Designing Wearable Light Displays for Users and Observers

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Abstract
Peripheral displays, such as ambient light displays, have a
pervasive character and thus are often integrated into
everyday items, such as lamps, or into wearables such as
jewellery, or clothes. Although many displays are designed
to present information that is meant solely for the user,
the information display can also be perceived by people in
proximity. Because of that a user's willingness to wear
resp. use a peripheral display often depends on the
reactions of observers, we argue that we need to consider
both the user and observers when designing peripheral
displays. We close this paper with a number of research
questions in the field of wearable light displays that need
to be investigated.

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Peripheral Display, Wearable, Light, Ambient, Social
Acceptability

ACM Classification Keywords
H.5.m [Information interfaces and presentation]:
Miscellaneous.

Motivation and Background
Thinking of peripheral interaction, interaction with
wearable devices comes to mind. Interfaces worn on the
user's body give excellent opportunities for interacting in a

more or less natural way and for displaying information to the user regardless of where she might be at the moment. Typically, wearable displays are designed to present personal information to a user.

As the displays are worn in daily life, they are often not only perceived by the user, but by people in proximity. Especially when a wearable display presents information visually using ambient light, its visibility to observers is even higher. This visibility plays a big role for the social acceptability of a wearable display.

Previous work has shown that the usage and acceptance of wearable technologies is highly influenced by its perceived level of social acceptability [7, 6, 9]. In our view, to design a socially acceptable wearable display means to take three areas into account:

Privacy concerns of the information's addressee Who should not see or not be able to decode the to-be-displayed information?

Self-Presentation of the user How does the display have to behave and look to make the user feel comfortable?

Perception of the display by observers How does the display have to look and present information to be accepted by observers?

If we have a look at previous work on wearable light displays, we see that the information's addressee is often not the only person who can perceive the information. Therefore, we argue that we have to consider both, the user and the observers in the design of such displays. In the following, we list examples in which the user is the

only addressee, but different persons can perceive the display of the information.

Solely user perceives display
eye-q [3], AmbiGlasses (with shaded frame) [8]

User and others perceive display
Reminder Bracelet [4], Damage [11], hello [1], ActivMON [2], Pediluma [6]

Especially wrist-worn displays, such as LED bracelets [4, 11, 1, 2] are semi-public displays that - although the information is personal - can be perceived by observers. Pediluma [6] is an ambient light fixed on the user's shoe which visualises the user's physical activity and is highly visible by people in proximity.

Profita et al. investigated how observers perceive the interaction with a body-worn e-textile interface. They found that the perception of controller placement and gesture interaction varied depending on the gender of the user. Besides, they found differences in the perceived importance of aesthetics and usability between US American and South Korean observers [9].

Rico et al. looked at the social acceptability of mobile phone gestures from the perspective of a user. In an on-the-street user study they found that location and audience had an impact on a user's willingness to perform gestures [10].

Research Questions
As we particularly research wearable light displays, we focus this field in the following research questions.
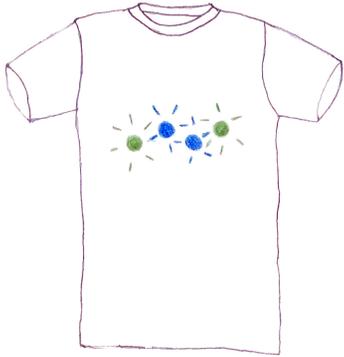
Figure 1: Plain t-shirt with single LEDs

Figure 2: Brightly patterned t-shirt with LED spots discreetly integrated into the t-shirt design

1. How do users and observers perceive different body locations for wearable light displays, and in how far do they accept them?

Suitable body locations have been investigated from a user's perspective for visual displays in general [5]. The social acceptability of different body locations for wearable displays has not been researched yet. Besides, peripheral displays, such as wearable light displays, are perceived differently than conventional displays due to their pervasive character. We need to answer the question how different body locations for wearable, peripheral displays are perceived and accepted by users and observers. Furthermore, when we investigate body locations, we have to explore in how far the possibility to remove a display changes its perception. E.g. on the wrist, a light display could be integrated into a bracelet, but also into the sleeve of a shirt. The nature of a bracelet to be removable or concealable in contrast to that of a shirt which cannot be removed without the user undressing might lead to a very different perception.

2. In how far does the fact that a display is recognizable as a display affect its acceptance by users and observers?

In contrast to conventional displays, peripheral displays typically have a pervasive character and can be integrated into everyday items, jewellery, or clothes. A wearable light display could e.g. be presented as single LED spots on a plain t-shirt (see sketch in Figure 1), or it could be concealed as being composed of single LED spots placed onto a brightly patterned t-shirt (see sketch in Figure 2). In the latter example, the single LED spots would hardly be identifiable. The perception and acceptance of these two different light displays might probably be totally different. Therefore, we need to investigate in how far the

fact that a display is recognizable as a display or not affects its acceptance by users and observers.

3. Where should input methods for wearable displays be located and how should they be designed?

A wearable light display might need input methods to be controlled. We need to explore where these input methods should be located and how these input methods should be designed. E.g. the input could be done directly on the display, on another part of the user's body, or on another mobile device. Also here, the perception of users and observers has to be explored, as specific gestures performed on the body might be perceived differently from a observer's perspective than from a user's.

Summary

Peripheral displays in general, and wearable light displays in particular are often designed in a way that not only the user as the addressee can perceive the display of information, but also people in his or her proximity. Besides privacy issues, this fact plays a big role with regard to the social acceptability of the display. A user's willingness to wear resp. use a display, especially in public, often depends on the reactions and acceptance of observers. We argue that to design a socially accepted peripheral display, we have to consider both the user and observers in the design process. We formulate a number of research questions in the field of wearable light displays that need to be investigated.

References

[1] Ahde, P., and Mikkonen, J. Hello: bracelets communicating nearby presence of friends. In *Proc. of PDC '08*, Indiana University (2008), 324–325.

[2] Burns, P., Lueg, C., and Berkovsky, S. Activmon: Encouraging physical activity through ambient social

awareness. In *Proc. of CHI EA '12* (2012), 2363–2368.

[3] Costanza, E., Inverso, S. A., Pavlov, E., Allen, R., and Maes, P. Eye-q: Eyeglass peripheral display for subtle intimate notifications. In *Proc. of MobileHCI '06* (2006), 211–218.

[4] Hansson, R., and Ljungstrand, P. The reminder bracelet: subtle notification cues for mobile devices. In *Proc. of CHI EA '00*, ACM (2000), 323–324.

[5] Harrison, C., Lim, B. Y., Shick, A., and Hudson, S. E. Where to locate wearable displays? reaction time performance of visual alerts from tip to toe. In *Proc. of CHI '09*, ACM (2009), 941–944.

[6] Lim, B. Y., Shick, A., Harrison, C., and Hudson, S. E. Pediluma: Motivating physical activity through contextual information and social influence. In *Proc. of TEI '11* (2010), 173–180.

[7] McAtamney, G., and Parker, C. An examination of the effects of a wearable display on informal face-to-face communication. In *Proc. of CHI '06* (2006), 45–54.

[8] Poppinga, B., Henze, N., Fortmann, J., Heuten, W., and Boll, S. Ambiglasses-information in the periphery of the visual field. In *Proc. of Mensch & Computer '12* (2012), 153–162.

[9] Profita, H. P., Clawson, J., Gilliland, S., Zeagler, C., Starner, T., Budd, J., and Do, E. Y.-L. Don't mind me touching my wrist: A case study of interacting with on-body technology in public. In *Proc. of ISWC '13* (2013), 89–96.

[10] Rico, J., and Brewster, S. Usable gestures for mobile interfaces: Evaluating social acceptability. In *Proc. of CHI '10* (2010), 887–896.

[11] Williams, A., Farnham, S., and Counts, S. Exploring wearable ambient displays for social awareness. In *Proc. of CHI EA '06*, ACM (2006), 1529–1534.