The Floor Strategy: Wayfinding Cognition in a Multi-Level Building

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Abstract: This short paper is concerned with strategies and cognitive processes of wayfinding in public buildings. We conducted an empirical study in a complex multi-level building, comparing performance measures of experienced and inexperienced participants in different wayfinding tasks. Thinking aloud protocols provided insights into navigation strategies, planning phases, use of landmarks and signage. Three specific strategies for navigation in multi-level buildings were compared. The cognitively efficient floor strategy was preferred by experts over a central-point strategy or a direction strategy, and overall was associated to better wayfinding performance.

Wayfinding in three-dimensional structures[1]

Many people have problems finding their way around public buildings such as airports, hospitals, or university buildings. We aim to identify how human wayfinding strategies and background knowledge foster navigation in a complex multi-level setting.

Almost all controlled studies into wayfinding performance and building complexity have limited themselves to investigating movement and orientation in the horizontal plane of isolated floor levels. Soeda, Kushiyama and Ohno (1997) observed wayfinding performance in tasks involving vertical level changes. They found that a) people loose their orientation due to vertical travel and b) – often falsely – assume that the topology of the floor plans of different levels is identical.

Wayfinding strategies for complex buildings

For two-dimensional (outdoor) settings a number of different wayfinding strategies have been described. Both Hochmair and Frank (2002) and Conroy-Dalton (2001) have described *least- angle strategies*: people try to minimise their global deviation from the goal direction while locally maintaining a straight heading whenever possible. Wiener, Schnee and Mallot (2004) were able to show that navigators rely on *region-based strategie*s of *fine-to-coarse*

[1] An earlier version of this experiment was reported at the International Conference Spatial Cognition, SC04, October 2004, Frauenchiemsee, Germany.

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planning with a hierarchical planning approach: the environment is cognitively segmented into regions which guide navigation decisions.
However, how do people navigate to a target location in the three-dimensional case of multi-level buildings? We propose a distinction of three strategies for finding one's way in cases with incomplete information:

1. *Central point strategy:* Stick as much as possible to well-known parts of the building, like the main entry hall and main connecting corridors, even if this requires considerable detours.
2. *Direction strategy:* Choose routes that head towards and lead to the *horizontal* position of the goal as directly as possible, irrespective of level-changes.
3. *Floor strategy:* First find the way to the floor of the destination, irrespective of the horizontal position of the goal.

Mapping these strategies to other accounts, the least-angle strategies can be directly related to the direction strategy, the region based strategy to the floor strategy. The idea of a route *skeleton* proposed by Kuipers et al. (2003) corresponds to the central-point strategy: Over time humans learn a set of central paths (the skeleton) in an environment. However it is not clear, apriori, if reliance on central paths will have a positive or negative impact on navigation performance, especially in the current setting.

Knowledge about the environment

The application of the strategies defined above clearly requires knowledge about the building. Thus experience or familiarity should be an important moderator of strategic choices. This is controlled for by comparing subjects visiting the building for the first time with repeat visitors.

Methods

12 student attendees – seven women and five men - of an annual conference volunteered for this wayfinding experiment. Six "experts" had previously visited the one-week conference at least two times, six "novices" participated for the first time. The conference centre in Günne, Germany was built in 1970 and shows a complex structure both horizontally and vertically (see Figure 1).
Passini (1992) based his seminal qualitative investigations into wayfinding processes on the analysis of individual wayfinding episodes and verbal comments. We extend this approach by quantifying verbal reports and comparing these with behavioural measures. The participants' tasks were to reach six locations in the building. They had to verbalise their thoughts while being video-taped.
For each task, the shortest route and a list of reasonable route alternatives was determined beforehand. Reasonable routes are defined as neither containing cycles nor dead ends or obvious detours. Navigation performance was measured with six variables:

1. time to complete each task
2. stops
3. getting lost, i.e., leaving *reasonable route alternatives,* detour behaviour
4. distance covered
5. distance covered divided by length of shortest possible route; expresses the proportion of superfluous way independent of task length.
6. average speed

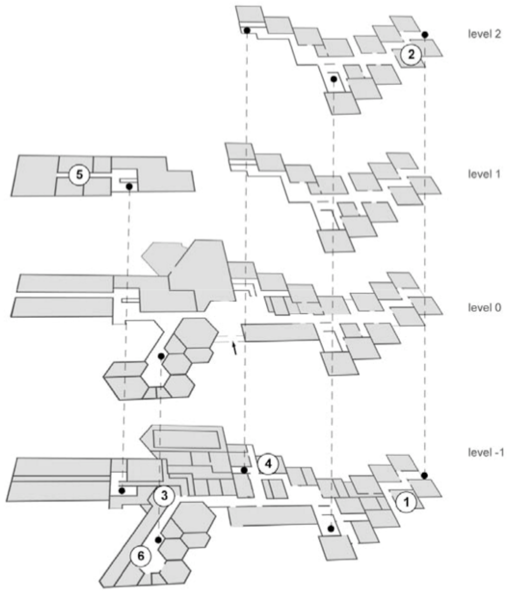

Figure 1: The floors of the building with circulation areas. Stairways are illustrated as vertical connections. Starting points and goals of the navigation tasks are marked by numbers. First, participants had to reach point "1" (anchor), from there point "2" (room 308) and so on.

The participants' verbal comments were analysed by two independent raters, yielding an inter-rater reliability of kappa .7. Additionally, the participants' remarks about their strategies were collected for each task. Four subjectively preferred strategies were identified: the already described direction, floor and central point strategy (see above) and, in addition, the "route is well-known" strategy when participants mentioned walking a completely familiar route.

Results

A. Strategies

Applying a certain strategy clearly alters wayfinding performance. Performance according to the preferred strategy was considered, with task difficulty controlled as a covariate in an ANOVA. As shown in Figure 2 best performance was achieved when walking a well-known route (except stops; all five $F(3,56)>3.1$, $p<.035$).

Partialed out means	Central point strategy	Direction strategy	Floor strategy	Route is well-known
Time [s] *	140	145	113	67
Stops [n]	1.05	1.50	1.62	0.18
Getting lost [n] *	0.23	0.69	0.35	0.03
Distance [m] *	142	119	97	68
Way/shortest way*	1.86	1.38	1.33	1.06
Speed [m/s] *	1.04	0.86	0.96	1.29

Figure 2: Average performance per task solved with the preferred strategy. The influence of task difficulty is partialed out. Significant differences are marked by asterisks.

When using the direction strategy or the central point strategy, the absolute and relative distance as well as time measures indicated the worst performance. With a central point strategy participants to some extent walked known (sub-) routes and therefore could walk quite fast without getting lost. As the routes taken were longer than in other strategies, it took longer to reach the goal. With the direction strategy participants got lost more often and needed to reorient, so that average speed dropped. The same amount of time was needed to reach the goal as in the central point strategy, even though the distance was shorter. But the floor strategy resulted in better performance with respect to *both* distance and time, thus avoiding the relative deficits of the central point and direction strategies.

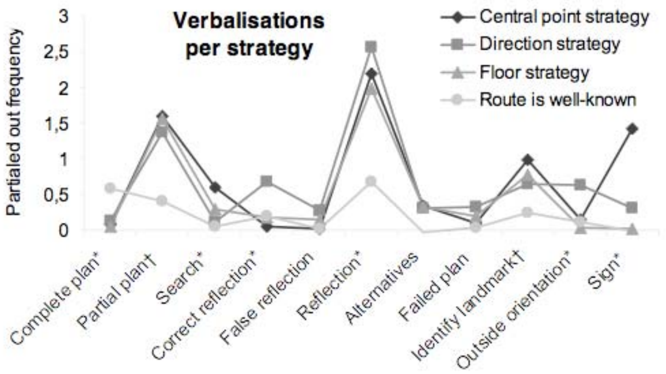

Figure 3: Average verbalisations per task solved with the preferred strategy. Significant differences are marked by asterisks, trends by crosses.

The differences between the strategies can also be identified in the navigation process itself, manifested in the verbalisations (see Figure 3, all described differences $F(3,56)>2.9$, $p<.044$). Again, walking a known route was quite different from the other strategies: Participants most often planned their route completely, presumably because they relied on stored (route) knowledge and did not need further reasoning. Participants using a central point strategy most often searched systematically, used signs most often and tended to identify landmarks most often ($F(3,56)=2.58$, $p=.062$) as well as planning their route only partially ($F(3,56)=2.56$, $p=.059$). Participants using a direction strategy mentioned the highest number of correct reflections and general reflections. Very similar results according to both performance measures and verbalisations could be found when the selected route alternative was considered instead of the subjective mentioning of a strategy, providing converging evidence of both measures

B. The Role of Experience

As experts have greater knowledge, we would expect this to be reflected in their performance. And indeed, experts performed better (see Figure 4). They got lost less often, covered shorter distance (absolute & relative), with greater speed, and therefore reached the goal quicker (all six $t(10)>2.23$, $p<.05$).

Can these differences be due to choice of strategies? Indeed, novices and experts differed in their preferred strategies (see Figure 5, n=61, $\chi2(3)=19.0$, $p<.001$). Novices most often chose the central point strategy and almost never walked a well-known route, whereas experts almost never chose a central point strategy and most often either walked a well-known route or used a floor strategy. The direction strategy was used in equal proportions by the two groups.

Performance	Novices M	Novices SD	Experts M	Experts SD
Time [s] *	128	22	95	21
Stops [n]	1.36	0.69	0.78	0.80
Getting lost [n] *	0.42	0.17	0.17	0.21
Distance [m] *	115	16	89	17
Way/shortest way*	1.55	0.22	1.17	0.16
Speed [m/s] *	0.96	0.06	1.10	0.09

Figure 4: Means and standard deviations of the performance of novices and experts.

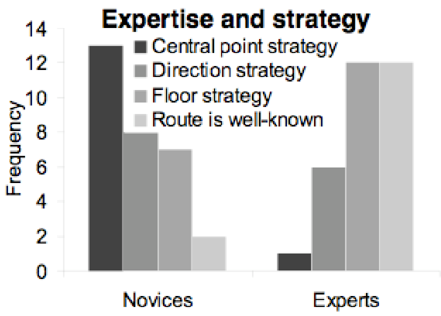

Figure 5: Frequencies of strategy selection in novices and experts.

Discussion

The shortest and fastest way to reach a goal is by using one's knowledge to walk a well-known route, as most experts do. If that is not possible, experts choose the floor strategy which is the best alternative in our scenario. Walking via a central point – like most novices do – or going directly in the assumed goal direction leads to worse performance. The advantage of the floor strategy can be interpreted as a result of a hierarchical planning process. Human performance declines if they have to use pitch rotations to explore a VR labyrinth (Vidal, Amorim & Berthoz, 2004). We might store the different levels of a building separately in memory rather than construct a 3D mental model of the building. This makes navigational decisions that require an integration of vertical and horizontal aspects more difficult. The floor strategy avoids this integration bottleneck with a hierarchical route planning heuristic: first we change to the corresponding vertical level and once we have reached it, the fine-planning is reduced to a two-dimensional problem space. In terms of Wiener et al.'s (2004) fine-to-coarse planning our *floor strategy* can thus be interpreted as a 3D variant of their cognitively efficient regionalisation strategy. As a design consequence, the floor strategy, which is most efficient for unknown goals in multi-level buildings, should be supported by easy transitions between the floors.

The benefits of the floor strategy identified in the present experiment warrant further investigations. What are the specific factors that contribute to the experts' preference for this strategy and what are the relationships to global or local features in the building? Do global features like the configuration of floors and the positioning of vertical connections have greater or smaller impact than local aspects like visibility of paths or signage, the latter of which was not addressed in this study at all. As cognitive scientists we are intrigued by the measures established in the Space Syntax community as extremely valuable for these questions. Thus a Space Syntax analysis of the conference centre is currently under development to shed further light on the interplay of cognitive strategies and building properties, especially for multi-level building scenarios.

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