial and return path with respect to the absolute position in the environment (independent of direction change left or right). For the return path participants used landmarks located before the intersection in the direction of turn slightly more often than for the initial path; landmarks at the remaining positions are used hardly ever. More importantly, in both cases the position before the intersection in the direction of turn (relative position depending on the direction of travel) is by far the most preferred one (initial path: 83.6% vs. return path: 88.6%).

Discussion

Even though the descriptive difference between performance for the initial path and return path is about 25%, this difference was insignificant due to a large variance in the data. This contradicts the first hypothesis. However, describing route directions for the initial path seems to lead to better recollection than describing the return path, which has previously been demonstrated empirically for wayfinding performance (Hamburger et al., 2013; Hinterecker et al., 2014).

We found some empirical evidence supporting the second hypothesis. But, in both conditions landmarks located at the position before the intersection and in the direction of turn were used for route descriptions in about 85% of cases. This supports previous findings on the initial path (Röser, Hamburger, et al., 2012; Röser, Krumnack, Hamburger, & Knauff, 2012) and further supports the structural importance of this position during a landmark-based wayfinding process (Röser et al., in revision), also for the return path.

In general, due to the overall worse performance, it could be argued that the task presented here might be too difficult for participants to solve (quite a few trials had to be eliminated due to errors) and one could ask for an easier task (e.g., recognition task). However, there are two opposing reasons: 1) the task provides a high ecological validity, since it is related to everyday wayfinding szenarios; 2) an easier task such as recognition of landmarks does not necessarily lead to better performance, since there is evidence that recognition data (i.e. landmarks) in this context might be worse than the wayfinding data (i.e. landmarks + direction) (e.g., Hamburger & Röser, 2014).

Furthermore, the choice of landmark words which are not conventionally associated with physical landmarks or locations might seem odd at a first glance. But, since they are not associated with any related content, this controls for semantic and idiosyncratic effects in this context. Since the objects (words) were used equally often throughout the experiments, memorability can be assumed to be equal.

We did not control for the correct order of directions and landmarks, since we are interested in the question about the ideal position and not in general memory strategies. However, previous experiments showed that possible sequential learning effects do not occur (e.g., right, right, left, etc without landmarks; Hamburger & Röser, 2014).

So far we concentrated on the allocentric perspective and Experiment 2 will now be realized in the egocentric perspective. Then, we will also be able to provide (comparison) data for Hypothesis 3.

Experiment 2 – Initial and return path egocentric perspective

Method

Participants

A total of 191 individuals (142♀, 42♂, seven did not provide gender information) participated. They were recruited via an email distributed among all students of the Justus Liebig University Giessen. The mean age was 24.53 years (*range* = 17–77). Sixty-four percent (123 participants) indicated to have a high-school diploma or similar, while 27 participants already had a Bachelor's and 16 a Master's degree. For the analysis a total of 88 could be included, since the others dropped out during the experiment and did not complete it. The remaining sample consisted of 76♀ and twelve ♂ with a mean age of 23.76 (*range* = 17–42). The percentage of high-school diploma or similar increased to 73%, while nine had a Bachelor's and six a Master's degree. All participants provided informed consent and participation was voluntary.

Material

The material of Experiment 2 was identical to that of Experiment 1, but now presented in an egocentric perspective.

Procedure

The procedure of Experiment 2 was identical to the first experiment's procedure, except for the perspective change. Now, participants learned the route and landmark information in an *I-perspective* (Figure 4). The position of the participants was the same at each intersection: in the middle of the path with a fixed distance to the center of the intersection. The eye-height was set to 170cm and the viewing direction was straight ahead.

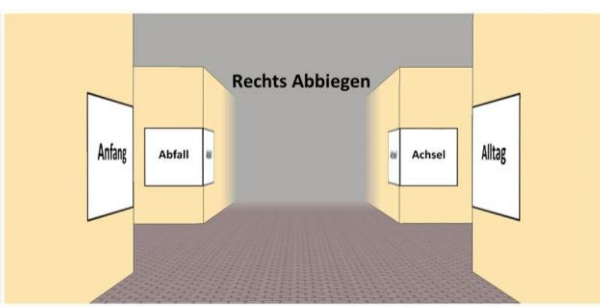

Figure 4: Exemplary intersection in the egocentric perspective; arrangement and words identical to Figure 2. "Rechts abbiegen" indicates the directional information (turn right).

Results

The descriptive results show that participants described a total of 514 landmarks correctly. The different landmark words were used equally often ($\chi^2(47)=39.732$, $p=.765$). A total of 370 correct combinations of landmarks and direction were provided. For the initial path 77.73% of all described landmarks were combined with the correct turning direction. For the return path this occurred in only 66.28% of cases. This difference is statistically insignificant ($t(86)=1.292$, $p=.200$). Figure 5 shows the chosen positions of the correctly described landmarks in combination with the correct directional information. Taken together a significant landmark position preference is visible ($\chi^2(3)=57.769$, $p<.001$; deviation from an equal distribution); these position preferences differ significantly ($\chi^2(3)=60.532$, $p<.001$) for the initial and return path with respect to the absolute position in the environment (independent of direction change left or right). For the initial path, landmarks located in the direction of turn were described more often, likewise for the return path. However, for the return path, landmarks located at the position before the intersection opposite to the direction of turn (from the perspective of the return path behind the intersection and in the direction of turn) are used for route descriptions in 21% of cases (Figure 5).

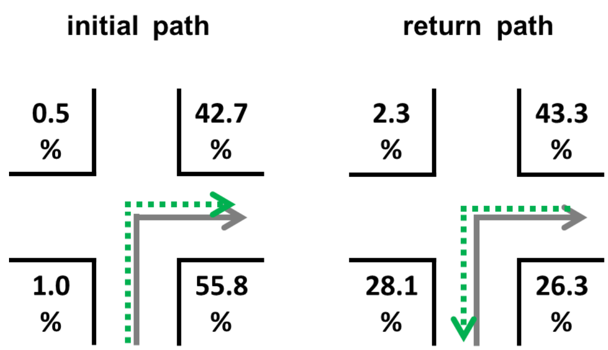

Figure 5: Distribution of landmark descriptions for the initial path (left) and return path (right) in combination with correct route directions (left/right) in the egocentric perspective. The gray solid arrows indicate the learning condition, while the green dotted arrows indicate the direction at retrieval. Please note that numbers do not necessarily add up to 100 due to rounding.

Discussion

We again did not find supporting evidence for the first hypothesis that route directions for the initial path lead to better recollection than describing the return path. The difference of about 11% is smaller than compared to Experiment 1.

For the second hypothesis empirical evidence has been obtained. For the initial path the positions in the direction of turn were the preferred ones. For the return path only the position behind the intersection and opposite to the direction of turn was hardly ever chosen. The remaining three positions were chosen more or less equally often. The findings for the initial path (highest preferences for landmarks at positions in the direction of turn) underline previous findings (Röser, Hamburger, et al., 2012; Röser, Krumnack, et al., 2012). The slight shift within the position preferences for the return path is a new finding but has previously been assumed by Hamburger et al. (2013) on a theoretical basis. Interestingly, for describing the return path participants additionally used landmarks located at the position before the intersection opposite to the direction of turn, which from the perspective of the return path is located behind the intersection in the direction of turn.

It could be expected that arrows (spatial information) instead of directional information (verbal) might produce different patterns of results. However, preliminary experiments so far do not reveal any differences with respect to this issue.

General Discussion and Conclusion

Hypothesis 1

Previous experiments supported the assumption of higher performance for an initial path in comparison to a return path (Hamburger, et al. 2013; Hinterecker et al., 2014). The current experiments just provided a descriptive tendency in the assumed direction. This may be attributed to the occurrence of a large variance in this rather difficult task of free landmark-based route description in comparison to simple recognition.

Hypothesis 2

In Experiment 1 a significant difference has been obtained but in both conditions (initial and return path) the position *before the intersection in the direction of turn* is chosen at least five times more often than the other three positions taken together.

In Experiment 2 the descriptive and statistical results show a large difference between the initial and the return path. The findings of the initial path (positions in the direction of turn; B and D; see Figure 6) correspond to previous findings (e.g., Klippel & Winter, 2005 → for position D and Röser, Hamburger, et al., 2012; in revision → for positions B and D). The condition return path reveals different preferences, in so far that only the position behind the intersection opposite to the direction of turn (A) was hardly ever chosen. There is an increasing usage of position C. This position before the intersection and opposite to the direction of turn marks the position behind the intersection in direction of turn from the perspective of the return path. Meaning that the preference shift from position D to position C is attributed to a mental transformation of perspective. Hamburger et al. (2013) predicted that positions D and A should be the ideal ones when describing a return path, since they are invariant, meaning that they are located "at the same position" in both initial path and return path: position D is located before the intersection in the direction of turn; position A is located behind the intersection and opposite to the direction of turn. Thus, no additional mental transformation from initial to return path should be required. However, the empirical results contradict this theoretical assumption. It may not account for the observed shift from position D to position C.

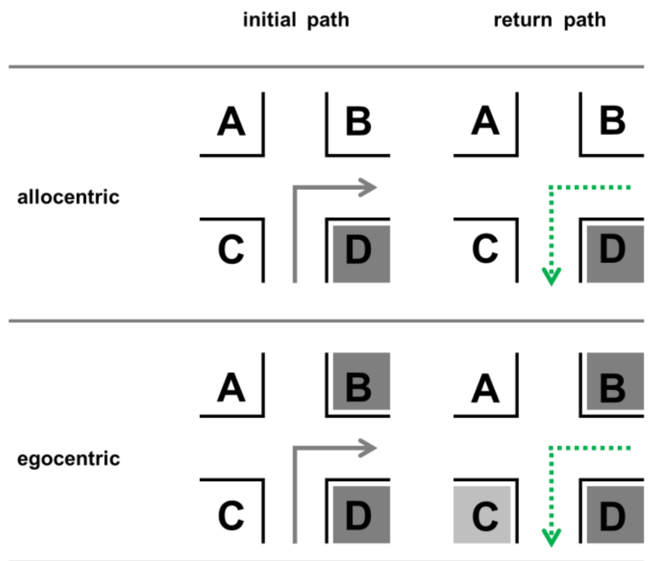

Figure 6. Change of position preferences. Position D (invariant) represents the ideal position in all conditions. In the egocentric conditions positions in the direction of turn are used most often to describe an initial path (B and D), while in the return path condition also position C is used in a substantial number of descriptions (for further details see text).

Hypothesis 3

The difference of the landmark location preference between the allocentric and egocentric perspective could be described in terms of viewpoint-based salience (Röser et al, in revision). In an egocentric perspective the landmarks differ within the degree of distance and how much of a landmark is visible (visible part). This influences the participants' preferences and leads to an increased choice of the landmark position behind the intersection in the direction of turn in the current experiments. Our data for the initial path fit very well with the assumption and findings of our landmark salience model (Röser, Hamburger, et al., 2012; in revision). This model includes the structural salience, moderated by the viewpoint-based salience and would predict for the current experiment that both positions in the direction of turn are used for creating a route description most and equally often. However, the differences of landmark usage in route descriptions between an initial and a return path in the egocentric perspective is not considered in our model to date.

To consider the task of finding the return path a new factor should be implemented in the model. We label this factor *task*, which is in accordance with one factor of Caduff and Timpf's (2008) landmark salience model. Their model differentiates between different *traveling tasks*, such as sightseeing or commuting. We extend this factor with the task *direction of travel*. This includes mental rotation/ transformation of viewing and traveling directions, as well as lingual requirements (Hamburger et al., 2013).

In conclusion, in everyday life perspective (egocentric) there is a shift towards the variant positions, meaning that they mentally as well as verbally need to be transformed. Why this increased cognitive load is voluntarily chosen by people remains an open question for future research.

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