VII.

Interaktivni sustavi i korisničko iskustvo

Teaching Eye Tracking: A Method to Record and Analyse Visual Attention

Michael BURCH
Center for Data Analytics, Visualization, and Simulation
University of Applied Sciences, Chur, Switzerland
michael.burch@fhgr.ch

Gabrijela VIDIĆ
University of Zadar, Croatia
gvidic@unizd.hr

Jessica ZEITER
University of Applied Sciences, Chur, Switzerland
jessica.zeiter@fhgr.ch

Raphael BRUNOLD
University of Applied Sciences, Chur, Switzerland
raphael.brunold@fhgr.ch

Abstract

Visual scenes, pictures, interactive user interfaces, or movies and animations are types of visual stimuli that are visually attended to be able to solve certain—simple or complex—tasks. Without tracking the eyes of human observers, it is difficult to analyse in which order and for how long some visual objects are observed to solve such tasks. Many insights from eye movements can be very helpful to understand humans' visual behaviour with the goal to detect design flaws in the stimuli and to improve them based on visual attention patterns. In this chapter, we describe how the research method of eye tracking can be taught in 10 lectures over a two-week course during a summer school at the University of Zadar. This helps students with nearly no experience in eye tracking to start designing and conducting their own eye tracking studies. They learn how to analyse visual attention data and to evaluate humans' visual attention behaviour. Our teaching concept consisted of theoretical and practical lecture units while the students worked in an active learning style, i.e., the taught concepts were studied on one's own desire to reach the teaching goals. Finally, the students described their study design, procedure, technical details, and the visual attention results in a written report. To illustrate the success of our teaching concept, we describe the results of one of several eye tracking experiments, focusing on food menus and which dishes are visually attended, comparing dish description with and without images as an independent variable in the eye tracking study. Finally, we discuss some limitations of eye tracking, particularly focusing on teaching, the eye tracking study itself, and general challenges in this research method.

Keywords: eye tracking, teaching, visual attention, user experiments

1. Introduction

Eye tracking (Burch, 2022; Duchowski, 2017; Holmqvist, 2011) is a research method that has been known for a while. However, its real benefit comes in the increasing amount of recorded spatio-temporal eye movement data and many application fields in which it has great potential (Blascheck, 2015). The real challenge lies not in the recording of the data, but in its analysis and visualization. Moreover, the data is often no longer static, allowing for post-processes and post-analyses, but it can also be dynamic—such as real-time eye movement dana—which require algorithms capable of rapidly analysing the data to provide real-time answers to the tasks at hand.

There is a shortage of experts not only in eye tracking but also in data science, i.e., researchers who are able to understand the challenges from both perspectives, helping to create a value from the data in form of patterns, insights, and knowledge. To mitigate this situation for future research in this domain, we are focusing on the teaching of both eye tracking and data science (Burch, 2020). However, since eye tracking is a multi- and interdisciplinary technique (Burch and Kurzhals, 2024), there are still many related disciplines that have to be taught, such as user experience, visualization and visual analytics, human-computer interaction, machine and deep learning, algorithmics, as well as mathematics, to mention only a few from a longer list.

Teaching young students in eye tracking is hence challenging due to the interdisciplinarity aspect of this technique. Focusing on eye tracking only is not enough to guarantee a successful researcher who is capable of solving state-of-the-art problems. Those come into play with the application of eye tracking, both from the hardware and software perspective. The reliable recording of the data (Duchowski, 2017) as well as the rapid analysis to detect patterns and anomalies in the visual attention behaviour (Holmqvist, 2011) of one, several, or even thousands up to millions of people in future scenarios (Blascheck, 2015) are important aspects.

In this chapter, we introduce some related work including research in eye tracking as well as teaching (Section 2). In the next step, we discuss the benefits of eye tracking from several perspectives such as data recording, data analysis, data visualization, and human users with their tasks at hand (Section 3). A discussion on the course's relevant components is provided, along with insights into the grading system (Section 4). During the courses, the students developed and designed eye tracking studies from which we select one popular example as a corresponding use case including the visual attention on food menus (Section 5). Finally, we discuss challenges and limitations in eye tracking, but also in teaching this topic (Section 6). We conclude by summarizing our research and providing some ideas for future work (Section 7).

2. Related Work

There have been many attempts in the past to record people's eye movements (Yarbus, 1967). Regardless of the stimuli shown to a person, the main research question focused primarily on the use of visual attention behaviour to understand how individuals perceive a stimulus (Kurzhals, 2014a), which difficulties they have to complete a given task (Yarbus, 1967), and to identify common visual scanning strategies that provide insights into their overall visual behaviour. Eye tracking devices have been steadily improved from the hardware perspective. However, nowadays more and more focus is put on the software perspective, designing and developing algorithmic and visual solutions to increasingly large spatio-temporal eye movement datasets (Kurzhals, 2014b; Kurzhals, 2016). Even physiological measures such as EEG, GSR, pupil dilations, or even body movements (Blascheck, 2015) are recorded to enable the computation of results from human behaviour, whether related to visual attention or motoric body movements.

Cognition (Koch, 2022) is also playing a crucial role in the field of eye tracking, but, unfortunately, it can hardly be measured to obtain reliable results that can successfully be combined with and linked to the eye tracking data (Katona, 2022). Moreover, perception and psychology are also important when it comes to analysing human behaviour, but still there remains a gap that researchers aim to close in the future (Hayhoe, 2002). The eye-mind hypothesis is one buzz word that comes into play when human behaviour is investigated from different perspectives such as visual scanning and cognitive processing. When analysing recorded eye movement data, we actually try to interpret the eye movement data for patterns and anomalies, which typically requires taking into account the eye-mind hypothesis, which suggests that we attempt to align visual behaviour with cognitive processes (Koch, 2022).

In general, teaching eye tracking comes with many challenges—structural, topical, and temporal—due to its inherently interdisciplinary character (Burch, 2022); as a result, it can only be taught partially by discussing the key components that can be easily understood by students. Hence, our teaching concept focuses on several major aspects such as eye tracking hardware and devices, user evaluation and usability, data analysis, data visualization, human-computer interaction, and eye movement data analysis and visualization software, combined with some related and important topics. To reach our goals, the students received input from two perspectives—theoretical concepts and practical experiments with real eye tracking devices. The teaching concept is partially based on active learning (Yang, 2017), which means that there are theoretical and practical teaching units, but the students have to read corresponding literature as well, discuss their findings in their project group, and practice the learned concepts by using one of the provided eye tracking devices.

3. Major Eye Tracking Concepts

Eye tracking involves several major concepts that require special focus to guide students through the course in order to teach them theoretically and practically. We particularly focus on four parts which include data recording, data analysis, data visualizations, as well as human users with their visual scanning behaviour.

3.1. Data Recording

How to obtain eye movement data is one of the first stages in starting a course on eye tracking. A historic explanation of eye tracking devices with included technologies such as infrared light, the human eye, video cameras, and further important aspects are discussed. The granularity of the recorded data over space and time makes a huge difference for the interpretation of the results and is typically dependent on the application domain. We also discuss remote/stationary and mobile/head-mounted eye trackers to explain the usage in different scenarios, for example sitting in front of a computer monitor or walking around in the real world. Visual stimuli can also differ in several aspects, with static vs. dynamic being one of the major aspects that actually do not make a difference for the recording but more for the data analysis, i.e., the software that must be included in each eye tracking device.

3.2. Data Analysis

The analysis of the recorded eye movement data (Netzel, 2017) plays a crucial role in each eye tracking study. Such an analysis should take into account users' demands to solve certain tasks as well as hypotheses and research questions. Typically, this is done by applying statistical approaches to detect patterns and anomalies in the data, i.e., to explore which impact an independent variable has on one or several dependent variables. An analysis can be applied to standard dependent variables from user studies such as error rates or completion times, but for eye movement data this is much more complicated due to the fact that eye movement data consists of spatial and temporal components (Burch, 2022). The combination of those two data dimensions requires more complex analyses like trend detection, clustering, dimensionality reduction, or even data mining.

3.3. Data Visualization

Analysing data for patterns and anomalies is a powerful approach; however, the results of such algorithmic solutions cannot be inspected by the data analyst in cases in which a visual depiction of the results is not provided. Hence, visualizations are important in eye tracking to find insights into data (Blascheck, 2017). Moreover, the visual outputs in forms of diagrams, charts, or plots are equipped with various interaction techniques, meaning that we must also address the research field of human-computer interaction (HCI) in our teaching scenario. Depending on the display used for an interactive visualization, different interaction techniques must be included, ideally in a way that supports collaborative interactions.

Eye movement data visualizations typically focus on three major visualization categories: statistical graphics, point-based visualizations, or area of interest (AOI)-based visualizations (Blascheck, 2017). The first one is mostly used for visualization of statistical data such as fixation durations or saccade lengths in the form of bar charts, histograms, line or box plots. Point-based visualizations do not aggregate the eye movement data. Prominent diagram types are gaze plots or scanpath visualizations. AOI-based visualizations aggregate the eye movement data spatially into areas or regions, denoted as areas of interest (AOI). Typical visualizations for this kind of data are visual attention maps, scarf plots, or AOI rivers. There is an endless list of visualization techniques for eye movement data, each one focusing on specific components in the data, as well as providing solutions to users' tasks at hand, hypotheses, and research questions.

3.4. Human Users

No matter how well-designed and implemented a visual analytics tool for eye movement data is, we still face the challenge of allowing real users to work with it. Even the best tool in the world must be evaluated by users, ideally in an eye tracking study. The users involved in the study bring into play their tasks at hand as well as experience levels and skills, but also personal issues such as visual acuity problems, colour deficiencies, or visuo-motoric challenges. Eye tracking is fascinating since, on the one hand, it is used to evaluate stimuli by analysing visual attention behaviour; on the other hand, it creates a complex data scenario for which advanced visual analytics tools must be developed to understand the eye movement data. Hence, we establish an evaluation loop, but always with users (or study participants) in the centre of the loop, also known as the users-in-the-loop phenomenon.

4. Teaching Concepts

In order to reach our teaching goals, we split the course into two major concepts. Each day consisted of a theoretical teaching unit, followed by a practical one, in which general practical tasks and further tasks in assignment sheets had to be answered. All of the practical units were supervised by the lecturer to provide valuable insights and address any questions and unclear issues. The theoretical assignment sheets were treated as homework, even though most of the students had already started the theoretical work at the university. After a few daily lessons the students received enough input —theoretical and practical—to start a real eye tracking study and apply the learned concepts to a research question with a user task from a self-selected application domain. After the course, the students had time to reflect on their eye tracking study and the findings in a written report. It may be noteworthy that the students had nearly no prior experience in eye tracking and the related topics such as visualization.

4.1. Theoretical Units

The course is based on 10 theoretical teaching units, each followed by a practical unit (Section 4.2) with a guiding assignment sheet. The topics of the units were selected to build on one another, and each was delivered in a 90minute lecture. The students could ask questions in an interactive manner. The individual units are as follows:

Day 1: Introduction to eye tracking: The benefits and challenges in eye tracking are discussed and application examples from several domains are introduced and explained.

Day 2: Anatomy of the eye: Understanding how the human eye works, including the roles of inner (eye muscles, the optical nerve, etc.) and outer organs (eye lids, eye lashes, etc.), is crucial for eye tracking and is of particular interest in this unit.

Day 3: Eye tracking methods and devices: Depending on the kind of study and the type of stimuli used, different kinds of eye tracking devices (remote vs. mobile eye tracker) are required.

Day 4: Static and dynamic stimuli: In an eye tracking experiment, it makes a difference whether static (pictures, maps, etc.) or dynamic stimuli (animations, videos, interactive user interfaces, etc.) are presented.

Day 5: Gaze-assisted interaction: Interacting with the eyes is a modern way to allow spectators to dynamically change the content they are viewing. This is particularly useful for individuals with physical disabilities.

Day 6: Eye tracking studies: Designing and setting up a study properly is crucial for ensuring reliable results and reducing possible biases.

Day 7: Eye movement data analysis: The recorded data can be algorithmically analysed focusing on a variety of metrics and statistical values.

Day 8: Visualizations for eye movement data: There are numerous visualization techniques for representing eye movement data. The choice of visualization depends on the specific data exploration tasks to be addressed and the needs of human users.

Day 9: Existing software for eye movement data analysis: Apart from simple visualization techniques, there are visualization tools and systems that offer various views and interaction techniques to find patterns and anomalies in the data.

Day 10: Overleaf, LaTeX, and paper writing: Finally, an introduction into paper writing is provided. A sample template is shared to ensure that each project group starts from the same reporting framework.

It may be noted that the course is designed for a two-week summer school, but can also be adapted to a classical course at a university typically spanning over one semester.

4.2. Practical Units

Each theoretical unit comes with a corresponding practical unit in which typical theory-related tasks are given. The theoretical concepts are taught in a way that encourages the students to genuinely absorb the given information. The practical unit allows them to do one or more tasks independently. These tasks depend on the topic of the unit and can be longer or shorter. For example, when the anatomy of the eye is introduced, the students are asked to monitor the eye movements of another student and describe how the eyes react on certain (different) visual tasks.

4.3. Daily Assignments

The daily assignments are given topicwise, and the students are expected to complete the tasks on each assignment sheet within one day. The lecturer reviews and grades the solutions. All of the assignment sheets and their solutions are discussed in the coming lecture. The assignments can be completed during group work, including the eye tracking study which builds on all of the learned concepts. The scores for the assignment sheets were overall positive, with most of the project groups completing the given tasks at a rate higher than 90 percent. This positive outcome suggests that the course was successful and that the students understood the theoretical content and applied it to the given assignments.

4.4. Applying the Learned Concepts

After completing theoretical unit number 6, which describes how to design user studies, particularly eye tracking studies, the students start their own eye tracking study. This means that they formulate a research question for which visual attention is important in order to answer it. Based on this research question, they design an eye tracking study, recruit participants (students from the course), conduct the eye tracking study, and after all the participants have participated, they analyse and visualize the recorded data. The analysis and visualization are typically performed by the software integrated into the eye tracking system.

It may be noted that the students cannot conduct any kind of eye tracking study, primarily due to the limited amount of time, the available participants, and the eye tracking device. However, as a first step, they learn about the challenges involved, and this initial study prepares them for larger eye tracking studies in the future.

4.5. Reporting, Summarizing, and Reflection

After the course, the students are required submit a written report comprising four pages in a provided template. The content of the report is based on the conducted eye tracking study, the research question, several hypotheses on the participants' visual behaviour that have been formed before designing the eye tracking study, interpretation of the recorded eye movement data in form of simple statistics and visualizations provided by the eye tracking software, some discussions on limitations and open questions, as well as possible future work. Actually, the report closely resembles a paper written for international conferences, at least in terms of style, although the content needs to be extended significantly.

4.6. Grading

The final grade is based on the scores received for each course component: the assignment sheets (25 percent), the eye tracking project (25 percent), and the final report (50 percent). After the final course evaluation, all the students passed the course with a total score of more than 90 percent, showing that they had learned the taught concepts in eye tracking, could apply them for a real eye tracking study, and could describe their findings in a written report.

5. Example From the Course

An eye tracking study was designed based on the question: In which ways does the presence of pictures in a restaurant menu influence gaze behaviour? This started with a pilot study to understand if the study setup was well selected, the tasks were understandable, and each experiment was in the expected time frame. Specifically, the differences in visual attention between a stimulus with and without additional images were investigated. This means that a text-based or text-plus-image stimulus was shown as an independent variable. This comparative setup allowed to measure and record the participants' eye movements as a dependent variable (Yarbus, 1967).

In addition to the analysis of spatial data, temporal aspects were investigated such as the required time to finish a task also known as the response time. Although only four participants were recruited, it is possible to identify certain tendencies in the participants' visual attention.

"A picture is worth a thousand words."

Nowadays, pictures are used specifically as eye-catchers to attract more attention from user. In fact, picture information can be processed 60,000 times faster than text information according to marketing specialist Krista Neher (Neher, 2013). In this context, the previous quote takes on a deeper meaning, which aligns with the guiding principle: image information before text information. Based on this assumption the following research question was investigated.

RQ: **Is there a difference in visual attention when a food menu includes pictures of the dishes and written descriptions, compared to a menu with only written descriptions (see Figure 1)?**

To answer this research question two different stimuli of a food menu were created. The first food menu only displays the name of each dish, the ingredients, and the prices. The second stimulus has the same structure but additionally includes pictures on the menu. Finally, by comparing the two different stimuli, conclusions can be drawn about the value of pictures when it comes to improving usability. The use of eye tracking helps by following the participants' eye movements on the food menu and then analysing their visual attention in order to draw conclusions over space and time.

5.1. Background and Previous Studies

Before designing the eye tracking study, questions were asked about whether there is a difference in visual attention when pictures are placed beside the written text versus when they are not. Eitel (2015) had a similar research question but was more concerned if the learning outcomes are better when a picture is presented before the text or after it. Although the aim of this study is different, the researchers also investigated whether the use of images leads to a different result.

Another comparable work analysed whether images have an impact on online reading (Beymer, 2007). However, the focus has always been on the appropriate image for the menu, whereas the mentioned study used both relevant and irrelevant images to the text. Based on the picture superiority effect, Yangandul (2018) found that participants paid more attention to image thumbnails than to the title text regions. However, from the outset, the focus has been on restaurant menus, as they seemed more familiar to most of the study participants, making it easier to bring everybody to the same level of expertise. Another work also focuses on restaurant menus but highlighted the impact of images and food names on menu evaluations (Hou, 2017). The difference to the current study is that they did not use eye tracking to obtain visual attention results, a fact that resulted in less precise user performance measures, since eye movement data is missing in the evaluation.

Figure 1. *The eye tracking setup: Visual attention maps of food menus with and without pictures of the dishes. The visual attention is also directed to the images (left), while in the text-based scenario (right) the participants paid more attention to the text, resulting a text reading task*

5.2. The Eye Tracking Study

The described eye tracking study was designed and conducted during the course and graded after the course. This study was based solely on the students' experience gained during the course, with the lecturer providing helpful feedback only when explicitly requested by the students.

5.2.1. Research Question and Hypotheses

The following research question was investigated in the eye tracking study:

- **Is there a difference in visual attention when a food menu includes pictures of the dishes besides the written descriptions (see Figure 2 for an example)?**

Based on this research question the following three hypotheses were formulated:

- **H1: Task completion times:** Participants can find dishes on the food menu **faster** when there are pictures of the dishes.
- **H2: Visual attention on pictures:** Participants **first direct** their **visual attention** towards the **pictures** of the dishes.
- **H3: Visual attention on text:** Participants **first direct** their **visual attention** towards the **text-based** name of the dish when shown the food menu with pictures.

The first hypothesis focuses on task completion time, while the other two address gaze patterns with a spatio-temporal data property, making the analysis and visualization much more complicated than in the case of traditional completion time measures.

5.2.2. Participants

All four participants (two male, two female) were bachelor students from different universities in Switzerland (German-speaking regions) and Germany. All of them were between 20 and 25 years of age with different educational backgrounds. One participant was a vegetarian. All students volunteered in the study. Before conducting the study, the participants were interviewed about their personal details, demographic information, dietary preferences,

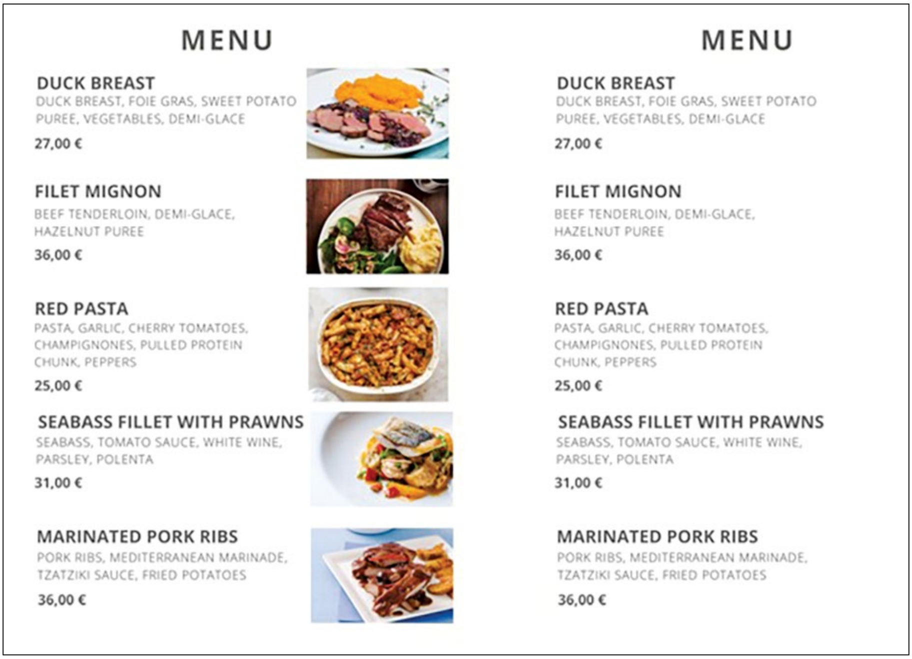

Figure 2. *Two stimuli used in the study: A food menu with pictures (left) and a food menu without pictures (right). The textual content for both options of the independent variable is the same; however, the option on the left-hand side includes additional pictures of the dishes*

and experience level related to restaurant visits. Two participants had a corrected-to-normal vision, which means that they wore glasses or contact lenses.

5.2.3. Stimulus Design

For the purpose of this study, two artificial stimuli were created in the form of two food menus. The first food menu consisted of five main dishes. The information shown on the menu included the name of each dish, its main ingredients, and the price, listed below the description of each dish. The background colours were neutral (white and a beige frame). In addition to all the mentioned information in the first food menu, the second food menu included pictures of the presented dishes on the right-hand side (see Figure 2). In both stimuli, the names of the dishes as well as the names of the ingredients were written in English, and the prices were expressed in Euro. The menu featured one fish dish, three meat dishes, and one vegan/vegetarian dish. To avoid additional influences on the results, no restaurant name or other information were shown on the food menus. The food menus were shown in a colour version.

5.2.4. Tasks

In this study, each of the four participants was assigned one out of the three prepared tasks: "Please look at the food menu and find a dish with fish". For the purpose of a follow-up study, two additional assignments were prepared but not used in this study due to time limitations: "Please look at the menu and find a vegetarian dish" and "Please look at the menu and find a dish of your own choice". Each of the participants was shown only one of the prepared stimuli (only with or without a picture) to avoid any influence on the results based on learning and experience effects that would result in a bias in the study results. It may be noted that the number of stimuli should be increased to average out these effects through replication, permutation, and randomization.

5.2.5. Pilot Study

Before the real experiment, a pilot study was conducted including one participant only to check whether the real study could be executed as expected. The pilot study showed that the stimulus should be displayed on the entire screen to show the whole menu. Additional influences such as scrolling could be avoided by this test. In addition to that, there is no need to define a certain time limit for the experiment, since the pilot test showed no issues in that regard. All participants will decide for themselves when to finish the experiment. Furthermore, there was also a "give-up" option in case a participant was unable to make a decision, though it was not used.

5.2.6. Environment and Technical Setup

The study was conducted in a classroom environment to simulate a noisy restaurant in which people usually make a decision about the dishes they want to order. We used the Tobii Pro Nano eye tracking device and a laptop with the Tobii Pro Lab software installed. Qualitative feedback in ormo f which scenario the participants preferred was collected during the study by the authors and was written down for each of the participants separately. There was no time limit for the participants to look at the menu, but on average it took less than one minute for each participant to finish the experiment.

5.3. Results

Since the eye tracking study was conducted with only four participants, the focus was on the visualization of the generated data replacing a pure statistical analysis of the task completion times. For this purpose, a visual attention map and a gaze plot were created for each participant (see Figure 3) that show an AOI-based and a point-based depiction of the data to obtain two perspectives on the data for spatial, temporal, and participant-related aspects.

The data visualizations already give indications for some gaze patterns and their differences. All participants of the eye tracking study were given the same task: "Find a menu item with fish".

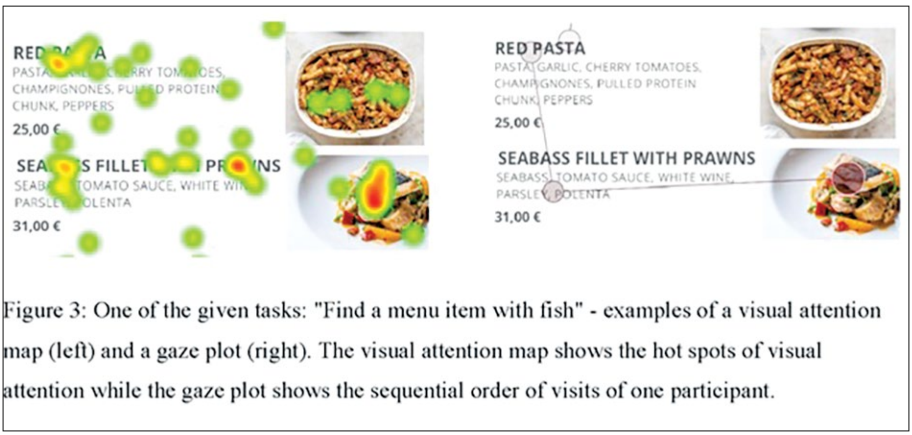

Figure 3. *One of the given tasks: "Find a menu item with fish"—examples of a visual attention map (left) and a gaze plot (right). The visual attention map shows the hot spots of visual attention, while the gaze plot illustrates the sequential order of visits by one participant*

5.3.1. Stimulus with Pictures

The participants generally followed the same strategy, but for the image version they were faster (H1): They started at the top of the menu and looked first at the name of the item, then glanced at the picture, and finally moved to the next dish until they found the correct one. If this pattern persisted in a larger study group, it might be possible to disprove the hypothesis that participants first direct their attention towards the pictures (H2). On the other hand, there are hints that the hypothesis might be confirmed that even in the presence of pictures participants first look at the name of the dish (H3). Although the general gaze patterns of the participants were similar, there were also noticeable differences between them. One participant directed more visual focus towards the pictures (larger number and duration of fixations, which can be seen in the corresponding gaze plot).

5.3.2. Stimulus Without Pictures

Also, in this group, a general strategy seems to emerge: Both study participants started at the top and mainly looked at the name of the dish then moved to the next menu item. Only when they found the menu item with a related term in its name (e.g., “sea bass”), they looked at the description below the name. The gaze patterns of the participants were very similar.

In conclusion, we are confident that the study design is suitable for a larger-scale study. The eye tracking study showed interesting initial results, and we are convinced that it is possible to answer our research question with a sufficient amount of data. It may be noted that this study is just an example of a student eye tracking project. It cannot be compared with a scientifically well grounded, designed, conducted, and evaluated eye tracking study. To achieve better and more reliable results, significantly more preparation time is required.

5.4. Summary

An eye tracking study involving four participants was conducted to investigate their visual attention behaviour while viewing food menus with and without pictures of the dishes. Although the study included only a few participants, some conclusions can be drawn. There are some indications that pictures attracted visual attention, but more studies must be conducted to confirm whether that is the main stimulus on food menus that attracts the visual attention of the participants. The participants first directed their visual attention towards the name of the dish when they were shown the food menu with pictures. It should also be pointed out that the language used for the food menus had a very important influence in this study. Namely, English was used, even though all the participants were from German-speaking countries. Therefore, for the next experiments, it is advisable to use the participants' mother tongue. For example, one participant did not know that sea bass is a fish. Additionally, since this study included only one of the three defined tasks, future experiments should also test the other tasks, as well as different stimuli. This field of research can be especially interesting in tourism and hospitality marketing, suggesting that further experiments should include a larger sample size of participants from different age groups, dietary preferences (e.g., vegan, vegetarian, halal, kosher, and others), restaurant experience levels, cultural backgrounds, as well as travel experience and travel motivation (e.g., "foodies").

6. Challenges and Limitations

Although we tried to teach the students in eye tracking and the many related disciplines, we are aware of the fact that there are still many negative issues that should be improved in the next iterations of the eye tracking courses. We categorize the identified negative issues into teaching-related, study-related, and general issues.

6.1. Teaching Challenges

One big challenge from the teaching perspective is the repertoire of possible subtopics in the lecture. Since eye tracking is an interdisciplinary field, we must teach numerous topics to allow the tracking of the eyes, the recording of the data, the analysis and visualization of the data, as well as the role of human users with their tasks, experiences, hypotheses, research questions, as well as their disabilities, for example vision deficiencies or visual acuity problems. Combining all related disciplines in a course that lasts only a few days is really challenging, particularly when trying not tooverwhelm the students with the vast amount of teaching material. Information overload is the worst-case scenario in a course; therefore, it is a balancing act to teach the students in a way that enables them to design and conduct an eye tracking study on their own. Moreover, they should be able to evaluate the recorded data with the provided tools.

6.2. Study Challenges

There are several challenges from the eye tracking study perspective. First of all, the equipment in form of an eye tracking device must function properly and, what is more, the project groups have to find time slots, since all of them had to share one eye tracker. However, although it was quite challenging to find an appropriate schedule, it finally worked out, although some groups had to work in the morning and others in the evening, which added an extra burden for some of the students. For future editions of the course, it might be beneficial to provide several eye tracking devices, although this would incur additional costs. The problem is not only on the students' side, who have to prepare and conduct their studies, but it also affects the study participants. For example, there is a higher chance to find participants in the morning than in the evening. Moreover, finding a good topic suitable for an eye tracking study is another problem. However, all project groups successfully identified a topic. While the teacher described some eye tracking studies during the course, the students developed their own studies based on topics that had not been covered in one of the courses.

6.3. General Challenges

Apart from teaching and study challenges, we have also encountered several other, more general challenges. The eye tracking studies are designed and conducted in kind of project group work with several students working on the same project. Even though this concept is suitable, if some students fall ill, the remaining group members are left to complete the tasks on their own, meaning they have fewer resources than other groups. This effect might have a negative impact on the learning outcome due to the fact that the rest of the group might be overloaded with tasks. Also, the group building can be problematic in the beginning because the groups should consist of students with similar interests in eye tracking and application fields. Moreover, not all students might participate in a project in a similar way, which might cause issues related to conflicts within the group that hinder the others from working. If the eye tracking study is based on an application field for which it is hard to find real-world stimuli, another burden is to create artificial stimuli, which again requires a large number of manual drawings or a clever algorithm that generates as many artificial stimuli as required. Finally, in the field of eye tracking, we are typically confronted with problems related to ethics, data privacy, and data protection.

7. Conclusion and Future Work

In this chapter, we described a teaching concept for eye tracking courses based on the technology itself, data recording, data analysis and visualization, users-in-the-loop, as well as evaluation based on users' tasks, hypotheses, and research questions. Eye tracking is an interdisciplinary field which requires teaching several interconnected topics in order to design and conduct a study, as well as to evaluate the recorded data. Omitting one or more of the topics would have negative consequences on the practical experiences the students gain. Although the teaching scenario in the eye tracking course was considered successful, there is much room for possible improvements. Consequently, in the future we will extend the course in several directions: for example, more eye tracking devices should be available, the practical part in form of working with the eye tracking devices should start earlier, the groups should be formed based on similar interests, and more data analysis and visualization software should be provided.

References

BEYMER, D., ORTON, P. Z., RUSSELL, D. M. (2007). An eye tracking study of how pictures influence online reading. In Proceedings of the IFIP Conference on Human-Computer Interaction. Springer. 456–460.

BLASCHECK, T., BURCH, M., RASCHKE, M., WEISKOPF, D. (2015). Challenges and perspectives in big eye-movement data visual analytics. Proceedings of the Symposium on Big Data Visual Analytics, (BDVA). 17 – 24. IEEE.

BLASCHECK, T., KURZHALS, K., RASCHKE, M., BURCH, M., WEISKOPF, D., ERTL, T. (2017). Visualization of eye tracking data: a taxonomy and survey. Computer Graphics Forum. 36(8). 260 – 284.

BURCH, M. (2020). Teaching eye tracking visual analytics in computer and data science bachelor courses. Proceedings of the Symposium on Eye Tracking Research and Applications, (ETRA). 17:1 – 17:9. ACM.

BURCH, M. (2022). Eye tracking and visual analytics. River Publishers.

BURCH, M. and KURZHALS, K. (2024). Teaching Eye Tracking: Challenges and Perspectives. Proceedings of the ACM on Human-Computer Interaction, Volume 8, Issue ETRA, Article No.: 237, Pages 1 - 17

DUCHOWSKI, A. T. (2017). Eye tracking methodology - theory and practice, 3rd edition. Springer. 978-3-319-57881-1.

EITEL, A., SCHEITER, K. (2015). Picture or text first? Explaining sequence effects when learning with pictures and text. Educational psychology review 27(1). 153 – 180.

HAYHOE, M. H., BALLARD, D. H., TRIESCH, J., SHINODA, H., AIVAR, P., SULLIVAN, B. T. (2002). Vision in natural and virtual environments. Proceedings of the Symposium on Eye Tracking Research & Applications, (ETRA). 7 – 13. ACM.

HOLMQVIST, K (2011). Eye tracking: a comprehensive guide to methods and measures. Oxford University Press. 0199697086.

HOU, Y., YANG, W., SUN, Y. (2017). Do pictures help? The effects of pictures and food names on menu evaluations. International Journal of Hospitality Management 60. 94 – 103.

KATONA, J. (2022). Measuring cognition load using eye-tracking parameters based on algorithm description tools. Sensors. 22(3). 912.

KOCH, M., KURZHALS, K., BURCH, M., WEISKOPF, D. (2022). Visualization psychology for eye tracking evaluation. CoRR.

KURZHALS, K., FISHER, B. D., BURCH, M., WEISKOPF, D. (2014a). Evaluating visual analytics with eye tracking. Proceedings of the Fifth Workshop on Beyond Time and Errors: Novel Evaluation Methods for Visualization, (BELIV). 61 – 69. ACM

KURZHALS, K., HEIMERL, F., WEISKOPF, D. (2014b). ISeeCube: visual analysis of gaze data for video. Proceedings of the Symposium on Eye Tracking Research and Applications, (ETRA). 43 – 50. ACM.

KURZHALS, K., HLAWATSCH, M., HEIMERL, F., BURCH, M., ERTL, T., WEISKOPF, D. (2016). Gaze Stripes: image-based visualization of eye tracking data. Transactions on Visualization and Computer Graphics. 22 (1). 1005 – 1014. IEEE.

NEHER, K. (2013). Visual social media marketing: harnessing images, Instagram, Infographics and Pinterest to grow your business online. Boot Camp Digital. 4 – 7.

NETZEL, R., OHLHAUSEN, B., KURZHALS, K., WOODS, R., BURCH, M., WEISKOPF, D. (2017). User performance and reading strategies for metro maps: An eye tracking study. Spatial Cognition & Computation. 17(1-2). 39 – 64.

YANG, S. C.-H., SHAFTO, P. (2017). Teaching versus active learning: a computational analysis of conditions that affect learning. Proceedings of the 39th Annual Meeting of the Cognitive Science Society, (CogSci).

YANGANDUL, C., PARYANI, S., LE, M., JAIN, E. (2018). How many words is a picture worth? Attention allocation on thumbnails versus title text regions. In Proceedings of the Symposium on Eye Tracking Research & Applications. 1 - 5. ACM.

YARBUS, A. (1967). Eye movements and vision. Springer. 978-1-4899-5381-0.