More than 10 Years of Evaluating Public Transport Maps

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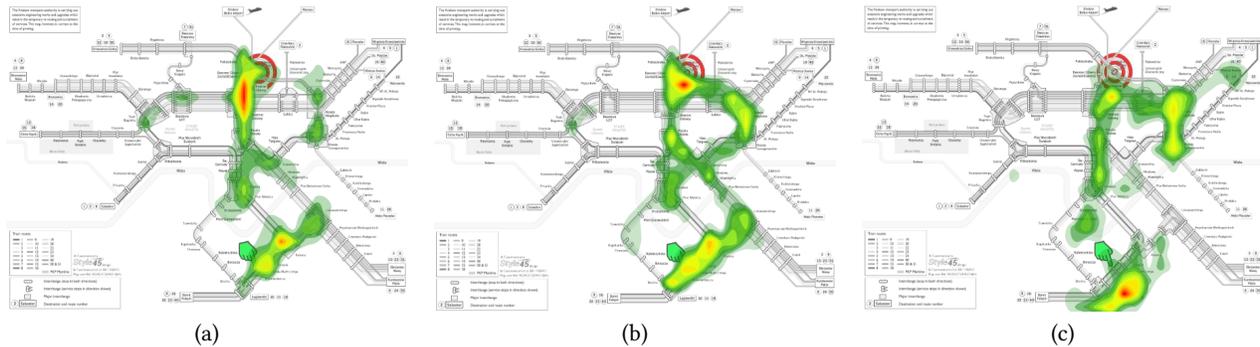Communicarta Ltd.
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Figure 1: Visual attention of public transport map users for different age groups: (a) People of ages 20 to 25. (b) People of ages 26 to 30. (c) People of ages 31 to 40.

Abstract

Public transport maps follow certain design rules that support the solution of user tasks typically focusing on route finding. There is not a unique set of design rules but such maps are typically differing in the combination of visual variables. To understand which of the various designs is the best one for travelers we applied eye tracking technology to record and analyze visual attention patterns to detect design flaws and based on them, improve the current design. Our work is twofold and focuses on research questions important for academic purposes but as an even more important aspect we include the expertise of a professional map designer, hence bridging the gap between academia and industry for this kind of design goal in UX. We describe our experiences and results of a more-than-10-years-collaboration.

CCS Concepts

• **Human-centered computing** → **User studies**.

Keywords

Public transport maps, Eye tracking, Eye movement data analysis

1 Introduction

Public transport maps [4] have been investigated in the past as a visual way to support travelers in a strange, typical town environment. Several design principles have been developed in recent years [13] to make the visual appearance of the maps and the solution of typical route-dependent tasks as easy as possible for human users. User experience plays a crucial role here since improving such maps can lead to a better product and higher sales numbers for the industry.

However, simply inspecting the design problem from a purely academic perspective would not lead to successful results, as domain knowledge [3] is often missing in the form of an industrial partner [12]. However, creating maps without experience with novel technologies, including eye tracking [1], may also not lead to promising results. Only the synergy of both worlds can be a starting point for efficient and effective solutions [7].

In this paper, we describe an empirical project in which the usability of public transport maps under different perspectives is investigated. Public transport maps (see Figure 1 for some visual attention maps overlayed on such maps) are actually created by domain experts taken into account a human-centered design to make them efficiently interpretable for the tasks at hand, including finding the route and getting an overview about foreign cities and their bus and train systems [12].

The project can be regarded as a successful collaboration between academia and industry, since it resulted in more than 30 peer-reviewed scientific publications on this topic in several conference proceedings and journals (see Figure 2). Due to the fact that there was no money involved in the project and no time pressure, many ideas could be developed and researched, making it a project without real constraints. The project started in 2013 as a pilot eye tracking study presented at an international workshop on
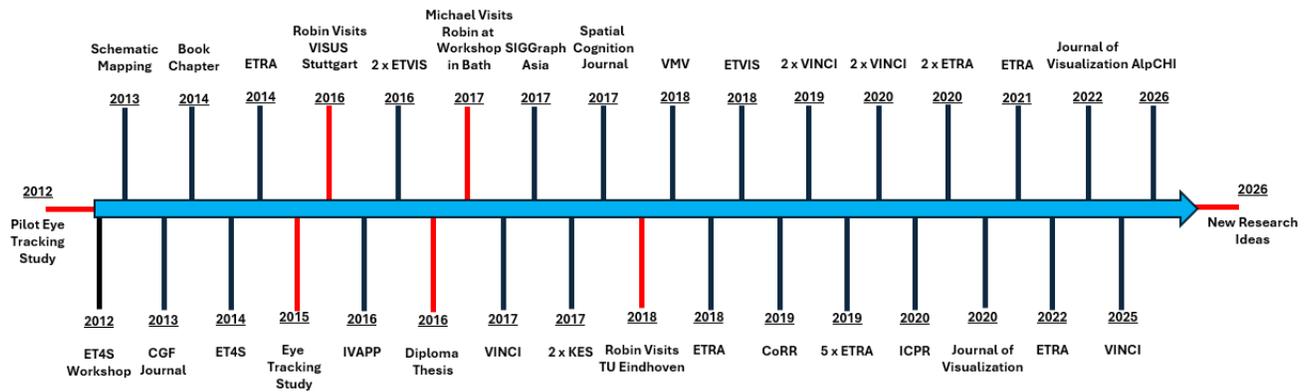
Figure 2: The collaboration led to several events and meetings (red color) and workshop, conference, and journal publications (black color) over the years.

schematic mapping [2]. The presentation and the following discussions led to a collaboration between an academic and an industrial partner for the following years and are still going on, meaning that there is actually no pressure in form of money or time constraints.

2 Related Work

Public transport map design is focusing on improving layouts and visual variables to better support travelers at solving route finding tasks [4]. Multi-criteria optimization is required to obtain suitable designs [11], for example as a semi-automatic process including man and machine. However, the geographic positions must be maintained as good as possible to avoid misinterpretations while the network topology is important as well [8]. Still, there are various different designs that all support travelers in different ways, but the best possible design remains an open research problem [7].

From a user experience perspective, not only the design is a crucial ingredient but also aesthetics that is well-known from the graph drawing field [9] including symmetries, reduced link lengths, or the reduction of visual clutter [10], all criteria have tremendous impacts on path finding tasks in maps and can reduce readability [5]. Not only the connections in form of lines but also the labeling of stations or additional sights and viewpoints can cause problems during the design as well as the interpretation phase [6]. Eye tracking [1] can be a useful technology to record and understand user behavior and usability in such maps for typical tasks that have to be solved when finding one's way by just inspecting such maps. Related topics including user studies, with or without eye tracking, can have benefits for research in academia and industry, building synergy effects.

3 Research Problems and Project Details

The project started with the research question if public transport maps can be used in the same way when they are just printed in grayscale and not in their traditional color coded style. This research question was the central idea after a brainstorming in a schematic mapping workshop. Robin Woods, a professional map designer, mentioned that a grayscale variant of printed copies would save

a lot of money during the production process of the maps. The project did not have any starting point nor any kind of deadline, it was more like a fun project with synergy effects and positive inputs from both sides - academia and industry.

3.1 Research Questions

We started this project with several research questions in mind.

- **RQ 1:** Is there any kind of user experience in the domain of public transport map design and how can it be measured and recorded?
- **RQ 2:** Based on such data measurements, how can we enhance current map designs and what are the problematic and challenging issues when modifying existing maps?
- **RQ 3:** Can the industrial partner provide a clear research question that is relevant for public transport map designers?

After a first meeting with the project partner at an international meeting we developed a relevant concrete research question that created one important independent variable in our eye tracking research: Can gray-scale maps keep up with their color coded counter parts or are they perceptually more problematic to understand?

3.2 Time and Costs

The project is a collaboration that is built on results from both perspectives - academic and industrial ones. For academic research we can support Bachelor, Master, and PhD students with a relevant topic to do their research while from an industrial perspective the benefits lie in learning about better designs for public transport maps and saving costs.

We rather see the missing monetary support as an advantage for doing research in many directions than a limiting factor. Hence, this project can be regarded as a win-win situation for both involved parties.

4 Academic-Industrial Benefits

There are several benefits that we were aware of when starting this project. During the project we found many more challenging but interesting research questions and goals that give even more ideas

for future projects. In summary, we can say that the project created many synergy effects for both sides.

4.1 Academic Perspective

From an academic perspective we see many benefits:

- **Expertise:** Researchers can brainstorm and learn from the expertise of a domain expert.
- **Education:** PhDs and bachelor/master students can be educated in a real-world scenario.
- **Testing:** New eye tracking equipment and the involved technologies can be tested.
- **Learning:** New ways for analyzing this kind of data can be learned and practiced.
- **Publishing:** The results of the research can be published at academic conferences, leading to more feedback and even more ideas.
- **Networking:** All of this creates a network of researchers around this topic.

To this end we published more than 30 papers and journal articles on this topic while even more have been published by other researchers investigating the publicly available dataset.

4.2 Industrial Perspective

From an industrial perspective we see lots of benefits as well:

- **Costs:** For the industrial partner there were nearly no costs.
- **User experience:** Industrial applications are better evaluated for end users and customers.
- **New technologies:** A new technology in form of eye tracking can be learned and applied.
- **Dissemination:** Other project partners can be better convinced due to additional visual attention patterns.
- **Results:** Other domain experts can be easier included by discussing results that they were not aware of.
- **Production costs:** The production costs for public transport maps can take into account an improved design.
- **Industrial competition:** The industrial partner can better keep up with the competition between other domain experts due to an improved design.

5 Challenges and Limitations

During this project we identified some challenges and limitations. The costs and time were not the actual challenge but more finding interested people who were willing to contribute, study participants as well as students who do research for their bachelor, master, or PhD theses.

- **Lack of interest:** Although the project included eye tracking technology and map design which are interesting topics we had some issues to find interested students, however, after some time we were able to fill these gaps.
- **Data analysis:** Eye tracking technology generates a wealth of spatio-temporal data which requires advanced data analyses and visual analytics techniques to find patterns and anomalies in the data.
- **Publication:** Finding suitable venues and getting the reports through the peer reviewing was sometimes a tedious task

but finally, we were able to publish more than 30 scientific papers on this topic.

- **Travel costs:** Funding for conference travel, registration, and accommodation costs must be covered by related projects focusing on eye tracking or spatio-temporal data analysis.

6 Conclusion

We illustrated a synergistic project between academia and industry that generated a wealth of peer-reviewed publications and many insights that we did not expect before starting the project. A single research question coming from an industrial partner created the starting point for this project related to public transport maps and eye tracking. We described the major stages and some of the major outcomes from both perspectives. For future work we plan to investigate further research questions related to this topic including signage and user behavior when traveling around the world.

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