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Investigating Wayfinding under Inconsistent Information

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Abstract. Route instructions used in wayfinding studies are usually taken to be perfect, but in real life we often receive erroneous or ambiguous instructions. The present study investigates wayfinding behavior under such inconsistent instructions in a virtual reality setting. We find that women are more accurate than men, and that wayfinders seem to be more affected by incorrect landmark information than incorrect turn information.

Keywords: route directions · defensive wayfinding · virtual reality

1 Motivation and background

Human wayfinding is a very active research area; see, e.g., [2, 5] for recent overviews. However, most empirical research investigates wayfinding behavior with the assumption that the provided navigation instructions are perfect and would lead a wayfinder to their destination if correctly interpreted. In real life, though, such instructions may often contain various errors and ambiguities, such as omissions of turns, confusion of left and right, or references to non-existing landmarks. How people cope with such erroneous instructions has hardly received any attention so far (but see [1, 6]).

Inspired by the 'defensive wayfinding' framework [8] and the empirical work of [1], we present results of a study where participants followed route directions in a desktop virtual environment (VE), with some of the instructions being incorrect in either the referenced landmarks or the turn directions (e.g., 'left' instead of 'right').

Tomko and Richter [8] present a systematic analysis of the kinds of inconsistencies that may occur between route instructions and the environment, and the impact these may have on wayfinding behavior. In particular, they propose that once such issues are encountered, people would treat the instructions with caution and would engage in 'defensive wayfinding.'

Brunyé et al. [1] identified two main strategies used by navigators; landmark-based or turn-based. Within this context, they investigated the effects of inconsistent route instructions. Participants received a simple map showing a top-down

view of a route with two decision points and two landmarks (one at each). Participants then received instructions of how to reach the destination and had to click on where they believed this destination was on the map. For half of the trials, instructions were correct, for the other half either a landmark or a turn were inconsistent, i.e., did not correspond to what was shown on the map. Not surprisingly maybe, participants were slower to select a destination in the inconsistent trials. More interestingly, which destination they chose can be attributed to their employed strategy. Brunyé et al. found that participants predominately used either a landmark-based or a turn-based strategy.

2 Methods

Similar to Brunyé et al., we are interested in the effects of inconsistent instructions, in particular regarding possible strategy changes after encountering such inconsistencies. These changes might then also reflect a switch to 'defensive wayfinding' [8]. We designed a simple city-like VE that combines several left and right turns to a destination, with landmarks placed at the intersections (Figure 1). More specifically, each navigation task consists of eight trials with four intersections that are associated with four different landmarks and a final destination landmark. Fog was added to the environment to limit visibility.

(a) (b)

Fig. 1: One of the VEs designed for the experiment. (a) participant view of an intersection; (b) map of the environment with four intersections and a landmark each. The map was not shown to participants.

Participants received a leaflet with route instructions on how to navigate to the destination landmark (each trial on a new page). The routes had a similar number of turns ('left', 'right', 'straight'). Half of the trials used consistent instructions, while the other half contained inconsistent landmark instructions or inconsistent turn instructions, respectively. In each inconsistent trial only one instruction was incorrect. Table 1 shows an example each. In the inconsistent landmark trial, participants would encounter a pizza restaurant instead of a bike shop; in the inconsistent turn trial, the left turn would lead to a dead end (wall).

Table 1: Example for an inconsistent landmark trial, and an inconsistent turn trial; inconsistencies highlighted in bold.

Inconsistent landmark trial	Inconsistent turn trial
The goal is to find Forex Bank. Go straight and turn right at the Music Shop. Keep going until the Burger King, and then turn left. Keep going straight, and turn right at McGinleys Pub. Keep going until **the Bike Shop** and then turn left. Go straight until you reach Forex Bank.	The goal is to find Burger King. Go straight and when you see The Ivy Bookshop, keep going straight. Keep going straight and turn left at the Apotek. Keep going straight until the Pizza Restaurant **then turn left**. Keep going straight and then turn left at the Post Office. Go straight until you reach the Burger King

25 participants performed the study (12 women, 13 men, mean age=24.56 years). First, they signed a consent form and filled in pre-test questionnaires including the Santa Barbara Sense-of-Direction Scale (SBSOD) [3] and the State-Trait Anxiety Inventory [7].[4] They completed a short training session in a VE similar to the experimental one, but with only one intersection. Then they began the actual experiment, without being aware that some of the instructions would be inconsistent. Once they managed to find a trial's destination, they automatically proceeded to the next trial. After eight trials, participants had to answer a post-test questionnaire with questions regarding their (experienced) strategy use and confidence in the instructions.

Participant trials were recorded using screen-capture software. These recordings were analyzed to identify the employed wayfinding strategies. For example, if told for the fourth intersection to 'turn left at the bike shop' but there is no bike shop, once realizing that the instruction is inconsistent, if turning left regardless, participants were determined to use a turn-based strategy. If continuing straight, as if in search for the bike shop, we assigned a landmark-based strategy.

If participants relied on landmarks in more instances than on turns for completing the inconsistent trials, they were determined to prefer a landmark-based strategy. Accordingly, if they relied more on turns, they used a turn-based strategy. If they did not favor either, they followed a combination of both strategies ('mixed').

3 Results and discussion

15 participants used a landmark-based strategy and 10 a mixed strategy of both landmark- and turn-based. No participant was identified to rely on a turn-based strategy. In the following, we will analyze potential performance differences between these two strategy groups, as well as gender differences.

[4] Anxiety is not further reported on.

For technical reasons, we were only able to record total time over all eight trials, not for individual trials. We do not find statistical differences in total time between the landmark-based (Mdn=744) and mixed group (Mdn=766); U=89, p=.437.

There are also no differences in accuracy in the inconsistent turn trials (landmark-based Mdn=12; mixed Mdn=13; U=107.5,p=.066), nor in the inconsistent landmark trials (landmark-based Mdn=14; mixed Mdn=15.5; U=81.5, p=.717). Accuracy was measured by counting the number of turns taken in a trial; total accuracy is the sum over all trials. Spearman's correlation analysis reveals that participants' overall accuracy is associated with their accuracy in the incorrect landmark trials ($r_s(25) = .66, p < .001$) but not with their accuracy in the incorrect turn trials ($r_s(25) = .32, p = .114$).

Looking at gender, we find no differences in time between women (Mdn=760) and men (Mdn=749); U=72, p=.744. But women were more accurate (Mdn=41.50) than men (Mdn=46); U=119, p=.025. This can probably be attributed to men performing significantly worse in the incorrect turn trials (women Mdn=12; men Mdn=13); U=114.5, p=.043. We did not find any differences in preferred strategies between the genders, but—as usual—men's SBSOD rating (Mdn=4.93) is higher than that of women (Mdn=3.73); U=114.5, p=.047.

To summarize, our results seem to indicate that wayfinders are more affected by inconsistent landmark information than inconsistent turn information. There is greater impairment of navigation performance with wrong landmarks than with inconsistencies in turn information, which seems to support the importance of landmarks in human navigation [2, 5]. However, this effect may have been exaggerated by the high prominence assigned to landmarks in the VE.

Further, we find that men navigate less accurately than women, in particular in the inconsistent turn trials. This might be caused by their reliance on orientation-based strategies [4], or their overconfidence in their spatial abilities and, thus, a lack of attention in the navigation task.

Regarding the initial hypothesis, we did not observe any changes of navigation strategy use. Answers given in the post-test questionnaire indicate that participants believed they were not following any specific strategies, but overall had no choice but to follow the instructions, despite their confidence and trust in them being reduced. Still, we believe the current study provides some interesting insights into wayfinding behavior under inconsistent information, but also see the need for further research.

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