

RAISING DESIGNERS' AWARENESS OF USER EXPERIENCE BY MOBILE EYE TRACKING RECORDS

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ABSTRACT

Understanding the interaction between a user and a product in different areas of application provides an excellent basis for the development of innovative user-oriented products. User-product-interactions usually are characterized by a combination of well-observable user actions and cognitive processes, which are considerably more difficult to detect. One method to support the investigation of user experiences is mobile eye tracking. In contrast to conventional observation, mobile eye tracking provides benefits that allow revealing previously hidden aspects of user experiences, such as the visual attention paid by the user to the product, which might lead to improved designs. This paper presents an educational approach using mobile eye tracking recordings to raise design students' awareness of user experience in an early stage. Applying the example of three different scene videos showing the interaction of a user and a power tool, an electrical bicycle and a medical device, it is described how design students can learn to analyze eye tracking data in order to evaluate aspects of usability and to identify explicit as well as implicit user needs. The paper finally discusses the appropriateness of mobile eye tracking recordings as a teaching medium to enhance the awareness of user experiences and gives recommendation for implementing this approach in design education.

Keywords: Mobile eye tracking, user experience, user-centred design, case-based learning

1 INTRODUCTION

User experience (UX) is a central element of design. Understanding a person's perceptions and responses while interacting with a product provides the great opportunity to design products tightly focused on the user's values and needs. However, user experience is known to be dynamic, context-dependent, and subjective [1]. Thus, user experience is difficult to generalize, almost impossible to explain by textbooks and consequently, challenging to teach in design lectures. Based on this insight the following question arises: How can we successfully educate design students to become aware of the high relevance of user experiences for designing a product?

One possible approach is case-based learning [2]. By meeting the user or by watching and discussing videos, which show users interacting with a product from an outside perspective, students can train to observe usability aspects and user responses. The disadvantage of this approach is that students will always be external observers and consequently, can only understand aspects of the user experiences. This is where eye tracking becomes interesting. An area, where eye tracking is already applied successfully is, for example, web design. Researchers in this area utilize eye tracking to analyze the experience of users interacting with a homepage [3]. The basis for the suitability of eye tracking to investigate in user experiences is the eye-mind hypothesis, which states that the direction of the gaze is typically associated with what people pay attention to [4]. In addition to that, eye tracking technologies provide two important benefits: (1) the user-product-interaction is recorded out of the first person perspective and (2) the user's gaze point is calculated and visualized, directly. Latter allows revealing previously hidden aspects of user experiences, such as visual attention, that might lead to improved designs. The basic idea of this paper is to combine the benefits of case-based learning and eye tracking to improve teaching user experience in design education.

The paper proceeds as follows. First, the fundamentals on user experience and mobile eye tracking records are introduced. Subsequently, three cases of the application of mobile eye tracking in case based learning concepts are described and the benefits of eye tracking are pointed out. Finally this paper presents an educational approach that uses mobile eye tracking recordings to early raise design students' awareness of user experience.

2 USER EXPERIENCE AND EYE TRACKING

User Experience can be understood as interplay of the four following elements: user, artefact, context and interaction [1]. In the field of product design the artefact, which is the central object of the interaction with the user, is the product to be developed, validated or benchmarked. In design education several approaches supporting user experience are already well-established (e.g. the persona technique [5]). In this context eye tracking can even further support raising design students' awareness of user experience. Eye tracking is exercised in multiple disciplines, whereas neuroscience, psychology, industrial engineering, marketing and computer science are only some examples of application [6]. The prevailing technology in use is video-based eye tracking [7]. In contrast to web design, which gets by with a stationary eye tracking system, analyzing user experience in product design requires the application of mobile eye tracking that can operate in the real environment. As illustrated in Figure 1, the mobile eye tracking system, which is used in the cases for this paper, integrates the cameras in glasses (SMI binocular glasses, 50 Hz). Besides the cameras recording the user's eyes in order to track the eye movements to calculate the gaze direction, a scene camera is built in, which records the field of vision of the user. To operate the glasses a recording unit is required, which can be fixed at the test person's belt (Figure 1, right). The output of an eye tracking recording is a dataset of gaze directions on a synchronized scene video. On this basis of these technical properties of mobile eye tracking provides four reasons, why it is well suitable to understand user experience.

- Investigations in user experience need to be done in the real environment of the application. Mobile eye tracking provides a high degree of freedom and allow tracking in reality [8].
- The mobile eye tracker is worn like glasses, which avoids distractive influences on the user. It is minimal invasive and biases the users behaviour to a low degree.
- The scene video is recorded out of the user's perspective. By taking the first person view of a user the student can put himself in the user's position and see the interaction "through his eyes".
- In the scene video out of the first person view, the gaze direction of the user is visualized. Hence one can exactly follow the visual attention of the user during the interaction.

The analysis of mobile eye tracking data can be split up into the two categories, quantitative and qualitative analysis. The quantitative analysis is based on the eye tracking video with the user's gaze point included. By viewing the video students can put themselves in the user's place and take his or her perspective. Quantitative analysis uses the gaze data to calculate values, e.g. how often and how long a user looks at a defined area of interest. Both types of analysis are applied in the cases described in section 3.

Compared to questionnaires and retrospective interviews, mobile eye tracking records the user-product-interaction in real time, which is important since it is known, that user experience is a dynamic process and can be described afterwards, without the loss of information, hardly. Instead, these methods have a better comparability between subjects. However, user experience is a subjective phenomenon, which reduces the need of comparability. If comparing to observations from outside or concurrent interviews, which both can be recorded in real time, one can see that concurrent interviews biases the user strongly in his behaviour and observations from outside cannot provide such closeness to the user than a video out of the first person perspective. This comparison leads to the conclusion that eye tracking can bring out new and deeper insights for the understanding of user experience.



Figure 1. Mobile eye tracking glasses with recording unit

3 MOBILE EYE TRACKING IN DESIGN EDUCATION

In this section three cases of implementing mobile eye tracking in the educational context are introduced. In each case product and application are described before the investigations in user experience by mobile eye tracking records are shown. Finally, the integration of the user experiences in education is explicated.

3.1 Case 1: Power tool for direct fastening

3.1.1 Product and application

In the first case a hand held power tool for direct fastening is used as an artefact. The tool is intended for driving fastener nails into a steel surface. Therefore an explosion is created inside the tool, which accelerates the nail. It is developed for professional use in the construction industry.

Besides the main user-product interaction, which is driving nails into steel, there are secondary interactions between the user and the power tool during the lifecycle of the product. One example of such a secondary interaction is the exchange of the piston. Instructed users can operate this task, by themselves. Due to the fact that this is not a daily task, users normally do not know the proceeding of that action by routine.

3.1.2 Investigation in user experience by mobile eye tracking records

This case is set up in a laboratory in order to create a search task. The participants take part in this experiment, are no regular users of a direct fastening tool. They are equipped with mobile eye tracking glasses and asked to change the piston, without getting any instructions before. Hence the goal of this experiment is not to study the user experience of that specific case but to create a general search pattern, which often appears in different user-product interactions.

The analysis of the gaze path shows that the participants directly start to search elements in order to disassemble the tool and to find the piston. Figure 2 illustrates three captures of the mobile eye tracking video in a short interval of time (left: 46.83sec.; middle 47.50sec.; right: 48.03 sec.). Concerning visual behaviour one can see an explorative gaze pattern, with short visual fixation durations on multiple areas on the tool (skimming pattern [9]). By watching the eye tracking video the user's perspective can be taken easily and the visualized gaze path gives the observer the feeling of searching something as well.

3.1.3 Awareness for user experience in education

The eye tracking video is shown in a first years' design lecture (90min/week) to 450 mechanical engineering students. The integration of eye tracking into the lecture has two learning goals. First, the awareness for secondary user-product interactions, especially the relevance of product services and repairs should be raised. Second, the awareness for search patterns during an interaction, which indicates an unintuitive design, should be created. Knowing that this case is constructed, we however assume that search patterns appear in different applications with various artefacts and are indicators for product improvements. In the auditorium, the eye tracking videos creates a high attention by the students to the topic. We think that this is because students can take the user's perspective and see "through his eyes", which allows the students to feel closer the real user experience.



Figure 2. Eye tracking video of interaction with power tool; from left to right: sequence of gaze points (within 1,2 sec)

3.2 Case 2: Electric bicycle

3.2.1 Product and application

The artefact of this case is an electrical bicycle. With the so called “Pedelec” one can drive up to 40 km/h in flat area. The user operates the bicycle by turning the pedals as usual. The electrical motor supports the pedalling with additional torque, but only when the user moves the pedals.

The focus of this investigation is to understand the user experiences, when navigating in urban areas while cycling. For navigation to a defined place the application “google maps” has been used via mobile phone. As illustrated on the right side of Figure 3 the phone is fixed onto the steering rod by a prototyped holder.

3.2.2 Investigation in user experience by mobile eye tracking records

The implementation of the mobile eye tracking glasses in this case aims to understand the users experience when navigating in an urban area, while driving an electrical bicycle. Three different drivers performed navigation tasks while wearing mobile eye tracking glasses.

The qualitative analyses of the gathered eye tracking data show a central finding, which was not expected in that dimension before. When looking at the navigation panel, the information which is lost concerning the driving direction, is immense. This bases on the time needed for understanding the navigation instruction on the mobile phone during cycling and on these kind of high velocities of driving.

3.2.3 Awareness for user experience in education

This mobile eye tracking study took place in connection with a two and a half day ideation workshop. Master students as well as industrial partners take part in the workshop. The eye tracking videos shown in the workshop have been recorded in advance. Here the students act as users and drive the electric bicycle on their own, whereas they experience the product in reality. Afterwards, a qualitative analysis of the videos has been performed within the whole group of workshop participants by watching the eye tracking recordings and isolating users’ needs.

The awareness of user experience in the context of education is strengthened in two ways. First the students put themselves in the position of the user and drive the bicycle on their own. Second, they interpret their visual gaze path in the workshop. Comparing both situations the students realize, that the loss of information during cycling on their own felt much lower, than is shown by the analysis of the eye tracking data, afterwards. This study helps the students to understand the relevance of cognitive load and focus of attention of users when investigating in user experiences. If concentrated on a special activity the surrounding can be ignored radically and the subjective feeling can differ from a real measurement strongly (here: the time on the navigation panel). Furthermore mobile eye tracking recordings can uncover implicit facts and needs, the user is not aware of.



Figure 3. Navigation task on electrical bicycle;
left: view on street; right: view on navigation panel

3.3 Case 3: Peritoneal dialysis device

3.3.1 Product and application

This case is extracted from a development project in the area of medical applications. Different dialysis therapies to treat insufficiently working kidneys were analyzed. One of the therapy forms is peritoneal dialysis, which is a renal replacement therapy. It better preserves the residual function and allows the patient to perform the therapy at home. The patients can apply the therapy, which requires the following actions by themselves. In the evening the machine, the connectors and the liquids have to be prepared before they are connected to the patient. Overnight the dialysis is working automatically. In the morning the dialysis equipment has to be disconnected and cleaned for its next usage through the patient or an assistant. In the project patients are visited at home in order to get an understanding of the user experiences with the application of peritoneal dialysis. The patients have been equipped with mobile eye tracking glasses and the whole procedure of preparation and connection has been recorded out of the patients' perspective.

3.3.2 Investigation in user experience by mobile eye tracking records

The mobile eye tracking study has been undertaken with the aim of understanding the experiences of the patient, identifying his barriers, transforming these inputs into users' needs and creates proposals for product improvements. Especially, in a medical application, which make it hard to understand a patient as an external observer, mobile eye tracking records allow to take the patients perspective and learn how the medical therapy really affects a concerned person.

In this case a quantitative analysis of the eye tracking data is performed to subdivide the patient's application into sequences, in order to create a procedure-model of the interaction. In addition to that, object-related key performance indices are calculated, which are shown in Figure 4 on the right side. The numbers of visual fixations on defined areas of interest (display, disinfection and clamps) are compared. The evaluation of the data shows, that there is a low attention to the device and its user interface (low accumulate fixation duration on device and intuitive usage pattern). In fact, concerning visual attention the interaction with the periphery and secondary artefacts was the dominant factor in this user experience.

3.3.3 Awareness for user experience in education

The eye tracking study including planning the experiments, recording the data, as well as conducting qualitative and quantitative analysis has been performed within a six month master theses. There are two central findings, which result out of the study. First, the importance of the context is very high, which is supported by qualitative and quantitative analyses. Not only focusing on the product and the user, but also on the surrounding as well as analyzing the user experience in the real environment are central methodical results of the study. Second, a deep understanding of the user experience over the whole application, including preparation and post processing is the basis for isolating the real needs and transforming them into product ideas. The awareness for the users experience as initial point of design and the relevance of the context is pointed out and understood by the students.

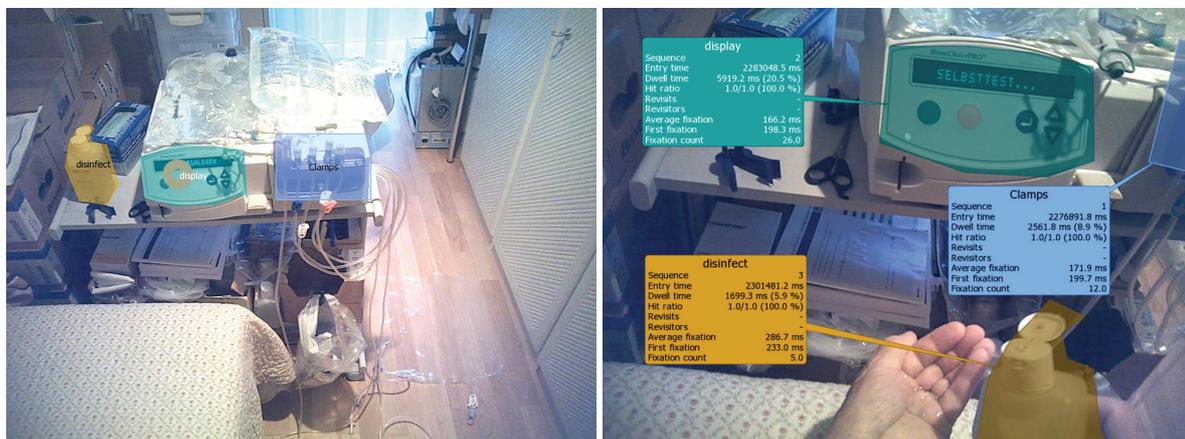


Figure 4. Patient during peritoneal dialysis therapy; left: gaze point on display, right: key performance indices of three areas of interest

5 CONCLUSIONS

The aim of implementing mobile eye tracking into design education is to early raise the student's awareness for user experience. For this purpose mobile eye tracking has been applied to three different case based learning concepts to various extend. From a first year design lecture (case 1) over an ideation workshop (case 2) to a master theses (case 3) the degree of the implementation of mobile eye tracking increases. The more effort the students put in the recordings the higher is the awareness of the user experience. Table 1 summarizes the relation between the type of course and the kind of the implementation of mobile eye tracking as well as the student actions. The dark green fields show the kind of implementation in cased based learning concepts applied to the describes cases in section 3. The light green fields are other possible settings in general.

Table 1. Overview of the implementation of mobile eye tracking records in design education

implementation of eye tracking	type of course			student actions
cases with general patterns				comprehend
record data & qualitative analyses				meet user, record, interpret
record data & qualitative analyses & quantitative analyses				meet user, record, interpret, calculate
	design lecture (big classes > 20p)	ideation workshop (small groups 3-20p)	master thesis (1-2 p)	

The use of mobile eye tracking in education raises the awareness of user experiences. Especially the relevance of search patterns and secondary user-product interactions (case 1), the impact of cognitive load and focus of attention of users (case 2) and the importance of context as well as the understanding of the whole user experience as basis for isolating users' needs (case 3) are learned by the students, by mobile eye tracking analyses. In our view, the success of the implementation of eye tracking in education bases on multiple reasons. First, eye tracking hardware and software is easy to handle. Second, the records can be captured in the real environment with a low bias on the users' behaviour. Third the students can see the interaction with an artefact "out of the user's eyes", because the recording is in the first person perspective and visualizes the gaze direction. Finally the gaze videos considered as a teaching media have a high visualization power and take the students' attention.

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