Developing Cognitively Simple Wayfinding Systems: A Mixed Method Approach

Nina Vanhaeren*, Kristien Ooms*, Philippe De Maeyer*

* Ghent University, Department of Geography

Abstract. Existing indoor navigation systems are not well adapted to their users. Our goal is to substantially improve the wayfinding experience for the users of those systems by adapting the routes that people are guided along to more cognitively simple routes. Guiding people along routes that adhere better to their cognitive processes could ease the wayfinder in the indoor environment. This paper identifies the aspects that should be included in a cognitively motivated route planning algorithm by using a mixed method approach. In this approach, the results of a focus group and an online survey are combined. The validation of the results in a real life experiment is subject of ongoing work. From the focus group discussions, it could be concluded that wayfinding complexity has to be considered at different levels: the global and the local level. Moreover, results of the online survey show that geometric simplicity and visual information at decision points is of substantial importance when studying wayfinding complexity in indoor environments. The implementation of these results in a cognitively motivated route planning algorithm could be a valuable improvement of indoor navigation support.

Keywords. Indoor navigation, Cognition, Routing algorithm

1. Introduction

Navigation is a complex process which involves planning and decision-making. Previous research has showed that particular characteristics of the indoor environment, in contrast to outdoor environments, impedes successful navigation in this environment (e.g. changing floors, complex decision points, the fewer options to monitor landmarks) (Ohno *et al.* 1999, Hölscher *et al.* 2006, Carlson *et al.* 2010).

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Although several attempts are made to guide people in such complex environments, these systems are not yet common practice. Possibly because the existing indoor navigation systems are not well adapted to their users. Route planning in existing navigation systems are often limited by distance or travel time optimization algorithms (e.g. Kwan and Lee 2005, Thill *et al.* 2011) although people not always prefer the shortest path (Golledge 1999). Routes that correspond to the cognitive model of the navigator are easier to comprehend. These more intuitive and easier-to-follow routes reduce the risk of getting lost, require a smaller wayfinding effort, guide in recalling routes and are overall perceived as more comfortable (Vanclooster *et al.* 2014). Moreover, these systems do not just have to provide the (shortest) route from origin to destination, they have to guide the user on the route while easing the user and avoiding confusion. By adapting the path algorithms in these systems, and guiding them along the paths that adhere better to cognitive processes, the user experience could substantially be approved.

To get a better understanding of the complex cognitive processes during navigation and to select the aspects that should be implemented in a routing algorithm that calculates such routes, a mixed method approach was applied. This mixed method approach combines quantitative and qualitative research techniques. This combination help the researcher to explore and generate new ideas, but also helps to develop the study design of the subsequent studies (Freitas *et al.* 1998, Breen 2006). Moreover, the combination of techniques enables the interpretation of the results (Safari and Fakouri 2016). Hence, the qualitative and quantitative research techniques complement and validate each other to support triangulation of the data to obtain more solid conclusions (Ooms *et al.* 2017). In this research, a focus group discussion, an online survey and a real life experiment are combined and we will elaborate the application of this approach in this paper.

2. Methodology

2.1. Focus Group

In this first study, the exploratory focus group, the discussions were guided by a rotating wheel according to the so-called GPS-method which was developed by the Flanders District of Creativity. The group of participants comprised academic researchers and experts with different background (i.e. Psychology, Geography and Architectural Design). A pilot study was conducted to evaluate the method and design a detailed time scheme. The moderator guided the discussions and tracked the time while a second research was taking notes. The session took around 3 hours and consisted of an introduction, an exploratory open discussion and proceeded with more

structured discussions resulting in a selection and a concluding discussion on the most prominent concepts that where brought up during the previous discussions.

2.2. Online survey

Based on the results of the focus group, multiple situations with specific local characteristics likely inducing confusion and discomfort (e.g. specific intersections, different stair cases, different door types) were selected. Videos of these specific situations were recorded from the navigator's perspective in various complex buildings (i.e. university hospital and three different university campus buildings) differing both in geometric complexity as in appearance. The survey was published on Amazon Mechanical Turk. In the online survey, videos of these situations were shown to the participants, as if they were navigating through the building. After watching the video, participants were asked to rank their comfort and confusion level about the recorded situation on a 5-point Likert-scale and they had to specify their motives for their ranking. Both the ranking and the open-ended questions where compared to the characteristics depicted in the videos.

2.3. Experiment

Since body-movement and the real-world perceptions, which have a substantial impact on information processing and spatial decision making (Schwarzkopf and Stülpnagel 2013), are excluded in these well-controlled lab environments of the previous studies, a real-life experiment will be executed to validate previous findings. The developed study design is in line with the experiment design of previous wayfinding studies (Hölscher *et al.* 2005, 2009). Eye tracking data of participants guided through different complex buildings along different paths (i.e. shortest path and fewest turn path) will be recorded. Performance measures (e.g. duration, stops, errors), eye tracking measures (e.g. fixation number, fixating duration) and annotations of the accompanying researcher, which are all measures indicating complexity and cognitive load, will be compared across the different paths and its decision points. This analysis will allow us to determine complex routes and to identify the environmental characteristics increasing the perceived complexity. Moreover, it will lead to an understanding how and in which occasions people make wayfinding errors.

3. Results

As expected, the results of the focus group discussions provided a broad overview of the elements to be regarded when studying wayfinding. The results confirmed the findings in literature: preferred wayfinding strategies

(Hölscher *et al.* 2006), the environmental characteristics of Weisman (Weisman 1981) and the usability hotspots of a complex building (Hölscher *et al.* 2006) were discussed and thus are of importance when studying wayfinding. Moreover, results indicate that route complexity has to be considered at different levels: local level (i.e. at decision points) and global level (i.e. legibility of the building).

Therefore, a selection of local environmental characteristics raised in the focus group discussions were selected to be tested in the online survey. The results of the online survey show that visibility, visual clutter and geometric simplicity are of substantial importance when evaluating comfort and confusion level, and thus the complexity of indoor navigation situations.

4. Conclusion

In this paper, a mixed method approach was applied to study indoor wayfinding processes in the indoor environment aiming at adapting existing navigation systems according to the findings. The applied mixed method approach combines qualitative and quantitative research techniques. In the initial exploratory phase (i.e. focus group), the researchers explored the issues related to indoor navigation and wayfinding. Consequently, this leaded to an adequate research design of the subsequent studies (i.e. online survey and experiment). Moreover, by combining the results of both the qualitative and quantitative studies the results of the focus group could be validated while the results of the online survey could be interpreted using the results of the focus group. To validate the findings of the two previous studies, a real-life experiment is being conducted. The validation and interpretation of the results of the different studies using the results of the other studies will lead to a coherent and well-founded conclusion of the elements to be included in cognitively motivated wayfinding support. The implementation of these findings in a route planning algorithm would substantially improve the existing systems.

References

Breen, R.L., 2006. A Practical Guide to Focus-Group Research. *Journal of Geography in Higher Education*, 30 (3), 463–475.

Carlson, L.A., Hölscher, C., Shipley, T.F., and Dalton, R.C., 2010. Getting Lost in Buildings. *Current Directions in Psychological Science*, 19 (5), 284–289.

Freitas, H., Oliveira, M., Jenkins, M., and Popjoy, O., 1998. The Focus Group, A Qualitative Research Method. *Isrc*, (010298), 1–22.

Golledge, R.G., ed., 1999. *Wayfinding Behavior: Cognitive Mapping and Other Spatial* Processes. Baltimore and London: Johns Hopkins University Press.

Hölscher, C., Büchner, S.J., Meilinger, T., and Strube, G., 2009. Adaptivity of wayfinding strategies in a multi-building ensemble: The effects of spatial structure, task requirements, and metric information. Journal of Environmental Psychology, 29 (2), 208–219.

Hölscher, C., Meilinger, T., Vrachliotis, G., Brösamle, M., and Knauff, M., 2005. Finding the way inside: Linking architectural design analysis and cognitive processes. In: B.T. Reksa C., Knauff M., Krieg-Brückner B., Nebel B., ed. Spatial Cognition IV. Reasoning, Action, Interaction. Springer, Berlin, Heidelberg, 1–12.

Hölscher, C., Meilinger, T., Vrachliotis, G., Brösamle, M., and Knauff, M., 2006. Up the down staircase: Wayfinding strategies in multi-level buildings. Journal of Environmental Psychology, 26 (4), 284–299.

Kwan, M.P. and Lee, J., 2005. Emergency response after 9/11: The potential of real-time 3D GIS for quick emergency response in micro-spatial environments. Computers, Environment and Urban Systems, 29 (2), 93–113.

Ohno, R., Kushiyama, N., and Soeda, M., 1999. Wayfinding in cases with vertical traveling. Journal of Architecture and Planning (Transactions of AIJ), 64 (516), 87–91.

Ooms, K., Dupont, L., and Lapon, L., 2017. Mixing Methods and Triangulating Results to Study the Influence of Panning on Map Users' Attentive Behaviour. Cartographic Journal, 54 (3), 196–213.

Safari, H. and Fakouri, F., 2016. Influence of geometry on legibility : An explanatory design study of visitors at the Kuala Lumpur City Center. Frontiers of Architectural Research, 5 (4), 499–507.

Schwarzkopf, S. and Stülpnagel, R. Von, 2013. What Lab Eye Tracking Tells us about Wayfinding A Comparison of Stationary and Mobile Eye Tracking in a Large Building Scenario. In: Eye Tracking for Spatial Research, Proceedings of the 1st International Workshop (in conjunction with COSIT 2013). 31–36.

Thill, J.C., Dao, T.H.D., and Zhou, Y., 2011. Traveling in the three-dimensional city: Applications in route planning, accessibility assessment, location analysis and beyond. Journal of Transport Geography, 19 (3), 405–421.

Vanclooster, A., Ooms, K., Viaene, P., Fack, V., Van De Weghe, N., and De Maeyer, P., 2014. Evaluating suitability of the least risk path algorithm to support cognitive wayfinding in indoor spaces: an empirical study. Applied Geography, 53, 128–140.

Weisman, J., 1981. Evaluating architectural legibility: Way-finding in the built environment. Environment and Behavior, 13 (2), 189–204.