Tactile Band: Accessing Gaze Signals from the Sighted in Face-to-Face Communication

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Abstract
Gaze signals, frequently used by the sighted in social interactions as visual cues, are hardly accessible for low-vision and blind people. A concept is proposed to help the blind people access and react to gaze signals in face-to-face communication. 20 blind and low-vision participants were interviewed to discuss the features of this concept. One feature of the concept is further developed into a prototype, namely Tactile Band, to aim at testing the hypothesis that tactile feedback can enable the blind person to feel attention (gaze signals) from the sighted, enhancing the level of engagement in face-to-face communication. We tested our hypothesis with 30 participants with a face-to-face conversation scenario, in which the blindfolded and the sighted participants talked about a given daily topic. Comments from the participants and the reflection on the experiment provided useful insights for improvements and further research.

Author Keywords
Accessibility; eye tracking; visual impairments

ACM Classification Keywords
H.5.2. [Information interfaces and presentation]: User Interface, K.4.2 [Computers and Security]: Social Issues – Assistive technologies for persons with disabilities.

Introduction

In face-to-face communication, sighted people communicate smoothly through the transmission and interpretation of nonverbal signals, such as eye gaze, facial expressions and gestures. Eye gaze in particular plays an important role in conversation. A common face-to-face conversation can contain a wealth of gazes and mutual gazes, which the sighed people take for granted in their daily routines. A sighted speaker consciously or unconsciously uses gaze or eye contact to communicate with the conversation partner. Through the conversation partner's eyes, she can sense interest, engagement, happiness etc. Gaze signals are frequently used by the sighted in social interactions as visual cues. However, these signals and cues are inaccessible for the blind and hardly accessible for low-vision people. In this paper, we propose a concept to help the blind people access and react to gaze signals in face-to-face communication in user study. 20 blind and low-vision participants were interviewed to discuss the features of this concept. One feature of the concept is further developed into a prototype, namely Tactile Band, to aim at testing the hypothesis that tactile feedback can enable the blind person to feel attention (gaze signals) from the sighted, enhancing the level of engagement in face-to-face communication.

Related Work

This research draws on theories of gaze behavior and related research on gaze based interfaces. A number of studies have investigated the importance of gaze behaviors of sighted people in social occasions. Argyle studied that in dyadic (two-person) conversations, about 75% of the time people are listening coincides with gazing at the speaker [1]. Kendon suggested that seeking or avoiding looking at the face of the conversation partner has important functions in dyadic conversations, to regulate the flow of conversation and to communicate emotions and relationships [4]. In recent years, research on gaze based interfaces moves forward with advances in eye tracking technology. Rantala et al. introduced eyeglasses that presented haptic feedback when using gaze gestures for input. The glasses utilized vibrotactile actuators to provide gentle stimulation to three locations on the user's head [7]. Hosobori et al. developed a communication interface namely EyeChime: three participants sit around a table, and sounds were generated and played when participants looked at the other person's face or when the participants' eyes met [3].

User Study

In our user study, we proposed a conceptual design, E-Gaze glasses, to help blind people access and react to gaze signals, which aims to enhance the engagement between the sighted and the blind people in social interactions. It has two main functions: to help access gaze signals and to react to the sighted by conveying eye gesture signals. Based on these two functions, four features of E-Gaze (Figure 1) were proposed as follows: (a)*gaze detection*, slight vibrations from E-Gaze indicate gazes from the sighted conversation partner; (b)*eye contact simulation*, when the sighted looks at E-Gaze, E-Gaze also looks back to establish "eye contact"; (c) *avoiding state*, if the sighted gazes long enough, E-Gaze looks away to avoid the long gaze; (d) *attention state*, the simulated eyes in E-Gaze opens bigger when the heartrate of the blind person increases, indicating an "attention state". We interviewed 20 blind and low-vision participants (8 females, M_{age} = 20.88, SD = 1.46; 12 males, M_{age} = 19.92, SD = 3.42) with ages ranging from 16 to 29

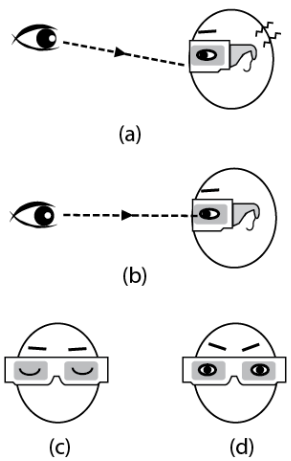

Figure 1. E-Gaze: (a) gaze detection; (b) eye contact simulation; (c) avoiding state; (d) attention state.

years old. Ten were from Yang Zhou Special Education School in Chinese mainland and the other ten were from Hong Kong Blind Union. The interviews were conducted online. In the interviews, we explained to participants features of E-Gaze using persona and scenarios. Finally, we collected in total 79 quotes of comments and suggestions about the design of E-Gaze. There were 44 positive responses and 35 negative responses. Example comments are presented as follows:

Gaze Detection

In general, the majority of the participants (17/20) felt gaze detection could be beneficial for the blind. One participant said: "*This idea (C1) is good, because we can easily know some people will speak to us*" (P20). However, three participants had negative comments on gaze detection. One of them argued: "*It is not necessary for knowing being looked at. The sighted could come to call your name directly*" (P18).

Eye Contact Simulation

Fourteen participants had positive comments on the eye contact simulation while six participants had negative ones. Example positive responses were: "*It is useful at the beginning of the conversation, when expressing the respect to your conversation partner*" (P1). "*The sighted could feel me being polite if E-Gaze has eye contact with them*" (P16). The negative responses were: "*E-Gaze can establish eye contacts with the sighted, but I cannot feel eye contacts*" (P11). "*I feel E-Gaze taking control over me and dominate my feelings. It replaces me to show eye gestures (feelings) to the sighted, which is out of my control*" (P14)

Avoiding State

Participants' attitudes towards avoiding state included seven positive responses and thirteen negative responses. An example positive response was: "*It (C3) can be very useful. Nobody liked being gazed at for a long time. It could be a feasible way to stop being gazed*" (P13). The example negative response was: "*The avoiding state causes misunderstanding. The sighted may consider you are not willing to communicate. If you are not patient about talking, you could tell her or change to the other topic.*" (P18).

Attention State

We collected six positive and fourteen negative responses towards the attention state. P20 expressed his positive opinion: "*It (C4) is interesting to let the sighted talking to you know that you are interested in the topic*." But some participants thought it was unnecessary to have this function. For example: "*The attention state is too artificial and looks like cartoon figures' expression. I prefer natural expressions*" (P9). "*I feel uncomfortable if E-Gaze exposes my attention state. It is my privacy*" (P2).

Based on results of the user study, we clarified our design direction: selecting gaze detection feature for the further design as the first step. Then we developed gaze detection feature to a prototype: the Tactile Band.

Preliminary Experiment

The Tactile Band was designed to enable the blind person to feel attention (gaze signals) from the sighted. The hypothesis is that the tactile feedback can enhance the level of engagement in face-to-face communication. In our concept, a wearable eye tracker (SMI Eye

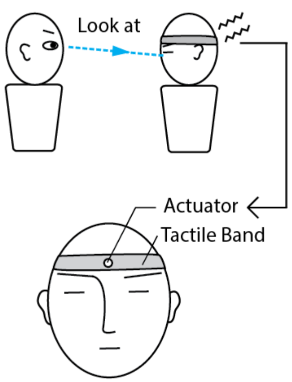

Figure 2. Design concept of the Tactile Band

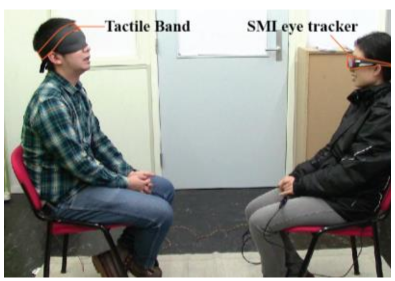

Figure 3. The blindfolded and the sighted participants had a conversation in a test.

Tacking Glasses[1]), worn by the sighted, can detect her gazes to the blind person. Gaze signals are mapped to vibration signals of an actuator embedded in the Tactile Band, worn by the blind person on her forehead. The blind person perceives a slight vibration from the Tactile Band as a signal of the sighted looking at her face (Figure 2).

The Tactile Band used a Wizard-of-Oz environment in the preliminary experiment. The wizard (a human observer) observed the real-time eye tracking video from SMI eye tracker and controlled vibration actuator of the Tactile Band. If the gaze hit the facial region of the blindfolded participant, a slight vibration was triggered by the wizard. If the gaze was still in the facial region, slight vibrations with equal intervals were triggered by the wizard. The vibration stopped when gaze was out of the facial region.

A within-subject design was conducted and it included one independent variable with three levels (no Tactile Band, Tactile Band without vibrations & Tactile Band with vibrations) and one dependent variable (engagement in a conversation). The level of engagement was measured with two subjective measures: relationship quality (IMI: Intrinsic Motivation Inventory questionnaire) [5] and partner closeness (IOS: The Inclusion of Other in the Self Scale) [2]. IMI included 45 items, assigned to 7 subscales. We were particularly interested in participants' mutual relationship in conversations. Therefore, we chose one subscale: relatedness (8 items), included the item like "*It is likely that this person and I could become friends if we interacted a lot*". IOS Scale was used to measure the closeness. It included seven increasingly overlapping circle pairs, which could indicate the distance of the relationship between themselves and their conversation partners.

The participants were 30 student volunteers from Eindhoven University of Technology (11 females, M_{age} = 29.73, SD = 5.69; 19 males, M_{age} = 28.16, SD = 2.17) with ages ranging from 21 to 42. They were paired randomly to have dyadic conversations and one of them was blindfolded (Figure 3). Three conversations were taken under the following experimental conditions for the blindfolded in a random order: (I) no Tactile Band; (J) Tactile Band without vibrations; (K) Tactile Band with vibrations. Before each conversation, one topic was randomly picked from 14 daily topics from IELTS oral exams included the item like "*Describe a job you have done*". Participants were asked to share ideas about the topic. Each conversation lasted around 10 minutes and after each conversation, participants were asked to answer a post-experimental questionnaire. After three conversations and post-experimental questionnaires, we did a short interview to collect the blindfolded participant's comments and suggestions towards the Tactile Band. Each conversation was video-taped and the interview was audio-tapped. The overall experiment lasted approximately 90-120 minutes.

Results
We used SPSS for the data analysis. The conversation quality was analyzed using RM-ANOVA with relationship quality and partner closeness as within-subject factors. Table 1 presents mean and standard deviation of relatedness and partner closeness across three conditions. Before running RM-ANOVA, we checked the data for violations of parametric analysis: the sphericity

[1] http://www.smivision.com/

	I (N=30)		J (N=30)		K (N=30)	
	M	SD	M	SD	M	SD
R	5.58	0.86	5.71	0.71	5.59	0.87
P	3.07	1.14	3.17	1.15	3.17	0.87

Table 1. Mean and standard deviation of relatedness (R) and partner closeness (P) across three experimental conditions: (I) no Tactile Band; (J) Tactile Band with no vibration; (K) Tactile Band with vibration.

assumption was tested using Mauchly's test. There were no significant effects of relatedness F (2, 56) = 0.64, p = 0.53, and partner closeness F (2, 56) = 0.20, p = 0.82 in three conditions. Since the blindfolded participants wore the Tactile Band, their comments and suggestions towards the Tactile Band were analyzed. Total 70 quotes of user comments were collected and they were merged into three categories: the modality (20 quotes), the prototype (31 quotes) and suggestions (19 quotes).

The modality

Comments of the vibration feedback were gathered from the result of the question: "*What do you think about the vibration feedback, when your conversation partner looks at your face?*" Two participants (P3, P11) mentioned they could not immediately map the vibration to the gaze signal in conversations. The other participant (P10) explained in the beginning the vibration feedback helped her concentrate on the conversation partner, but after while it became just a subtle clue that she often neglected.

The prototype

We asked participants two open questions: *"Which aspects make you like /dislike the Tactile Band?"* Six participants liked the Tactile Band. The example comments were: *"The Tactile Band did not feel interfering too much. It was easy to wear and it had subtle cues." "It was used quite soft material, which was comfortable to the skin."*(P10, P14) Some participants also explained why they disliked the Tactile Band. The primary reason was they disliked having the Tactile Band on the head. The example comment was: *"The head feels like a scary location for such direct vibrations. It might also be obtrusive for the conversation partner."*(P14)

Suggestions

We received suggestions for improving the Tactile Band in two directions: try other modalities to map gaze signals and improve the wearability of the Tactile Band. As for other modalities, two participants stated temperature changes could map to gaze signals. For example: the soft warmth on eyes indicated a kind of the close feeling (P15). Other participants mentioned cue tone, soft touch and different intensity of the vibration. For the wearability of the Tactile Band, participants gave many suggestions and the top three were: at hand, around the arm and using the mobile device, where were more invisible during the conversation.

Discussion

We get useful implications for further improvements in both the design and the experiment: improve the prototype such as the wearability, redesign the scenario in the experiment and give more time to the participants to get used to mapping between gaze signals and tactile signals.

According to the observations and user comments, we need to improve the wearability of the Tactile Band. For example, it could be worn on the wrist, which is less visible than on the forehead. The intensity of the tactile feedback could be fine-tuned. Other types of tactile feedback can also be explored besides vibration, such as a sense of pressure by changing the shape of the material.

Besides the improvements of the prototype, redesigning the scenario in our experiment is also needed. In interviews, some blindfolded participants expressed several alternative contexts in which they would find them to be more useful. For example, a slight vibration (gaze) signal from the conversation partner predicts the start of the conversation to help them be more concentrated. We also consider in turn-taking, eye gaze plays an important role as it indicates where the speaker's focus of attention is directed. An alternative scenario can be that, one sighted speaker discusses with two blindfolded participants in triadic (three-person) conversations. The sighted stops talking and gives her turn to one of two blindfolded listeners by the gaze signal.

Spending more time in learning the mapping between gaze signals and tactile signals may be helpful. The blindfolded participants knew the importance of the gazes and they had the direct and clear understanding of gaze behaviors. However, gaze is a visual cue in their perception. It will take some time, even a long-term training for them to map gaze signals to tactile signals, which is unnatural for them. As for the blind people, we found they tend to have the indirect and fuzzy understanding of eyes and gazes [6]. They knew the importance of gazes from descriptions in novels or by others. Mapping gazes with tactile signals is a new experience for them, which is likely to require more time for practicing to get used to.

Conclusion

In the experiment, we get useful insights and design implications. The prototype needs to be improved with the wearability with fine-tuned intensity of the tactile feedback. Other feedback can also be explored such as the cue tone or the sense of pressure caused by the shape changing of material. We also find the approach of adopting blindfolded participants have some limitations. In our future work, we will involve some blind participants in testing the prototype.

Acknowledgements

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TEI'16 Chairs' Welcome

Welcome to ACM TEI'16, the 10th-anniversary edition of the International Conference on Tangible, Embedded and Embodied Interaction, hosted at Eindhoven University of Technology, the Netherlands from February 14th to February 17th, 2016.

This year's conference marks TEI's tenth anniversary. We see this as a perfect opportunity for recalling some of our founding values and complementing these with contemporary values, for reemphasizing the relationship between interactive products and systems and the body, and for learning from each other's approaches and rationales. To do this, we have established the theme '**Our Body Is Our Manual**': As the interactions we propose in our products and systems are aimed to inform our embodied selves, we should also allow ourselves to be informed by our bodies when designing and researching these interactions. Through a wide palette of work ranging from highly technical to highly artistic, and from highly applied to highly conceptual or theoretical, we wish to trigger discussion and reflection, with the aim of emphasizing what binds us.

TEI'16 hosts a four-day program, starting out with the **Graduate Student Consortium** and a series of **Studio-Workshops** that embody the essence of our community by offering intellectual and practical experiences to conference attendees with diverse skills and backgrounds. The main program is kicked off by **Takeo Igarashi**, who in his opening keynote discusses computer tools that allow end users control over the design of artifacts in their lives. After the opening keynote, the Papers track commences, in a slightly different set up than before. This year we do not include Q&As in the presentations but instead wrap up each session with a reflective discussion between the presenters. The day concludes with the **Demos, Posters** and **Work-In-Progress** exhibition. From day two until day four the **Art Exhibition** questions and frames the impact of new technologies on our lives and proposes new modes of embodiment. Following day three's Papers sessions we host a full afternoon of **Studio-Workshops**, engaging all TEI attendees in active, hands-on discussions. Day four includes three Papers sessions, a lunch lecture and panel discussion, and the closing keynote by **Tom Djajadiningrat**, who reconsiders tangible interaction by discussing new technologies, illustrated through examples by Philips Design.

This year we received 178 submissions to the Papers track, which were all equally subjected to a double-blind peer review process of at least three reviewers and a meta-reviewer. A total of 45 accepted papers makes for an acceptance rate of 25%. For the Work-in-Progress track we received 100 submissions, which were subjected to a double-blind peer review process of two reviewers each. This resulted in 40 accepted submissions, making for an acceptance rate of 40%.

Of course, organizing this conference could not have been possible without the energy and commitment of many, many people. We would like to thank everyone who contributed to TEI'16: the authors for submitting their quality work to the conference, all the organizing committee chairs for managing their part of the conference, the program committee and external reviewers for safeguarding the quality of the conference, the local organizing committee, the sponsors, supporters and partners, and the TEI steering committee.

We wish you a great conference!

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