E-Gaze: Create Gaze Communication for People with Visual Disability

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ABSTRACT
Gaze signals are frequently used by the sighted in social interactions as visual cues. However, these signals and cues are hardly accessible for people with visual disability. A conceptual design of E-Gaze glasses is proposed, assistive to create gaze communication between blind and sighted people in face-to-face conversations. We interviewed 20 totally blind and low vision participants to envision the use of the E-Gaze. We explained four features of E-Gaze to participants using persona and use scenarios. Participants discussed the features on their usefulness, efficiency and interest. The results helped us clarify the design direction and further research.

Author Keywords
Social interaction; eye contact; visual impairments

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces.

INTRODUCTION
Gaze signals are important in social interactions. It is closely related to the expression of interpersonal attitudes as well as the development of mutual trust and deeper relationships [2]. Even a small conversation includes a wealth of gaze signals: 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. Meanwhile the conversation partner can also look at her face and smile to her, delivering the agreement with gestures or facial expressions. Gaze signals are frequently used by the sighted in social interactions as visual cues. They are however inaccessible for the blind and hardly accessible for low-vision people. Gareth R. White et al. [11] interviewed 8 visually impaired expert users and one of them indicated a communication problem. The problem was that it was often difficult for them to meet people because they could not see and make eye contacts with the sighted people. In this paper, we proposed a conceptual design, E-Gaze glasses, to help blind people access and react to gaze signals. It aimed to create gaze communication between blind and sighted people in face-to-face conversations and enhance their mutual engagement in social interactions. Our previous work related to this user study was reported earlier at a conference [9].

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RELATED WORK
This research draws on theories of gaze behaviors and related work on social interaction assistance for blind people.

Gaze Behaviors in Social Occasions
A number of studies have investigated the gaze behaviors of sighted people in social occasions. Argyle studied that in dyadic (two-person) conversations, about 75% of the time people are listening, which 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 [5]. Roel Vertegaal et al. used an eye tracker to measure gazes at the faces of conversational partners during four-person conversations. The result indicated that gaze was an excellent predictor of attention in conversations [10].

Social Interaction Assistance
The other research area related to this work is to make visual cues accessible to blind people in face-to-face communication. Shafiq ur Rehman et al. implemented a haptic chair for providing facial expression information to blind people. Nine vibrators were located in the back of the chair which indicated some specific facial features [7]. Sreekar Krishna et al. also provided an assistive technology for accessing facial expressions of interaction partners. His research prototype was a vibrotactile glove worn by the blind person and it could convey the conversation partner's seven facial expressions such as happy, sad and surprise with different vibration patterns [6]. Sara Finocchietti et al. proposed ABBI, an audio bracelet for the blind person's social interaction, to rehabilitate spatial cognition on where and how the body was moving [4]. These examples were all

about assistive devices to help blind people access nonverbal signals such as facial expressions and body gestures, but none of them were about gaze signals that are important in nonverbal communication.

E-GAZE DESIGN

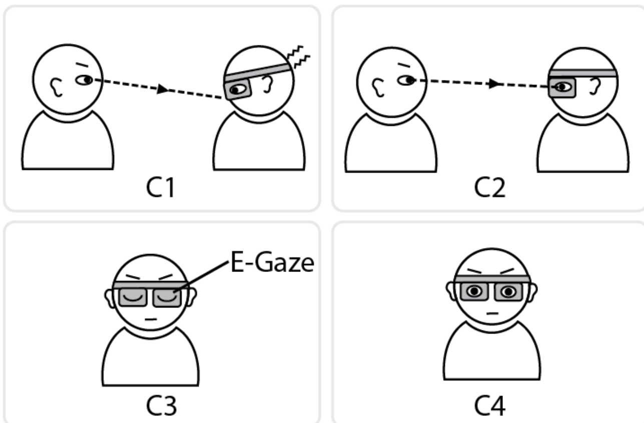

Figure 1. E-Gaze: (C1) gaze detection; (C2) eye contact simulation; (C3) avoiding state; (C4) attention state.

E-Gaze glasses, a wearable device, is designed to help blind people access and react to gaze signals from the sighted, enhancing the engagement between blind and sighted people in face-to-face communication. E-Gaze is based on the AgencyGlass [8], a prototype that was attached on a sighted user's face and displayed the user's eye gestures. It was to decrease the emotional workload of the sighted people by simulating eye gestures. In our research context, we have a different aim. We aim to enhance face-to-face communication between blind and sighted people. Based on this interest, we introduced AgencyGlass into our concept E-Gaze. E-Gaze has two main functions: to help blind people access gaze signals and to help them react to the sighted by displaying eye gestures. Based on these two functions, four features of E-Gaze (Figure 1) were proposed as follows: C1) *gaze detection*, slight vibrations from E-Gaze indicate gazes from the sighted conversation partner; C2) *eye contact simulation*, when the sighted looks at E-Gaze, E-Gaze also looks back to establish "eye contact"; C3) *avoiding state*, if the sighted gazes long enough, E-Gaze switches to avoid the long gaze; C4) *attention state*, the simulated eyes in E-Gaze open bigger when the heartrate of the blind person increased, indicating an "attention state".

USER STUDY

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 years old. Ten were from Yangzhou Special Education School in Chinese mainland and the other ten were from Hong Kong Blind Union. The interviews were conducted online and each interview took roughly 90 minutes. In the interviews, we explained to participants four features of E-Gaze using persona and scenarios, which aimed to elicit participants' past experiences and memories to help them envision the use [3]:

> *Example scenario: Jack is 19 years old, a senior high school student. He was born blind…Jack feels a slight vibration from E-Gaze on the right forehead. His head turns right and wants to know who is looking at him. After a short while, his classmate Jim comes to say: "I see you see me and it reminds me of asking you a question." In this scenario, the slight vibration of E-Gaze indicates gazes from the sighted.*

After explaining the use scenario of each of the four features, we asked participants: "*What do you think of the idea? Imagine that you are Jack in this scenario.*" Twenty participants used five-point Likert scale, ranging from 1(strongly disagree) to 5(strongly agree), to evaluate each feature based on three dimensions: usefulness, efficiency and interest.

RESULTS

Quantitative Results

Four features of E-Gaze were evaluated for their usefulness, efficiency and interest by RM-ANOVA. The quantitative results were shown in Figure 2. There was a significant main effect of usefulness in four concepts of E-Gaze as determined by RM-ANOVA, F (3, 57) = 4.80, p = .005, η^2 = .17. In usefulness, a post-hoc test revealed that the mean score of gaze detection was significantly higher than attention state (p = .005). RM-ANOVA also revealed a significant main effect of efficiency F (3, 57) = 4.46, p = .007, η^2 = .16. For efficiency, a post-hoc test indicated that the mean score of gaze detection was significantly higher than avoiding state (p = .012). However, there was no significant effect of interest as determined by RM-ANOVA ($p > .05$).

Qualitative Results

We collected in total 104 quotes of comments and suggestions about the design of E-Gaze. There were 44 positive responses, 36 negative responses and 24 responses for design improvements. We gathered positive and negative comments from answers to the question: "*What do you think of the idea? Please tell the positive and negative feeling about E-Gaze.*" We also collected suggestions for design improvements for further research. Example comments and suggestions are presented as follows:

C1: Gaze Detection

In general, the majority of the participants (17/20) felt gaze detection could be beneficial for blind people (Table 1). One participant said: "*This idea (C1) is good, because we could 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). Questions and suggestions were

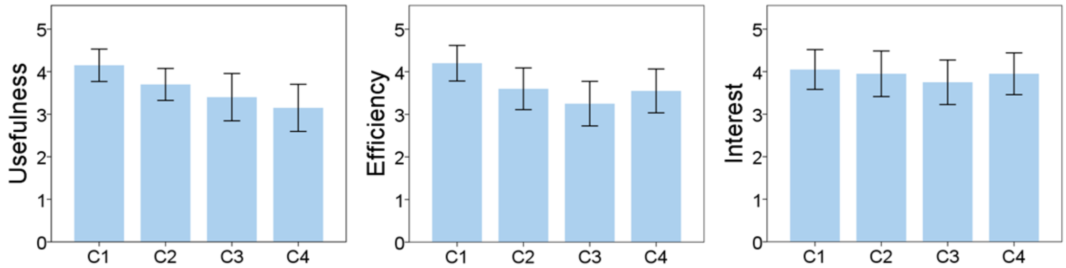

Figure 2. Results of usefulness, efficiency and interest related to the four features of E-Gaze: (C1) gaze detection; (C2) eye contact simulation; (C3) avoiding state; (C4) attention state.

also provided by participants. Two participants questioned the potential scenario: "*if being looked at by many people, what could be the vibration feedback of E-Gaze?*" (P2, P12)

Attitude	#	Example key words
Positive	17	Confident, warm, respected
Negative	3	Not necessary, useless

Table 1. Attitudes towards C1: gaze detection

C2: Eye Contact Simulation

Fourteen participants had positive comments on the eye contact simulation while six participants had negative ones (Table 2). 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 contacts 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). For suggestions, two participants wanted to sense the movement of the eye contact (P8, P14). P14 also wished E-Gaze to detect his feelings and thoughts from his brainwaves and used proper eye gestures to react to the sighted.

Attitude	#	Example key words
Positive	14	Polite, comfortable, interesting
Negative	6	Horrible, unnatural, useless

Table 2. Attitudes towards C2: eye contact

C3: Avoiding State

Table 3 shows participants' attitudes towards avoiding state, including 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). P2 stated: "*If I am interested in a conversation, I want to continue talking rather than automatically change to the avoiding state even when being gazed for a while.*" P14 also said: "*If I am indeed impatient about talking, E-Gaze should have some subtle changes such as looking around or looking away. These responses are more positive and friendly to the sighted.*"

Attitude	#	Example key words
Positive	7	Natural, avoid embarrassed
Negative	13	Block communication, impolite, impatient, disrespected

Table 3. Attitudes towards C3: avoiding state

C4: Attention State

We collected six positive and fourteen negative responses towards the attention state (Table 4). 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). Seven responses were about suggestions. The examples were: "*I wish E-Gaze could express my mood. It changes to attention state when I feel excited and it also changes to normal when I calm down*" (P12). P6 mentioned: "*E-Gaze is expected to be controlled by the dopamine in my body, which indicates the level of happiness and excitement. If the dopamine is high, E-Gaze naturally changes to the attention state*" (P6).

Attitude	#	Example key words
Positive	6	Show interests
Negative	14	Not private, not feasible, useless, strange, uncomfortable

Table 4. Attitudes towards C4: attention state

DISCUSSION

Next we reflect on the findings and discuss design implications of E-Gaze.

Gaze Detection

Based on both quantitative and qualitative results, we consider gaze detection is an interesting direction for further development. Several scenarios proposed by the participants demonstrate that gaze detection could be useful: 1) before the conversation, it can help the blind person find the sighted who is looking at her and she could initiate a conversation rather than passively wait; 2) during the conversation, if know being looked at, the blind person can become more confident in talking. In addition, gaze detection could be helpful for blind people to protect their privacy. P19 mentioned if the sighted peeked at his laptop screen in public, he could feel gaze signals instantly and signal a warning. However, we also found this feature has its limitations: vibration feedbacks might not be the perfect solution to map gaze signals if being looked at by many people from different sides. It could be difficult to distinguish different people's gaze signals in this case.

Control over the Eye Gestures

E-Gaze also aims to help blind people show eye gestures to communicate with the sighted. Some eye gestures of E-Gaze might cause misunderstandings in communication and even lead to a misinterpretation of the user's real intention. For example, some participants mentioned that the avoiding state feature (C3) misinterpreted their real intention in communication: if they were interested in a conversation, it would not be appropriate for E-Gaze going to the avoiding state. If they were not interested, E-Gaze could look away or look around as a euphemistic reminder rather than change to avoiding state. The users need more subtle control over the eye gestures.

Privacy Considerations

Privacy also needs to be taken into consideration in design. The development of the sensory technology allows more physiological signals of the participants to be detected. However, detection of the physiological signals might cause privacy problems. Some participants expressed negative opinions towards the concepts of detecting their physiological signals. One participant stressed that he did not want E-Gaze to change to an "attention state" automatically since he did not want others to know he was engaged in something, which belonged to his own privacy.

CONCLUSION

In this paper, we presented a conceptual design of E-Gaze glasses, not only let blind people perceive gaze signals but also help them give visual feedback to the sighted by using simulated eye gestures. In order to evaluate the E-Gaze concept, we interviewed 20 totally blind and low vision participants and in the interviews the concept is explained to them using persona and use scenarios. We get useful insights from results. For example: eye gestures of E-Gaze should give more subtle control to users to avoid misunderstandings in communication and privacy needs to be taken into consideration in design. The results also help us to clarify the direction for next steps. In future work, we will further develop the gaze detection concept to a functioning prototype to enable blind people to feel the attention (gaze signals) from the sighted, to enhance the level of engagement in face-to-face communication with the sighted.

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