# Design Probes Study on User Perceptions of a Smart Glasses Concept

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## ABSTRACT
Until today, mobile computing has been very much confined to conventional computing form factors, i.e. laptops, tablets and smartphones, which have achieved de facto design standards in outlook and shape. However, wearable devices are emerging, and especially glasses are an appealing form factor for future devices. Currently, although companies such as Google have productized a solution, little user research and design exploration has been published on either the user preferences or the technology. We set ourselves to explore the design directions for smart glasses with user research grounded use cases and design alternatives. We describe our user research utilizing a smart glasses design probe in an experience sampling method study (n=12), and present a focus group based study (n=14) providing results on perceptions on alternative industrial designs for smart glasses.

## CCS Concepts
• Human-centered computing~Empirical studies in HCI;

## Author Keywords
Wearable computing; technology acceptance; user experience; experience sampling method; user studies

## INTRODUCTION
Head mounted displays (HMDs) have been an active area of research since the beginning 1990's [1, 4], and it has since come a long way from the early, bulky prototypes, which were mainly used as an interface to access virtual environments. Today, wearable computing is an emerging technology trend, which is currently being increasingly developed as consumer electronics products. Especially, the trend on developing light weight HMDs is strong, and one of the most interesting form factor here are glasses, which has gained enormous attention due to the Google Glass project [6]. Also, other products such as the Oculus Rift [15] have brought HMDs to the attention of large audiences and application developers.

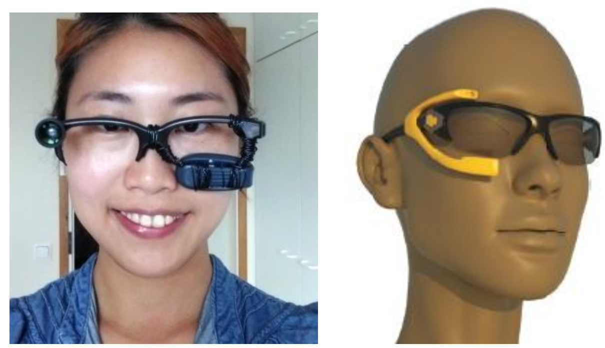


**Figure 1. Smart glasses design probe in use by a test participant (image taken from participant's self-recorded diary), and example of the created industrial designs.**

New technology trends always bring challenges for interaction and user experience designers, raising questions related to, e.g., usability and social acceptance. This is especially true in the case of HMDs, which employ various features to access and capture audio-visual media, and which adopt form factors that greatly differ from the conventional mobile technology, e.g. smart phones. The lack of keyboard and the limited space for physical buttons leads to the employment of unconventional input technologies, voice and gestures, which may hinder the use in social situations or public use contexts. As the equipment may employ features such as audio-video capture, issues related to privacy and visibility of system status may arise. Whereas there has already been discussion on the privacy questions related to the technology and especially Google Glass [7], there is still lack of user research looking at the technology and its potential future applications, especially from the user perceptions point of view.

In this paper, we introduce our user research charting the early perceptions with a HMD employing glasses type form factor. We apply experience sampling method (ESM), similar to [24], complemented with a low-fi concept mock-up. As a contribution, we present, to our knowledge, the first user study based report on perceptions of

- privacy and social acceptability



*MUM '15, November 30-December 02, 2015, Linz, Austria*



ISBN 978-1-4503-3605-5/15/11…$15.00

DOI: http://dx.doi.org/10.1145/2836041.2836064

- different context and interaction modalities

of a glasses type HMD concept in everyday life context. In addition, we created four alternative designs, which were assessed in focus groups.

Our research provides topical and user study grounded background knowledge for future designers for wearable, glasses type interaction devices.

## RELATED WORK

### User Research on Head-Mounted Displays

Altogether, interaction research with HMDs has been a popular research area, much of the early work done with bulky technology set-ups [1, 4]. Much of the prior art with HMDs relates to exploring mixed reality at various levels of the virtuality continuum [14] – either virtual worlds or augmented reality. Moreover, the user studies with HMDs have been dominantly made in laboratory settings, focus been in interaction research. In addition, wearing HMDs has been investigated as an interaction method for the angle of physiological aspects, e.g. as part of a treatment for fear of flying [23], or by comparing it with other technologies [18].

Related to the applied research focusing around a real world use case, previous research has examined the building renovation and construction and the role of HMDs in it [22]. Thomas et al. have presented early work in the area of architectural design, namely using HMDs as an augmented reality tool that allows a building design to be viewed in its physical surroundings [20]. Recently, due to the improved access to the terminal HW as well as SW development tools especially with Oculus Rift and Google Glass, research has started to demonstrate different exploratory use cases for HMDs. Oculus Rift HMD has been demonstrated e.g. for creating a simulation that enables the user to fly on the sky like a bird [10]. In addition, research has started to address specific use cases where glasses type HMDs could be applied for, e.g. for helping with Parkinson's disease [13]. The general excitement around Google Glass project has been demonstrated e.g. in the invited keynotes given by Thad Starner at ISWC'13 [19] and Mark Billinghurst at IUI'14 [3], which both emphasize how the wide adaptation of glasses type can have a possibility to change the world - how we interact with information and each other.

Despite of the buzz around the technology, the research addressing the end user perceptions and a wider set of possible use cases is currently still very scarce. Koelle et al. [12] studied user perceptions of smart glasses with imaginary scenarios, and conclude e.g. that glasses should be rather designed as a task focused rather than an all-purpose device. However, their work did not extend to research on everyday life use contexts in the wild. This calls for user research, where the area is investigated through a field study, where participants are probed to chart and assess the different possibilities with the technology. This said, this is where the positioning of our research is, and where its novelty and contribution lies in.

### Research Method

#### *Experience Sampling Method (ESM)*

The use of imaginary technology is a relatively common approach in charting the early user perceptions for technologies, where the technical maturity or availability is not yet there to allow user research with functional prototypes. For instance, context-aware mobile computing has been investigated by letting the study participants to keep a diary on the use situations of imaginary mobile phone applications [2], and an audio memory aid with an experience prototype simulation [8]. Experience sampling method allows exploring a wide set of different everyday life context, yet with the unpredictable set of factors and in random order. In our research, we have conducted an early perceptions user study in the field, using Experience Sampling Method (ESM), enhanced with a user diary and with the use of a low-fi mockup of the wearable HMD unit, see figure 1. A similar approach has been used earlier in [24] in the context of portable pico-projectors. In [24], Wilson et al. describe a two-phased user research in order to chart user's perceptions and preferences on the technology, which was yet mostly unknown to the people. In the first study utilizing ESM, the participants (n=15) were probed to use pico projectors and project different content in real life context, and feedback on these occasions was collected. In the area of context-aware computing, ESM has been used to chart user perceptions on collaborative context status updated in social media [17].

Different level prototypes can be used to chart different aspects in the design cycle for technologies, as illustrated for mobile mixed reality in [5]. The use of low-fi prototypes, fits well to the early phase of the design cycle, where they can be used to prompt the user with tasks, and the give a more realistic flavor of the use of the (yet imaginary) technology. Iachello et al. use a term *paratype* for 'introducing simulated interaction with a certain technological artifact within a specific setting of real social action, and documenting the effects of this combination' [8], and use the technique to chart user perceptions of a ubiquitous memory aid. In our research, we utilized a low fidelity mock-up as a design probe.

Design probes are physical artifacts, which are used to provoke people to think of different aspects of a system and for collecting these ideas. This approach offers possibilities to conduct user research in-the-wild also for complex or futuristic technology concepts, as illustrated also by earlier research. It has been pointed out that the use of design probes provides not only inspiration for design in the dialogue between the user and the designer, but also they help in understanding the challenges and real life aspect of the living experience [21].

## USER STUDY SET-UP

### Research Questions

In our research, we focused on charting the user perceptions on (imaginary) glasses type HMDs in a variety of everyday life use contexts. In particular, we sought answers to the following research questions:

R1. What were the most commonly emerged concerns and benefits the participants perceived for using glasses type HMD?

R2. What were the social aspects related to the device (imaginary) use, and what kind of reactions their use provoked?

### Design Probe

In order to explore these phenomena, we created three identical prototypes of the smart glasses for a user study. The device consisted of a normal glasses frame with a small camera lens and a module that was similar in size to an eye-tracker attached (figure 1). The prototype was not functional, but allowed study participants to role-play imaginary situations and envision potential uses of smart glasses during the study by providing visual and tangible cues to the participant and the people around them. The mockup is illustrated in use in the study in figure 1.

### Study Procedure

The overall process of the user research included the following steps:

- Introduction session
    - Filling in the consent form
    - Completing the background information form
    - The test moderator explained the concept of the smart glasses including showing pictures and a video about possible functionalities of such devices
    - The moderator explained the study procedure
- Diary study
    - First phase: In this phase the test participant carried the prototype device with them and completed paper diary questionnaires. This phase lasted for 2 days.
    - Second phase: In this phase the smart glasses prototype was not used, and forms were filled electronically. This phase lasted for 3 days.
- End interview
    - The moderator reviewed the diary entries and photos taken by the test participant in a semi-structured interview
    - The participant completed a survey assessing their overall experience of using the smart glasses.

In total, 288 text messages were sent to the 12 participants. The time at which the text messages were sent was different every day, in order to capture the participant doing different activities and in different locations. In the following, the test procedure is explained in more detail.

In the introductory session the aim of the study was described to the test users, and they were asked about their familiarity levels with HMDs and augmented reality in general. Before starting the study, all the users were given a short introduction on how the smart glasses concept was imagined to work, and what were the (imaginary) possibilities of using the device. Functionalities such as taking photographs, viewing augmented information, and control possibilities via voice, gesture and eye-tracking were explained to the participants.

In total each participant completed 5 days of diary studies during which they were sent 24 text messages, prompting them to act. For the first 2 days, the participants were asked to carry the device and diary questionnaires with them. In this phase, every user received 6 text messages per day, which requested them to undertake a test process with the prototype and complete a paper questionnaire.

Each time after receiving a prompting text message, the participant was asked to put on the smart glasses as soon as it was safe to do so. They were instructed to try to use it regardless of what activities they were doing, and to imagine all the possible uses of the device in that context. The participants were also asked to take photos of themselves and the surroundings if it was possible. Following this, participants completed the paper questionnaire in the study diary. The questionnaire consisted of questions related to the location, current activity and the reaction of people nearby to the smart glasses. Questions also included alternative interaction methods, including voice, touch, gesture and gaze controlled, from which they should select those that suited their current context. Additionally, two Likert scale questions were used to capture the subjective usefulness and comfort of the smart glasses.

For the final 3 days of the study the user did not use the physical smart glasses prototype. In this phase, every user received 4 text messages per day, prompting them to record their location, activity and imagined uses for the smart glasses, as in the first phase of the study.

At the end of the study, the participants returned the prototype and the study diary, and participated in a final interview. The interview included different questions about the experience; we asked if they felt embarrassed using the smart glasses, their comfort level, their feelings, other people's reactions, and if they would like to use this kind of product in future. We also questioned them about their ideas for potential uses of the device, and the biggest benefits and the worst moments of using the device. Finally, we asked participants to add any additional ideas or comments about the smart glasses and their experience of participating in the study. The test participants were rewarded with a 20€ shopping voucher for participating in the study.

### Participants

Altogether 12 participants aged between 16 and 36 (M=26.3, SD= 4.6) took part in the study. The test group was gender balanced, consisting of 6 males and 6 females. Table 1 provides summary descriptions of each participant.

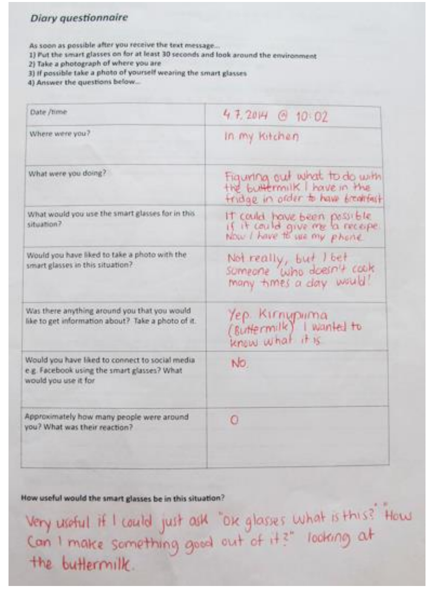
| User | Gender (M/F) / Age / Work / Hobbies etc. |
|---|---|
| 1 | M 31. Works for a large company. Watching TV. Lives with his family. |
| 2 | F 24. University student. Surfing Internet and reading. Lives with boyfriend. |
| 3 | M 26. University student. Doing sports and surfing Internet. Lives alone. |
| 4 | F 25. Working. Playing games on tablet. Lives alone (with dogs). |
| 5 | F 16. High school student. Taking lot of photos and watching movies. Lives with parents. |
| 6 | M 29. University student. Playing video games. Lives with a flatmate in a student apartment. |
| 7 | F 27. Works as tourist guide. Doing sports and cooking. Lives alone. |
| 8 | M 23. Works as a librarian. Plays drums in a band. Lives with two friends. |
| 9 | M 25. University student. Surfing internet and reading books. Lives with flat mate in a student apartment |
| 10 | M 26. University student. Listening to podcasts and music. Living with flatmate. |
| 11 | F 36. Works in the tourism industry. Jogging. Lives with her husband |
| 12 | F 28. University student. Photography and cooking. Lives with her husband |

**Table 1. Summary descriptions of study participants.**

## DATA

### Collected Data

After concluding the study and analyzing the results, the participants had completed 234 diary entries, of the possible 288. The entries were hand-written on a given form, example illustrated in Figure 2. Figure 3 shows the number of diary entries and photographs taken by each user during the total duration of the study. Only 3 of the participants (#3, #4 & #12) gave responses in response to all 24 of the trigger points. Figure 4 shows the number of entries gained for each ESM trigger.



*Diary questionnaire*

As soon as possible after you receive the text message...
1) Put the smart glasses on for at least 30 seconds and look around the environment
2) Take a photograph of where you are
3) If possible take a photo of yourself wearing the smart glasses
4) Answer the questions below...

| | |
|---|---|
| Date /time | 4.7.2014 @ 10:02 |
| Where were you? | In my Kitchen |
| What were you doing? | Figuring out what to do with the buttermilk I have in the fridge in order to have breakfast |
| What would you use the smart glasses for in this situation? | It could have been possible if it could give me a recepe. Now I have to use my phone |
| Would you have liked to take a photo with the smart glasses in this situation? | Not really, but I bet someone who doesn't cook many times a day would! |
| Was there anything around you that you would like to get information about? Take a photo of it. | Yep. Kirnupiima (Buttermilk) I wanted to know what it is |
| Would you have liked to connect to social media e.g. Facebook using the smart glasses? What would you use it for | No. |
| Approximately how many people were around you? What was their reaction? | 0 |

How useful would the smart glasses be in this situation?

Very useful if I could just ask "OK glasses what is this?" "How Can I make something good out of it?" looking at the buttermilk.

**Figure 2. An example of one of the diary entries recorded by the study participants. Each text message prompt resulted in the participant recording a one page diary entry such as this.**

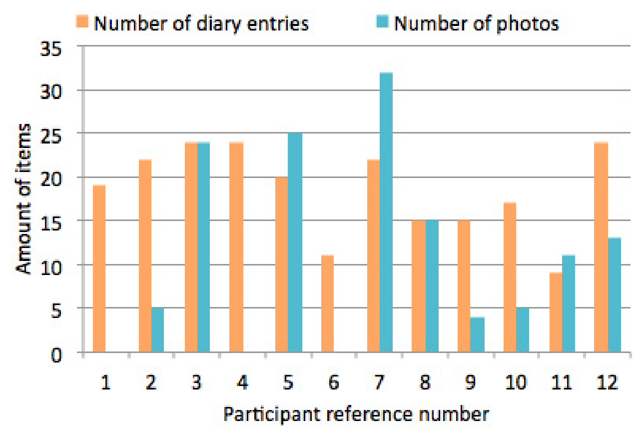



**Figure 3. Total number of diary entries and photographs recorded by each test participant during the study.**

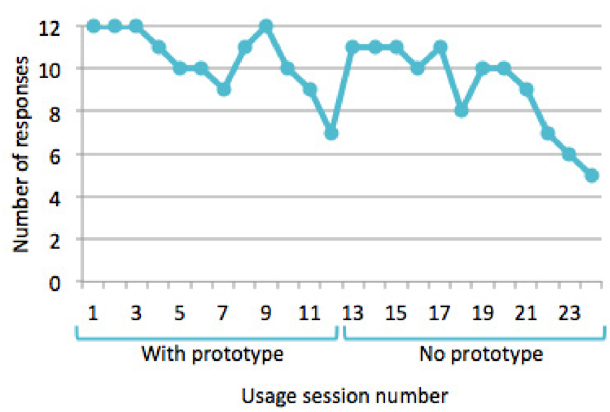



**Figure 4. The number of responses recorded at each of the trigger text message points.**

The data from the participant's diaries was first transferred to Microsoft Excel. Based on the location contexts in which the participants recorded diary entries, two researchers identified 14 different context categories. This was further reduced by combining categories such that 10 different categories were produced. A third researcher then parsed the participants' data into the context categories.

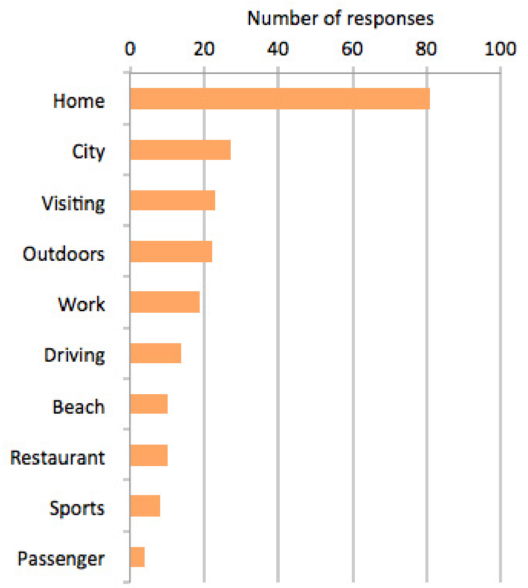



**Figure 5. The number or responses per context category.**

## RESULTS

### Contexts of Use

Based on the usage locations recorded by the participants, ten context groups were identified. Here, each category represented a similar contextual setting, being as follows: Home, City (e.g. market place, car park, train station), Visiting (friends, parents), Outdoors (walking, jogging), Work, Driving (car, bike), Beach, Restaurant (or cafeteria), Sports, Passenger (in car, bus). We then applied this grouping to the data, in order to identify common issues related to the usage context. Of a possible total 288 diary entries, 234 entries were made and categorized. Thus, 54 locations at which the prompt messages were received were unknown due the incomplete diary entries. Figure 5 shows the number of responses per context category. The reported subjective usefulness and comfort of use in each of the contexts is presented in Figure 6, retrieved from the individual diary entries for each context.

Due to the low number of samples in the passenger context (4), this was not included in statistical analysis. A Kruskal Wallis test was performed to find the effect of context on perceived usefulness. There was no statistically significant difference between the contexts ($H(8) = 9.022$, $p = .340$). Similarly for the effect of context on comfort level, no significant difference was found ($H(8) = 11.812$, $p = .160$)

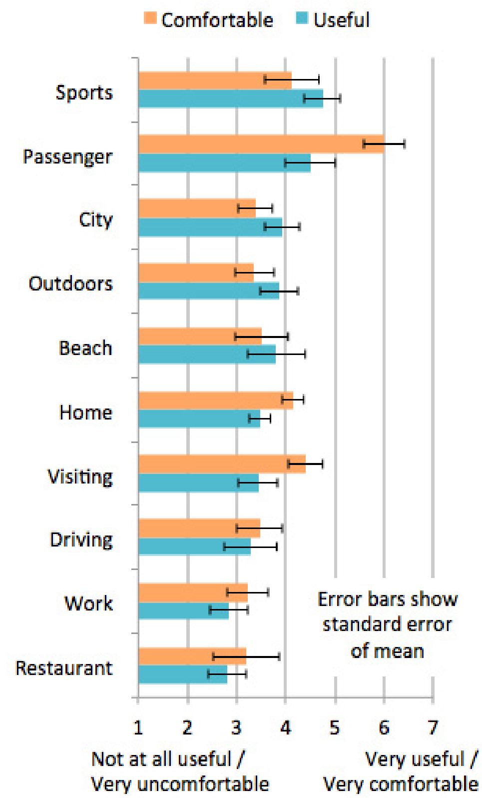



**Figure 6. Subjective usefulness and comfort of use per usage context category, ratings on Likert scale 1-7. The contexts are presented in order of perceived usefulness with the most useful at the top.**

**Figure 7. Examples of ESM triggered diary entry photos of the situations where the participants regarded the glass useful because it enabled hands-free use.**

### Prominent Themes

In this section, we go through the most prominent themes that emerged from the diary entries.

### *Hands-full use situations*

Throughout the participants' comments in both diaries and end interview, the glass was most commonly regarded as a useful and practical device when hands-free use was needed for interaction or information search. This is illustrated in the example, Figure 7, and e.g. in the following user comments. *"When your hands are full and occupied…like washing dishes or riding a bicycle." (User #3).* and *"The best situation was when I was cooking so I did not had to go to my room to check the recipe it at my computer" (User #1).*

### *Cheating with Extra Information*

In addition to the hands-free use, another commonly commented purpose suggested (or feared) for the glasses use related to cheating, see Figure 8 for examples. Mostly this was connected with the ability to search extra information without the others noticing it. The possibility to cheat was mostly regarded with negative connotations. In this respect users commented, e.g. *"When I was playing chess with a small girl, she got mad when she lost because she thought that I cheated." (User #3).*

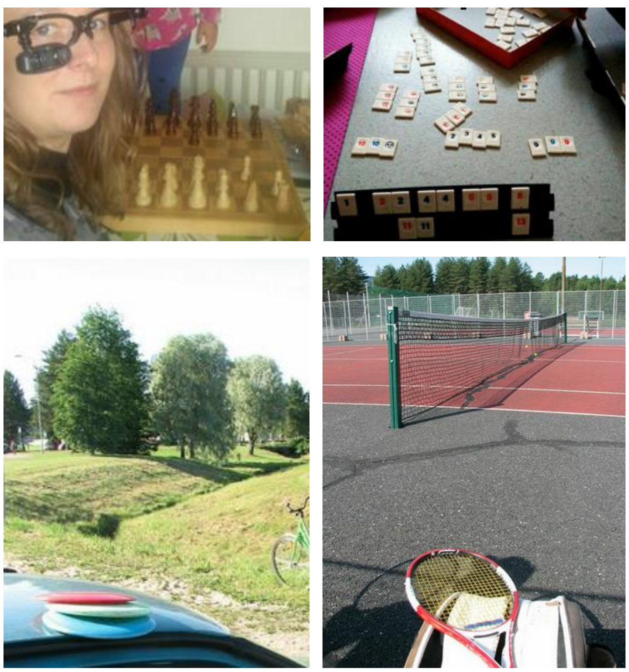


**Figure 8. Diary entry photos related to the comments on cheating – Playing chess, playing a tiles game, playing Frisbee golf, playing tennis.**

### *Legal issues*

Another concern which gave rise to several comments related to legal issues (Figure 9), or merely on was the use of the device prohibited in some situations. For instance, it was wondered if the use of the device was allowed when driving a car: *"I would use it when my hands are occupied, or when I was driving. I don't know is it forbidden or not?" (User #4).*

In addition, the ability to take photos or videos unnoticed was discussed. For example, *"I think it would be good that you have to touch the glasses to take a picture to give an aid for people to see that you're taking a picture of them. There are also laws about taking people's pictures and they should be respected in this regard." (User #2).* Similarly, *"I was at the beach with my friends and they thought it would be invading privacy if I would havee taken pictures of other swimmers wearing their bikinis." (User #1).*

**Figure 9. Examples of ESM triggered diary entry photos of the situations where the participants were concerned about possible legal issues.**

## Social Aspects

In regard the social aspects, it was pointed out that use of the glass could have a negative effect on the face-to-face interaction with the people present, and divert the attention away from the social situation. This is illustrated e.g. in the comments related to possible interruptions caused by the glass: *"For example if I am with my friends or driving I don't like something suddenly coming in front of my eyes. It can distract me from my friends and the environment. It's invisible to the others but it will distract me." (User #5). "You always have to be ready if somebody sends you a message, with glasses you're always online" (User #2).*

**Figure 10. Photos illustrating situations, where social context was seen to matter in the use of the glass**

Privacy concerns were also mentioned, but interestingly, mostly in the context of assumptions other people might be drawing about the expected use of the device. Several participants mentioned that they were concerned that the nearby people would think them doing something unethical or forbidden with the glass – e.g. taking photos on the girls at beach, or recording actions of a police. For example, *"When I was in supermarket, imagining searching a product, one of the staff was suspicious of me." (User #8)* and, *"I was embarrassed when I was at the store and I had to use it in front of people." (User #3).*Examples of diary entry photos related to social aspects are illustrated in Figure 10.

### Interaction and Functionalities

*Modalities*

When doing the ESM triggered diary entries, the participants were also asked to select which modes of interaction they preferred for the particular situation. The interaction modalities that the participants considered to be the more appropriate in each usage context are presented in Figure 11. It should be noted that participants were able to identify more than one modality at each test point.

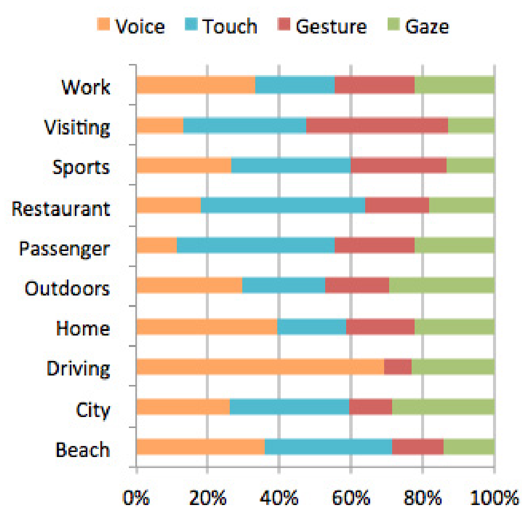



**Figure 11. Preferred interaction modalities per location category. Note, participants were able to select multiple modalities in each response.**

As seen in Figure1, driving context was with the strong preference for voice input. The least desired contexts for voice input took place when the user was a passenger, visiting someone or in the restaurant – all these being social contexts. Thus, the use of modalities has a connection with the social acceptability. In addition, the choice of preferred modalities link to the use of the device when the user's hands were occupied by another task, and when interacting by touching the device was impossible.

*Expectations with the Technology*

Altogether, 2/12 participants regarded the glasses as a replacement for a smart phone, whereas 10/12 saw it as a complementary device. Here, especially the easiness of the hands-free use was again seen as a benefit, as well as the immediate access to the device, taken that the glasses were already worn: *"It could also be safer than using an old style car navigation, because with smart glasses you can keep your eyes on the road. Maybe it could be useful when jogging or other situations when you can't use your hands, for example replying messages." (User #2)*

Interestingly, we also evidenced some expectations of very advanced device features, e.g. related to the connectivity and glasses as a universal interaction device. For instance, a voice command to the glass was wished to open a door on the user's path.

### Answers to the Research Questions

Based on the data derived from the user research, we are able to draw the following summarizing answers to the research questions.

R1. The most commonly perceived benefits from using the glasses were the ability to search information and interact with the device in situations, where hands-free usage was required. In addition, the easy access to the device was appreciated, especially to complement smart phone use, where the phone needs to be first taken into the hand e.g. from the pocket or handbag. The most commonly mentioned concerns related to use of the device related to the cheating that was seen to be possible with the unnoticed use of the glasses, or to the feeling that other's thought the user was doing something unethical with the glasses.

R2. In regard to the social aspects, the glasses were seen to hinder the face-to-face social interaction due interruptions, or to cause suspicions towards the user.

## EXPLORING THE FORM FACTOR DESIGN ASPECTS

### Alternative Designs and Their Evaluation

As the next step, we sought to explore different industrial design concepts for glasses type wearable computing, deriving design rationale from the results of the user study. Thus, we created four designs, illustrated in Figure 12. The designs included different design directions, altering the noticeability, the wearable platform (glasses vs. headphones), the visual style (from clinical to sporty) and the ability to attach the wearable computing part to ordinary glasses or headphones.

The designs were assessed with focus groups, a recommended method for obtaining feedback on open-ended research questions [11]. As a target user group, we focused on young adults with active user profile in mobile technologies and social media. We conducted three focus group sessions, altogether with 14 participants (6 females, 8 males), aged 20-32 (M = 26.4, SD = 2.8). The length of each focus group session was one hour.

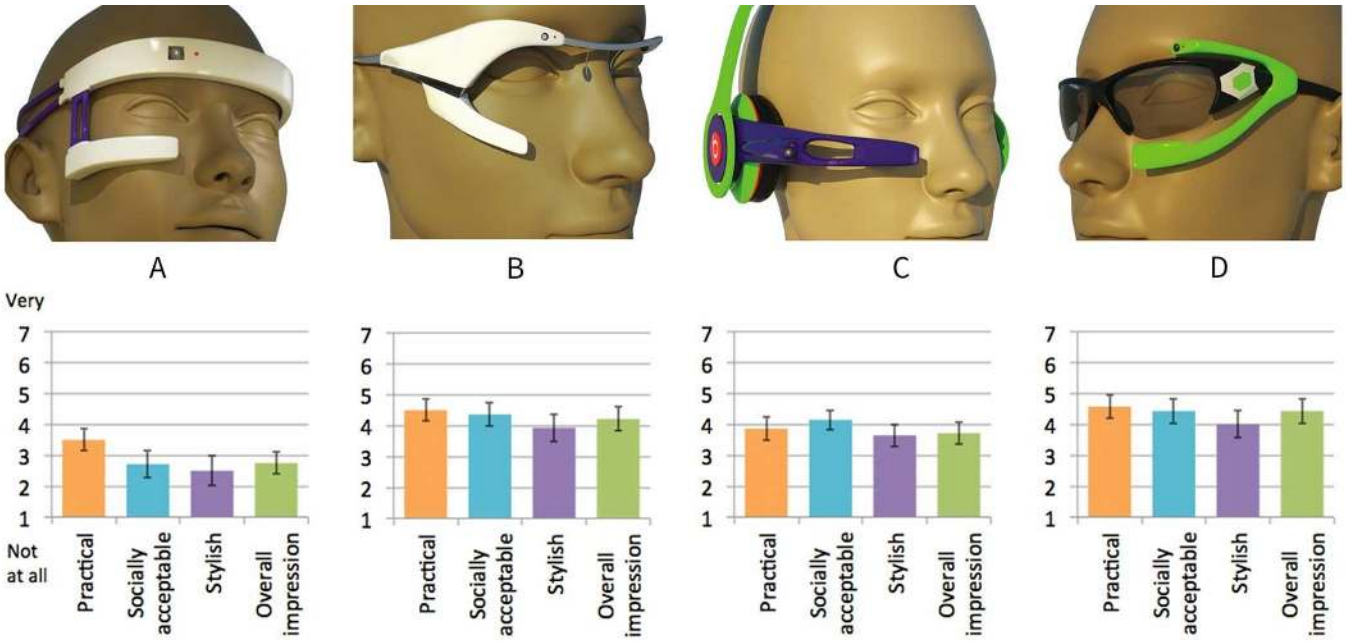



**Figure 12. Alternative design approaches created for glasses type wearable computing. Charts show subjective user ratings with error bars indicating the mean error.**

| Design Concept A | Design Concept B | Design Concept C | Design Concept D |
|---|---|---|---|
| This concept was considered as suitable for industrial site, or hospital use (the latter being influenced by the white colour of the device). It was considered bulky and uncomfortable to wear. | Generally this was considered comfortable. However, several participants felt the design with all the functional elements on one side was too radical. (Note, the current version of Google Glass is also asymmetrical, but less visually so) | This design raised divided opinions about its social acceptability, with some considering it would draw less attention in public than glasses based concepts, whilst others held an opposing view. Several participants commented on its use in the home. | Participants who wore corrective spectacles preferred this, however issues of style were raised. The idea of removing the functional elements when not needed and e.g. carrying them in a pocket until needed, was proposed by participants. |
| ***Exemplary participant comments*** | | | |
| *This looks suitable for working, so it does not have to be aesthetically pleasing.* (#F2)<br>*This looks like hospital equipment* (#F3)<br>*Clearly the ugliest* (#F1)<br>*Uncomfortable and sweaty to wear (#M1)* | *The asymmetrical one-sided design is disturbing.* (#F1)<br>*Looks comfortable. (#F2)*<br>*Easy to put on and does not cover face so dominantly. (#F1)*<br>*For those with strong, personal style. (#F3)* | *Looks most familiar, does not separate from the crowd. (#F2)*<br>*Useful at home, not outside as not socially acceptable. (#M4)*<br>*Colours appeal to boys between ages 12 and 13. (#F3)* | *Too sporty for normal use. (#F1, #F3)*<br>*How does it fit to the style of the user's own glasses? (#F3)*<br>*Should be as unobtrusive as possible. (#M5)*<br>*Easiest to use, detach and carry with you.* (#M4) |

**Table 2. Salient findings related to each design as illustrated in Figure 12.**

### Results
In the beginning of the focus group, we included a task where Google Glass was introduced and videos of its use were presented. Here, concerns related to privacy were raised e.g. *"The product is interesting, but the thing that someone is always filming is a threat"* (#M3)*,* and *"I'm concerned about privacy, it's for people who like sharing things"* (#F1).

The created design alternatives were then presented as paper prints to the participants. Participants rated each design for practicality, social acceptability, style and overall appeal on 7-point Likert scales, see Figure 12. To identify any significant differences between the participants' opinions on the designs we conducted paired sample Friedman's tests. For practicality no significant difference between the designs was found ($p = .102$). However for social acceptability, style and overall impression significant differences were identified (respectively; $p = .0001$, $p = .0090$, $p = .0016$). Post-hoc Wilcoxon's signed rank tests indicated that design A was considered significantly worse in social acceptability, style and overall impression. There were no statistically significant differences between the other designs. However, qualitative comments revealed that design alternative provoked different responses. Overall 10/14 participants selected concept design D as their favourite, with design C being preferred by 3/14 and B by 1/14. The salient findings concerning each design, together with supporting participant statements are presented in Table 2.

## DISCUSSION

### Social Acceptability and Privacy
Social acceptability issues with smart glasses have also been pointed out in [12], and we gained similar findings e.g. on unnoticed recordings, which were verbalized especially in the focus group session. Interestingly many of the ESM study comments relating to the social acceptability and privacy concerns considered the user, not the people around him/her. Whereas general privacy aspects were considered, e.g. people's awareness of being photographed, participants verbalized more concerns related to the risk that people (erroneously) thought they were doing something unethical with the glasses. We regard this as an interesting finding. Thus, the social acceptability is not only in the possibilities to misuse the device, but in the perceived image of being regarded a stalker or otherwise suspicious person.

Regarding the interaction modalities, earlier research has shown that small and subtle gestures that go unnoticed from the pass-byers are socially more acceptable than interaction with large gestures [16]. Although our results of preferred interaction modalities are only indicative, similar trend can be seen (figure 6). More unnoticeable interaction methods are preferred in public spaces.

### Utilitarian Needs
Whereas user experience is defined to include both utilitarian and hedonic aspects [7], the participants mostly suggested use cases which had a utilitarian purpose, such as information search. This was somewhat expected, as with an imaginary technology, it may be hard to identify hedonic ways the technology could be used, whereas task oriented and utilitarian needs are easier to come up with. The diary entries and interviews indicate that users perceived smart glasses to be more useful outside of their home, in more active and dynamic environments where there were more possibilities to use the glasses in different ways.

Also the idea of using the glasses as a complementary device with a smart phone rises from the utilitarian needs. The glasses were seen as a way to access information and to interact when the handling the phone was cumbersome, slow or impossible due the busy hands.

### Methodological Notes
We acknowledge that our study is limited by several factors. Firstly, the small data sample prevents us from drawing statistically significant results, and thus the findings are qualitative. For instance, when interpreting the data in Figure 5, it should be noted that in particular the Passenger category received relatively few responses (4). However, as the study was qualitative in nature, we still were able to extract interesting findings from the data.

Secondly, we did not use a functional prototype of the device, but rather approached the research questions with design probes. With this, we could focus on the potential of the glasses, and not restrict the participants thinking e.g. by the available technical functions or reliability of the current technology. In the design part of the research, we acknowledge that the introduced designs are rather different from Google Glass type glasses. Here, our purpose was to present some alternatives to this 'de facto' form factor, which was also introduced at the beginning of the focus group session.

As might be expected, the response rate on the ESM triggers decreased during the study, with progressively fewer responses being received to later prompt messages (Figure 4). In Figure 4, it may be noted that the response rate temporarily increased at the beginning of the second phase of the test when no physical prototype prompt was used. When designing the study, we expected the decrease in participant's eagerness to fill out the diary to happen over time. In order to gain more data, we decided to limit the diary days with the actual design probe, and add extra days where the participant was asked merely to use his/her imagination. We considered that this would motivate participants to continue participating in the study as the need to carry the glasses probe was removed. Due to the experience gained over the first days, we considered we considered participants would be able to imagine the experience. Based on Figure 4, this compromise proved to be a good approach, as the declining response rate grew again to a very high level after removing the design probe for the latter part of the ESM study. Altogether we consider that the research method was quite successful in capturing different types of real world contexts and user perceptions on glasses in them.

## CONCLUSION

In this paper, we have described our user research on the concept of using wearable computing in the form of smart glasses capable of information search and display, communication, and media capture. In our research, we have used an experience sampling method (ESM) to collect data by sending the participants (n=12) text message triggers and asking them to imagine the use of the glasses in their current context. Our data body consists of 234 diary entries and 134 photos, complemented with interview material. In addition, we created four different industrial design examples of smart glasses, and assessed them with focus groups (n=14)

Overall, smart glasses were seen as a quite useful tool, especially in situations where the user's hands were occupied elsewhere, and when they could complement the use of a smart phone. The most common concerns related to the technology use were related to the possibility to cheat or retrieve information without other people noticing it. Also, concerns related to the locations where the device was used, or should be prohibited from use. Social concerns related to disruptions and others misunderstanding the user were raised. Interestingly, when wearing the glasses, the participants commented more on the fear that people would perceive or suspect them of using the device for stalking or cheating, rather than someone else actually doing so.

Exploration around industrial design concepts of smart glasses type wearable computing provided varied reactions to different visual styles of appearance. The visibility of the system status, ability to take the wearable computing completely off in an easy manner, and visual design according to the primary use context (work or leisure) were identified as salient things to consider. Also attaching the wearable computing elements as part of a headphones design rather than glasses was found to be an interesting alternative, which could follow fashion trends and ease adoption and social acceptability of the technology for wider audiences.

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