Experiences with User Studies when Investigating Light Displays

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Abstract
Following the human-centered design process, we conducted several user studies in order to understand the context of use, specify user requirements, produce design solutions or evaluate designs. In this paper, we will report what we learned when using various methods in the different development phases. We used online surveys and offline brainwriting in order to identify requirements and find first design ideas for a light display in the vehicle. We further used a participatory design process for a light pattern which helps in a specific scenario. Also, we ran usability tests as well as repeated measures experiments for evaluation in our driving simulator. In the workshop we want to share our experiences and to learn about benefits and drawbacks of methods that other researchers applied in the automotive domain.

Author Keywords
Experiment design; human-centred design; lab studies; light display; usability; user experience.

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces

Experiences

When developing interactive systems, it is crucial to include the actual users as much as possible. ISO 9241-210 defines an iterative human-centered design process for interactive systems [1]. This process consists of four major steps: understanding the context of use, specifying user requirements, producing design solutions and evaluating designs. In the following, we will summarize what we learned from the studies we conducted in the previous years to develop ambient in-vehicle light patterns.

Identifying requirements for a light display

In the automotive domain, it can be difficult to observe current interactions of drivers e.g. with assistant systems without distracting them. When we wanted to identify benefits and drawbacks of different locations for a light display, we first conducted a brainwriting session to see where and why drivers would locate a light display in the vehicle [3]. In contrast to brainstorming, participants write their ideas on a card and pass it to their neighbor after a given time. In this way, we received many ideas. However, in order to get more insights for each idea, we created an online survey based on the previous results. In this way, we were able to only ask for characteristics of specific locations from many different users instead of creating either a generic survey for locations or fixing the design to a previously chosen subset of locations.

We learned that using this combination of offline brainwriting and online survey gave us various initial directions first and much feedback about these possible directions afterwards, while being time efficient.

Designing light patterns with the help of drivers

After we created a light display, we searched for a light pattern which helps drivers to change lanes [4]. We organized a workshop with two sessions and let drivers create designs. In the first session, participants sketched different designs for a given scenario using pen and paper. Afterwards we discussed each design. Between the sessions, we developed light patterns. Most of them were directly derived from the sketches, while some patterns were designed to meet the requirements that participants stated during discussions or could be derived when analyzing the sketches. In the second session, we observed the participants in the driving simulator. Each participant drove with the help of at least one pattern, while the others were watching. We did not want to have a time consuming experiment, but instead see, if the expectations of the participants were met. Further, we wanted to see if the participants change their designs after seeing its realization. After everyone drove in the simulator, we again discussed each design as well as new ideas and requirements.

We learned that it is very helpful to show participants what they designed and get their feedback as early as possible. Some people realized that their designs were too complicated when seeing its implementation. Further, many participants preferred the light patterns which were based on the derived requirements and not directly on the sketches.

Experiments in the driving simulator

After investigating various designs for the light patterns, we conducted an experiment to compare a refined light pattern to a pattern which was based on state-of-the-art [5]. We ran a repeated measures experiment with three conditions in our driving simulator. Each condition had 3 test and 18 training trials. Each trial had a unique combination of distance to a closing car on the left lane and speed of that car. To evaluate the light patterns, we measured violations of safety gaps, as well as subjective workload, distraction, and intuitiveness of the display.

We used Raw TLX instead of NASA-TLX, but it still took much time and confused the participants. Therefore, we would not use it again and rather increase the number of trials. In addition, we did not see many significant effects, because we had too many variations of the trials in ratio to the number of participants. On the other hand, many different trials enabled the users to give better qualitative feedback in discussions after each condition.

In our latest experiment, we again conducted a within subjects experiment to evaluate a refined version of the light pattern [2]. This time, we reduced the number of variations of the trials and did not measure workload. In exchange, participants did more training and test trials. In addition, we increased the number of participants.

We saw more significant effects for a more limited set of overtaking situations. Still, qualitative feedback at the end of each condition was very interesting for future iterations.

Summary and Open Questions

In general, it was very helpful to get as many ideas as possible in the beginning and receive feedback about the design as often as possible. In addition, we received valuable insights when discussing the designs after the conditions within the experiments. However, we would like to discuss what other researchers learned in their studies, e.g.:

- What is your best practice to estimate driver's stress?
- How to observe drivers unobtrusively?
- How to get feedback while driving without distracting the driver?
- How big is the difference between measurements in a driving simulator compared to a real drive?
- Did you observe significant difference between different kinds of driving simulators?
- What is your experience with between subjects experiments?
- How do you avoid to have too specific driving situations while still being able to observe significant effects?

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