Towards Novel Urban Planning Methods - Using Eye-tracking Systems to Understand Human Attention in Urban Environments

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ABSTRACT

Data on how humans perceive the attractiveness of their (urban) environments has been mainly gathered with qualitative methods, including workshops, interviews and group discussions. Qualitative methods help us to understand the phenomenon, albeit with the cost of sufficient information as concerns its details. We may end up confirming something that we as researchers have 'programmed' to get as a result. Here we take a complementary approach, having collected eye tracking data from two case experiments. The participants to these experiments were professional urban planners and non-professionals respectively. We asked them to view planning-related artefacts comprising architectural illustrations, photographed landscapes and planning sketches.

CHI'19 Extended Abstracts, May 4-9, 2019, Glasgow, Scotland, UK.

ACM ISBN 978-1-4503-5971-9/19/05.
DOI: https://doi.org/10.1145/3290607.3299064

After analysing the findings from these experiments, we draw guidelines for using the eye tracking system in urban planning processes for gathering the human perceptions of attractive urban environments.

CCS CONCEPTS: • Human-centered computing → Empirical studies in HCI

KEYWORDS: Urban planning; participatory planning; eye-tracking

ACM Reference format:
Teija Vainio, Ilari Karppi, Ari Jokinen, Helena Leino. 2019. Towards Novel Urban Planning Methods – Using Eye-tracking Systems to Understand Human Attention in Urban Environments. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI'19 Extended Abstracts), May 4–9, 2019, Glasgow, Scotland, UK.* ACM, New York, NY, USA. 8 pages. https://doi.org/10.1145/3290607.3299064

1 INTRODUCTION

The 21st century global wave of urbanization has made Homo sapiens a predominantly urban species. Thus, the liveability of urban areas is now an existential question par excellence [9]. Attractiveness, in turn, is a key tangible component for an individual to perceive urban environments as liveable. Consisting of widely researched and carefully measured items [5], attractiveness provides a good point of departure for our analysis.

Attractiveness of a place is not only viewed in terms of economic or local strategic attributes. Individuals both consume and produce the factors of place attractiveness [15]. Thus far, the elements of attractive urban environments have been investigated mainly with qualitative methods, such as surveys, workshops, interviews and ethnographic means [see 7, 8; 10; 11; 12]. However, for practical planning decisions, the conclusions of qualitative feedback may not be sufficiently detailed. Moreover, as the non-experts in urban planning often lack the appropriate professional vocabulary, describing what is interesting or disturbing in the structure and elements of the urban environment is challenging. To tackle this communicative gap, we present in this text a complementary approach. We widen the use of technology for capturing human perceptions, already tested in landscape planning [3], to the built urban environment.

This paper describes our experiences of using an eye tracking system to gather data on human perceptions in urban environments as a part of CONTURB research project carried out at Tampere University, Finland, between 2011 and 2015. The focus of the project was to study the interplay of urban dwellers, planning technologies and transforming urban environments. One of the roles vested in technologies in urban planning is to support the planning and decision-making processes with visualizations [4,13], exemplified by geographical information systems (GIS), the public transport map Digital Matatus [2] or a scenario building Envision Tomorrow [6]. Additionally, technology can be utilized to analyse automatically gathered data on human mobility and behaviour patterns [8].

In the recent years, new technology and information systems have also been applied to gather human perceptions in urban and rural environments, for example in landscape planning, to gather experiential data with the help of eye tracking systems [3,14].

One of the main strengths of eye tracking technology in the design of urban environments is its power in gathering quantitative data on human observations. Human observations bring valuable insights to our understanding of the characteristics of eye-catching surroundings in urban contexts. Based on a deeper understanding on the attentional factors in urban environments and what people look at in planning pictures and sketches, we can provide valuable information for urban planners and decision makers. Consequently, our study investigates how people observe planning illustrations and what elements catch their attention in these pictures. In addition, we compare these results with those showing what catches human attention in real urban environments illustrated with photographs.

2 BACKGROUND AND MOTIVATION

According to Herzele and Wiedermann [8] 'the abstract qualities derived from human — environment studies are perceived through physical features. However, existing knowledge on the physical appearance of perceived qualities is still limited. Moreover, there is scientific evidence that indicates that physical features cannot be systematically related to qualities in an objective way. Each place has a unique set of interrelationships between physical features and perceived qualities. ` Therefore, what people find attractive in urban environments is very context- sensitive and subjective matter. By analysing what physical elements people look at in different environments helps us to understand what caught human attention and thereby we could better understand the elements of the urban design quality from the non-expert's perspective. Eye tracking technology provides complementary tools for this purpose. With eye tracking technology, we are able to gather objective data on what people look at, but as Bojko has stated, we must consider that 'where you look depends on the properties of what you are looking at, as well as your goals, experiences, and expectations' [1].

Therefore, in order to understand why people look at something in the urban environment and if this is because an attractive or disturbing element has caught their eye, we need a rich variety of data. To do this, we analysed the process of how professional urban planners and architects viewed urban planning documents and photographs and compared the findings with the way of how regular urban dwellers viewed the material. We chose the professional planners, because they work with visualizations and are key players in tensions between different views of urban environments in planning [17]. We also wanted to know how professionals themselves view illustrations. The research question we addressed in this paper is as follows:

> *What are the strengths and challenges when applying an eye tracking system to gain insights on human attention with planning illustrations and photographs of urban environments?*

3 EXPERIMENTS

This paper presents part of our results in the research project on creating meaningful continuities between urban dwellers, technologies and environments in planning (CONTURB), funded by the Academy of Finland 2011-2015. The study related to eye-tracking methods was carried out in two phases and in two Finnish city areas (Espoo, Tampere) during the years 2013-2015.

3.1 Procedure

The professional planners amongst the participants were invited by email. The non-professional participants were selected randomly from the centre streets and a fringe-located shopping mall in Tampere area. The first test took place in March 2014, and the latter ones in June 2015.

In the first phase, the researchers explained the test procedure to the participants, and the eye tracking system was calibrated. The participants were shown six photos of urban environments during the first two tests and 15 photos during the third test. They were asked to watch the photos freely, and the photos were displayed for 15 seconds each. The question in the beginning of the test was as follows: 'What are the characteristics of desirable urban environments?' In our test setup, there were no reading texts or text image comprehension. The visualisations used in the test were either photographs representing real urban scenes or architectural illustrations and planning sketches made for ongoing planning processes in Espoo and Tampere. There were street views as well as bird-eye perspective views amongst the planning sketches.

In the second phase, the participants filled out the questionnaire before the eye-tracking test. Afterwards they were shortly interviewed about their experiences on the test.

The eye tracking system used in our tests was Tobii T60 XL Eye Tracker with a high-resolution 24-inch TFT wide screen monitor. The system does not include a chin rest. The tests took place in undisturbed conditions in office rooms (Espoo), in a university classroom (Tampere) and in a public shopping mall (Tampere fringe, office room). After administering the eye tracking tests to the Espoo planning professionals, we organised a workshop where the participants of the test were invited to discuss the results. This helped us to study the broader scope of interpreting the test results.

3.2 Participants

There were altogether 29 participants in our study aged 18 to75; 65% were female and 35% male. In the first settings, all the participants were urban developers, either architects or urban planners. During the last session, there were 20 non-professional and 5 professional urban planners amongst the participants.

This composition of participants distinguished our test from many related experiments; it is usual in experiments to operate with psychology or urban design students.

3.3 Outcomes

The outcomes of the experiments were analysed using both qualitative and quantitative methods. At the first phase of the research project, the visual summary of the quantitative data analysis was discussed with the participants to be able to interpret the results. At the second phase, the quantitative data was enriched with the questionnaires and short interview. The results of the second phase were analysed with descriptive statistical analysis and content analysis. The quantitative data analysis was focused on comparing

1. areas of interest (AoI) and fixation count, i.e., the number of times the participant fixates on an active AoI or within all active AoIs belonging to an AoI group (count)

2. visit count, i.e., the number of visits within an AoI or an AoI group.

Areas of interest (AoI) refers to technically predefined areas in visualisations. We defined them using our expert knowledge of the central structures and elements in urban environments.
The participants were voluntary, and we explained the study and testing procedure; they were informed that they could withdraw from the study at any time. In data gathering, analysation and archiving, we followed the ethical research guidelines of the University of Tampere and put emphasis on 1) respecting the autonomy of research subjects, 2) avoiding harm and 3) protecting participants' privacy and data [16].

4 PRELIMINARY FINDINGS

The eye tracking system was a novel technology for most of the participants and researchers. Most of the participants were using the technology for the first time, but they felt the technology was quite easy to use.

4.1 Professional planners' and non-professionals experiences

Strengths: None of the professional planners had used the eye tracking system before. However, as the system was quite easy to use and quick to calibrate, participants experienced adjusted comfortably. None of the non-professionals were familiar with the eye tracking technology, either, but they felt the technology was quite easy to use. One of the main strengths was the easy test setup in a location that was familiar and easy to reach for the participants. With light-weight technology, the test setup could be basically where the people were. Altogether, the test lasted approximately 5 minutes/ user, so it did not take too much of the participants' time, and they could easily agree to take part in the experiment.

Challenges: Since the participants had no experience with the eye tracking technology, some confusion on how the data could explain the attractiveness of urban environments was brought up. In addition, participants thought that the familiarity of the environment that was presented to them could have an impact on where they looked and where they did not.

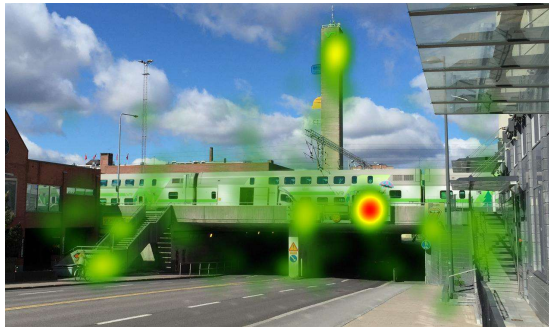

Figure 1: Figure 1 A heat map describing a street view (photo credits T.Vainio)

4.2 Researchers' experiences

Strengths: As the eye tracking systems is mobile, tests could be conducted near the participants' work environments or other easily accessible places. Also, the possibility to gather quantitative data on human perceptions, including the unconscious episode of perception, is a clear strength. With respect to organising workshops afterwards and discussing with the participants about their experiences, the method proved to be fruitful, as all of the participants were keen to see the results of the eye-tracking method. In addition, the participants found it easy to discuss the method and the results in these sessions. The discussions would have been certainly different without the first phase implementation with the eye-tracking method.

Challenges: One of the main challenges was with the huge amount of the quantitative data. With statistical analysis, descriptive statistics were easy to calculate, but the main challenges were how to interpret both the qualitative and quantitative data. Defining the areas of interest (AoI) was also a demanding task. According to Bojko [1], AoIs should be defined according to what is relevant to the study objectives. In addition, as 'accuracy and precision of eye trackers are not perfect, avoid small AoIs and include padding where possible' [1]. As the question of attractiveness of urban environments guided our research, we wanted to compare distinct AoIs in visualisations presented to the subjects of our study. Therefore, we chose AoIs that did not overlap.

We also wanted to combine the eye tracking data with qualitative analysis. Regarding qualitative analysis, the main aim is to understand how someone looked at something. In our study, we reviewed the qualitative results first with graphic illustrations called heat maps. As heatmaps describe how intensively participants individually or as a group looked at something at a picture, heatmaps don't explain how to distinguish areas that are attractive from areas that are disturbing. Therefore, as attractiveness of an urban environment cannot be concluded only based on heat maps, we necessarily needed quantitative data to support our analysis.

In our case, the qualitative analysis of a free viewing open-ended task was supported with organising a workshop afterwards and going through the results by displaying the heat maps and letting the participants discuss the heat maps and their experiences of a particular picture, see Figure 1. This phase was very crucial for interpreting the final results and providing design implications for the actual urban planning processes.

5 GUIDELINES

Based on our experience on using an eye tracking method in an urban planning context and securing the quality of data provided by this method, we summarise our findings as the following guidelines:

- Design areas of interest (AoI) so that they support certain questions and hypotheses. Areas of interest could be defined in multiple ways, but cropping should support the study's original design goals and questions.
- Define the goals for measurements.

• Define if the goal of the element in an urban environment is to be attractive or indistinguishable

• Compare areas of interest. Eye tracking technology provides quantitative data and therefore comparing, for example, two types of elements in the same plan, offers understanding of what is most likely to catch people's attention.

• Analyse the quantitative results with participants. This supports the argument that quantitative data provided by eye tracking technology does not explain the whole visualisation, and one may make opposite conclusions regarding what participants originally intended to look at.

According Bojko [1], for example, goals, experiences and expectations have an impact on where people look. Therefore, to understand why people look at something and to distinguish between attractive and disturbing elements, we need different kinds of data to interpret the results.

For HCI practitioners and researchers, these guidelines provide useful insights for validating the quantitative results.

6 FUTURE RESEARCH AND CONCLUSIONS

Our future research will focus on investigating how new technologies, such as eye tracking in the urban planning domain could be integrated as part of the urban planning processes that are based on the participatory design approach. Consequently, the general development of eye tracking technology as a data gathering method in urban planning is an integral part of our research agenda. With this technology, the comparison of human perception between different stakeholder groups and populations is possible. Secondly, the comparisons between different designs are supported by quantitative data and therefore bring more knowledge on what the actual eye catchers in urban environments are. The method is highly underused in the urban planning domain.

Using these techniques, we can support design decisions in urban planning processes by gathering quantitative data with eye tracking systems to provide more knowledge on what people look at when analysing urban environments. The findings of our research are of interest not only to the academic debate on urban planning, but also to practitioners who utilise visualisations in planning and design or coproduce novel forms of civic engagement with urban dwellers. Many other interest groups are potentially interested to know what catches human attention in urban environments or visualisations.

To conclude, we argue that eye tracking technology offers valuable insights by providing quantitative data on what people look at in diverse types of environments and therefore supports communication between different stakeholders during urban planning processes.

ACKNOWLEDGMENTS

Our thanks go to our subjects for their participation in our tests and to the Academy of Finland for funding the research

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