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CHI'15 Extended Abstracts, Apr 18-23, 2015, Seoul, Republic of Korea
ACM 978-1-4503-3146-3/15/04.
http://dx.doi.org/10.1145/2702613.2732833

Abstract
Wearable technology has been envisioned, amongst other things, to enhance face-to-face social interaction. For example, the visibility of wearable devices to other people (e.g. a wearable display) could augment the wearer's appearance by displaying public and socially relevant information about them. Such information could increase nearby people's awareness of the wearer, thus serve as tickets-to-talk and, ideally, enhance their first encounters. We present the design of CueSense, a wearable displays that shows textual content from the wearer's social media profiles, determined by the level of proximity to another user and match-making between their contents. We report the findings from a preliminary user study with 18 participants, followed by discussion as well as ideas for future research and further refinement of the concept.

Author Keywords
Co-located social interaction; wearable display; ticket-to-talk; social cue; proximity-awareness; match making; user study; user experience.

ACM Classification Keywords
H.5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interfaces.

Introduction and Related Work

Use of technology often creates situations where people are immersed in the digital world and ignore others in their surroundings [12]. In contrast, we are interested in utilizing technology to also encourage and enhance co-located social interaction. In particular, inspired by the early visions of Wearable Communities [7], this paper explores the potential in enhancing social interaction with the synthesis of (1) wearable mobile devices (2) displaying social media information (3) in the context of encounters between strangers.

Earlier research has identified both opportunities and challenges of technology enhancing co-located social interaction. Despite being able to provide a ticket-to-talk (i.e. a reason to open a conversation with others [11]), people expect to have control over their own technology how it should behave during their social interaction with others [6]. Some of the earlier works are the Meme Tag [2] and the BubbleBadge [4]. The Meme Tag is a wearable meant to support people in the formative stages of cooperative work. The device displays one meme, i.e. an idea or an opinion, at a time generated by users who can then exchange them with each other. The BubbleBadge is designed to look like a brooch that is capable of displaying information. It claims to augment face-to-face interaction by providing information about the user or the environment.

More recent designs have utilized wristbands and e-textiles among other form factors (e.g. Augmented Reality –based solutions). For example, Social Fabric Fitness increases awareness and group performance with a shared display on the back of an athletic shirt [10]. The system was found to support collaboration among group members and make the running experience more fun and motivating. Furthermore, CommonTies is a smart wristband that alerts the wearer of another CommonTies user that shares certain interests or criteria with them [1].

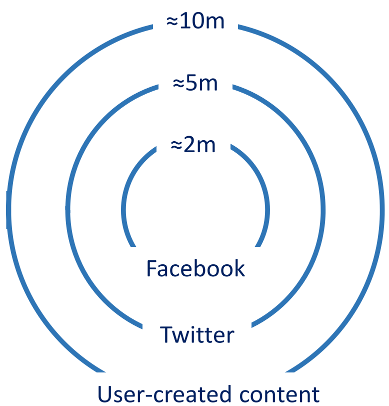

Figure 1. CueSense Proximity Levels

Design of the CueSense Prototype

Starting Points for Design

As an empirical starting point for the design process, we conducted small-scale participatory design with focus groups to understand how wearables in general could enhance social interaction. We had altogether 11 participants discussing issues related to different activities and information one could share about oneself or receive about others in various social situations. To stimulate discussion, we had examples of existing wearable products, such as Google Glass and smart watches.

One of the key findings was that commonalities between people could serve as *cues* and trigger interaction between newly-met strangers. However, commonalities are hard to identify before engaging in any interaction; for example it is hard to tell what are the other's favorite books or music only based on the physical appearance. This finding and the early visions of Wearable Communities [7] inspired us to aim at wearable technology that could enhance and trigger social interaction between unfamiliar people in their encounters.

On the other hand, social network services like Facebook and Pinterest have been successful in connecting remote people – both strangers and friends – with similar interests. However, the rich social interaction happening in such services has not been much utilized to also enhance face-to-face interaction.

Figure 2. Initial Arduino-based prototype of CueSense

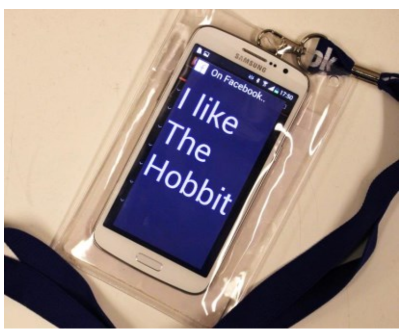

Figure 3. Example of the information presentation mode in CueSense

Description of the CueSense Concept
After the focus groups, we designed our prototype, CueSense, a small wearable display that could be placed anywhere on the wearer's clothes. CueSense displays simple textual content related to the user. CueSense was designed with the expectation to be easy to see and grab the others' attention. The displayed content is partly based on Facebook and Twitter profiles, partly on user-input answers to predefined questions (e.g. about one's favorites). Unlike in the earlier work, we provide tickets-to-talk for face-to-face interaction based on existing profiles in social media. Furthermore, in situations where two CueSense users meet, it performs match making of the content, presenting only information that both have in common and thus could serve as a ticket-to-talk.

According to Hall's proxemics theory, there is a relation between physical distance and social relationship and interaction. People perceive and interpret others' actions based on distance, posture, and orientation of others [5]. The concept of proxemics has been utilized in different practices, such as creating intuitive interaction when collaborating face-to-face with multiple devices [9] or reinforcing privacy protection by considering who are within proximity that can spy on the private content [3]. Consequently, CueSense builds on the proxemics theory: it was designed to present different content on three different levels of proximity (Figure 1). At public distance, approximately 10 meters, CueSense shows a user-input answer to a predefined question (in the following user study: a country that one would like to visit), which represents information that we expected that people would be open to share about themselves in any situation. At approximately 5 meters, within Hall's "social distance", CueSense shows matched content from Twitter, such as usernames and tweets of common followers. At approximately 2 meters, within Hall's close social distance, CueSense shows matched Facebook profile information. We considered Facebook content (e.g. liked books, artists, or pages) to be slightly more personal than the above-mentioned Twitter content because Facebook is usually used among friends. In Twitter, one can follow or be followed by people who are not familiar from real life. Thus, this difference explains the difference between proximity levels.

Prototype Implementation
The prototype was initially implemented on Arduino Uno with a small display and a Bluetooth module to pair with a smart phone for content mining (Figure 2). Proximity sensing is performed by initiating Bluetooth discovery every few seconds, which returns the received signal strength indicator (RSSI) of the other device. Unfortunately, because of technical stability issues with the Arduino implementation, for the user study CueSense was additionally implemented as an Android application. A mobile phone with a 5.5-inch display, as seen in Figure 3, was used to simulate a wearable display in the user study.

The content was mined from Facebook and Twitter with the provided APIs to receive public information about a particular user account. What information is public depends on the user's privacy settings but most often the application could mine information like a list of favorite books and movies, inspirational people, likes and education in Facebook, and followers, followees and the users' favorite tweets in Twitter. Matching of the users' information is performed by exchanging anonymized and encrypted data between the users'

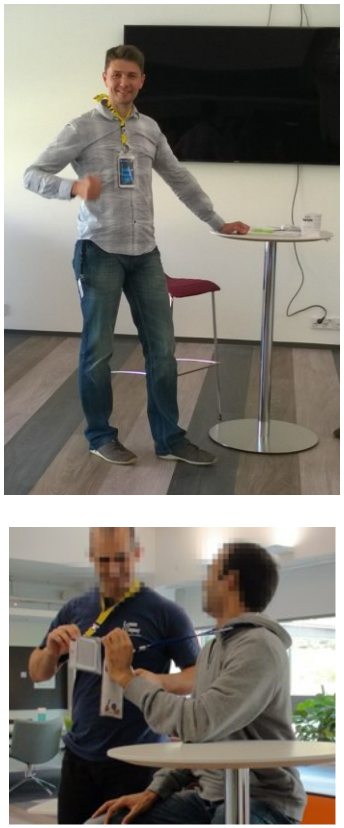

Figure 4. The context of the user study. **Above:** a participant wearing the device and waiting for another participant. **Below:** two users interacting based on what the CueSense showed to them.

devices over Bluetooth. Data matching between users was implemented to top of Levenshtein's algorithm [8]. The content is displayed with large font size (covering the whole screen) on a relatively large mobile phone screen (5.5"), which we believe to both attract others' attention and allow reading over a distance of up to 10m (see Figure 3 for an UI example).

Preliminary User Study

To get early feedback of the appropriateness and overall user experience of the application, we conducted nine pair-wise user tests. The following briefly reports the test setup and limitations, the main findings, and draws conclusions for future research questions and further development ideas.

Methods & Procedure

The study was conducted as a pair-wise testing and interview session in an open indoor area at a university campus (i.e., semi-public place) to explore the effects of wearable devices in social encounters. With both passersby and people spending time in the surroundings, the context also gave the users a sense of audience and of being observed by others. We had altogether 9 sessions with 18 participants (13 males and 5 females). The participants were students of the university.

In the beginning of the session, the participants (unfamiliar to each other) were in two different locations. This was to mimic a first-time encounter between them later in the session. The researchers briefly explained CueSense and the study. The participants were asked to login to their Facebook and/or Twitter in the mobile application and answer a simple question about themselves (which country one would like to travel to). Due to the prototype form factor, CueSense was suggested to be hung around the participants' necks (Figure 4). It is a position that is easy to notice in face-to-face encounters and a position where name tags are usually worn. Next, the participants were brought together for their first encounter supported by CueSense, and were later allowed to freely explore the system (e.g., the proximity-based change of the content and the match making feature).

The proximity sensing and the different levels was tested in a pilot test and was found rather unreliable because of the dynamic environment. The participants were wandering around rather quickly, and as the difference between the closest level and middle level was rather small (only 3m) the proximity sensing could not response fast enough. Consequently, we had to reduce the number of proximity levels to only two (within 10m and 2m). Now, the closer level included both Facebook and Twitter information.

Results

Overall, most participants agreed that CueSense is something that could be used when they have a specific purpose of being social and getting to know strangers. They envisioned that CueSense could be used in contexts where people are motivated to get to know each other, such as in a party or a conference. The system was also often seen as a tool that could be used for group formation thanks to the match making. Some participants thought CueSense as an extension of name tags that enhance people's first encounters in various contexts. Furthermore, although people in general are concerned about privacy of their information in social media they did not seem to be bothered about that here; it seems that the possibility to meet new people or get to know a familiar stranger better overrode the privacy concerns that they possibly had.

Although social media content was seen interesting, it also induces challenges. The detailed personal information distracted participants' attention to the devices and their own past online activities: "*I was trying to remember what I've liked on Facebook and checked the display to see if there is anything weird*" – (M, 25). Having such wearable display thus seemed to increase self-consciousness of the wearer. Additionally, some participants felt that looking at another's wearable display is not socially desirable: "*I feel impolite to look at [another's device], so I looked at mine instead when matching occurred*" – (M, 23). This did not only apply to the interaction between the participants; the participants reported that they noticed people in the vicinity to quickly look at what they were wearing, however, quickly averting their gaze away when they were noticed. Overall, because the shown content is dynamic and defined by both the distance and the other user, the participants had to pay much attention to the device; this was away from the fluency of the face-to-face interaction. Although this is an important design challenge, we expect this issue would fade away when people are familiar with the system.

Regarding the changing of content in relation to proximity levels, participants hardly noticed the changing of content. Although CueSense played a subtle audio cue when moving from a proximity level to another, the change needs to be communicated more noticeably. One reason was that there were no commonalities between some of the participant pairs. Having no matched content on the next proximity level meant that CueSense did not provide any visual content or audio feedback. Therefore, using CueSense in more similar groups would ensure commonalities and allow richer social experiences with the system.

Another reason could be that even though the concept of CueSense was explained to the participants in the beginning, the relation between the content and proximity levels seemed not to be clear enough. Consequently, the change of content often appeared to be random. Moreover, using CueSense in a dynamic and lively context made it hard for the participants to notice the changes of content: "*using [CueSense] when walking by someone, it is hard to notice the matches*" – (M, 25). A few participants suggested that CueSense could be used in contexts where people are not moving as much – instead of along busy pathways.

Discussion and Future Work

CueSense presents a design of a wearable display with proximity-awareness and match making of the social media content of two encountering persons. The preliminary user study results suggest that CueSense has potential to provide ticket-to-talk and enhance the first encounters of strangers in certain types of contexts. The proximity-awareness is conceptually very interesting when applied to open-ended social encounters where people can freely move around and the distance between users changes.

However, the preliminary user study with a limited prototype and naturally leaves much to improve in order to truly demonstrate the novelties of the concept and study the user experience. For example, the current implementation is limited to the encounters of exactly two users, and does not yet support group situations, i.e. having more than two users. Scaling CueSense to serve encounters of several users adds additional challenges to take into account: e.g. with whom CueSense to perform match-making, what happens when another user joins the existing pair-wise situation with a matching commonality, etc. Similarly, the implementation of proximity-awareness as well as match making had their limitations. With a too simple match-making algorithm, the prototype filtered out *potential* common interests between users. To solve this, we could make the match-making algorithm more inclusive, or totally remove it and try if displaying any information has similar social influences. The latter could work with people with homogenous interests, such as in a party for the students of the same discipline or a specialized conference.

Overall, we will continue exploring various design solutions for these challenges and building more refined prototypes, also with truly wearable form factors. Furthermore, we plan to run more user studies in various settings to achieve a more comprehensive picture of the social possibilities and limitations of the concept. This includes varying the levels of familiarity and heterogeneity of the participants, physical places and types of displayed content, and utilizing long-term user trials in authentic everyday situations.

Acknowledgements

The research was funded by Academy of Finland (grant 264422).

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