VisualLink: Strengthening the Connection between Hearing-impaired Elderly and their Family

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Abstract
Elderly who suffer from hearing impairment usually have difficulties talking on a phone due to the absence of face-to-face signals. This difficulty gradually weakens the connection between the elderly and their beloved family living remotely. To assist these hearing-impaired elderly, we propose VisualLink, a visual aids system for them to better receive and comprehend a call. Specifically, VisualLink notifies elderly of a call using notifications on large screen (TV) and wearable device with haptic feedback. The elderly then pick up the call via a VisualLink phone with a traditional-look, which automatically uses speech recognition to transcribe the call and show the caption on the screen, with interactive visual content such as images authored by the caller. In the evaluation of the prototype, participants gave VisualLink positive feedback for its ease of use and usefulness for making them better connected to their family's life.

Author Keywords
Hearing impairment; Assistive Technology; Human Factor; Experimentation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Hearing impairment is one of the common problems of elderly adults. According to World Health Organization (WHO), near one-third of people above 65 years old are affected by hearing impairment [1]. Elderly who suffer from hearing impairment have difficulty having conversations in their daily life. This is especially true when they communicate with the counterpart in a call due to the lack of face-to-face signals such as facial expressions and body gestures. Unfortunately, options for aiding hearing impairment are limited. A common way is wearing a hearing aid. However, in Taiwan, only 2.5% and 3.4% of aged 65~74 and aged 75~84 of hearing-impaired patients, respectively, are using hearing aids [2]. According to our interviews with hearing-impaired elderly, the primary reasons for which hearing-impaired elderly seldom wear hearing aid are that: 1) hearing aid is uncomfortable to wear and it sometimes has disturbing noises. 2) Wearing a hearing aid implies some kind of incapability and disability that elderly is reluctant to reveal. 3) Hearing aids are relatively expensive for those having a low income. Due to these reasons, hearing-impaired elderly has been having difficulty receiving and understanding the conversation of the counterpart in a call. This difficulty in turn gradually weakens the connection between the hearing-impaired elderly and their beloved family members who can only call to contact the elderly in most of the time because they live far away. Therefore, our goal is to strengthen the connection between hearing-impaired elderly and their family. We conducted a user research to further understand the design problem. Through an iterative design process, we designed and aimed at making communication between hear-impaired elderly and their family more effective. The components include a sticker, an authoring interface, and a conferencing system. The sticker is attachable onto an elder's wearable such as a watch and delivers haptic feedback when it receives an incoming call. A call authoring interface enables the caller to select visual multimedia to play later or currently in a call to make their conversation more comprehensible to the elderly. The conferencing system is with a traditional telephone look and automatically captions the speech and directs the call to a television. The system is aimed to let hearing-impaired people better receive and understand the content and context of the conversation with their family, thereby strengthening their connection.

Literature review

Although not comprehensively, we have reviewed literature related to the issues of hearing impairment to better understand the difficulties and communication barriers hearing-impaired elderly face in their daily life. The highlights of our review are:

Elderly depression and social isolation: According to a study conducted by National Council on the Aging [3], hearing-impaired adults age 50 and older with hearing impairment were more likely to be depressive, anxious, and less likely to participate in social activities.

Visual Assistance: Hearing-impaired elderly usually have to rely on visual cues to comprehend conversations because visual cues can expedite the time required for the correct identification of speech stimuli and increase the accuracy of speech stimuli identification [4][5].

Family connection: Patients with hearing impairment might confront challenges in interpersonal relationships, including communication and self-identity. Hearing impairment not only affects an individual, but also one's family and friends, causing relationship alienation [6].

Identifying these highlights made us determine the direction of using visual cues to help hearing-impaired elderly receive and understand the conversation in a call.

Figure 1: The interview with stakeholders of hearing-impaired elderly.

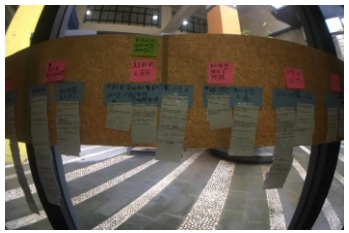

Figure 2: Affinity Diagram with quotes and notes after our two-phased interview.

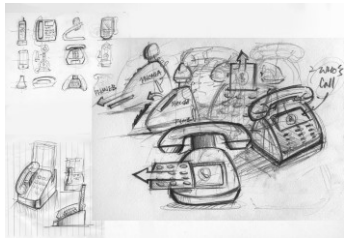

Figure 3: A simple sketch of telephone design

Research

After the literature review, we conducted a series of expert and user interviews to understand users' needs, behaviors, and values. We built an affinity diagram to identify the major themes to inform our design. We summarize the interviews below.

Expert Interviews

We interviewed the chief and volunteers in a village called Li-gong Village in Hsinchu City, a village among which the aged population is 18% of the entire population of the village (Figure 1). The goal of this interview was to understand the problems hearing-impaired elderly confront. The major lesson learned was hearing-impaired elderly's difficulty of noticing doorbells, kettle whistle sounds, and phone ringing sounds. This informed us to use a non-auditory alert to signal an incoming call.

User Interviews: Elderly and Family

To further gain experiences of hearing-impaired elderly and family members communicating with them, we interviewed three hearing-impaired elderly and five people whose grandparents suffer from hearing impairment. Below we show the highlights of the findings.

Communication barriers: Being afraid of misunderstanding a conversation, some hearing-impaired elderly are unwilling to chat and answer phone calls. Some interviewees even reported that they eventually gave up interacting with other people.

Reluctance of use hearing aid: Only a few hearing-impaired elderly use hearing aids because of discomfort, high price, and its implication of hearing disability.
Visual cues assist listening: Without wearing hearing aids, hearing-impaired elderly rely on visual cues to help understanding conversation, such as body languages, lip reading, subtitles, or pictures. However, these cues are lacking in a call.
Elderly resist to learn new technology: They are reluctant to use and learn technology they are unfamiliar with because of being afraid of its complexity. They tend to use those they have used before, including traditional telephone and television.

Persona

We built three types of personas for showing a range of motivations, goals, characteristic, and behaviors of hearing-impaired elderly and their family members. We show three summarized personas below:

Lily (Elderly) is a 75-year-old female. She lives alone and has difficulty learning new technology. She became isolated due to the lack of interaction. She is eager to interact with her family but is afraid of bothering them.
Jane (Young people) is a 25 years old, optimistic female. She loves her job and travels a lot for business. She relies on technology heavily and likes to share photos through social networks to her social contacts.
John (Elderly) is a 68 years old male. He has some problems with hearing impairment that bring him difficulty communicating with his daughter. This situation often causes his negative emotion.

(a) Pictures authored by the caller will also show on the conferencing system.

(b) We add a haptic sticker on their daily wearable object (e.g. watch, bracelet)

(c) Family members can author multimedia that they want to play later or currently in a call with elderly.

Figure 4

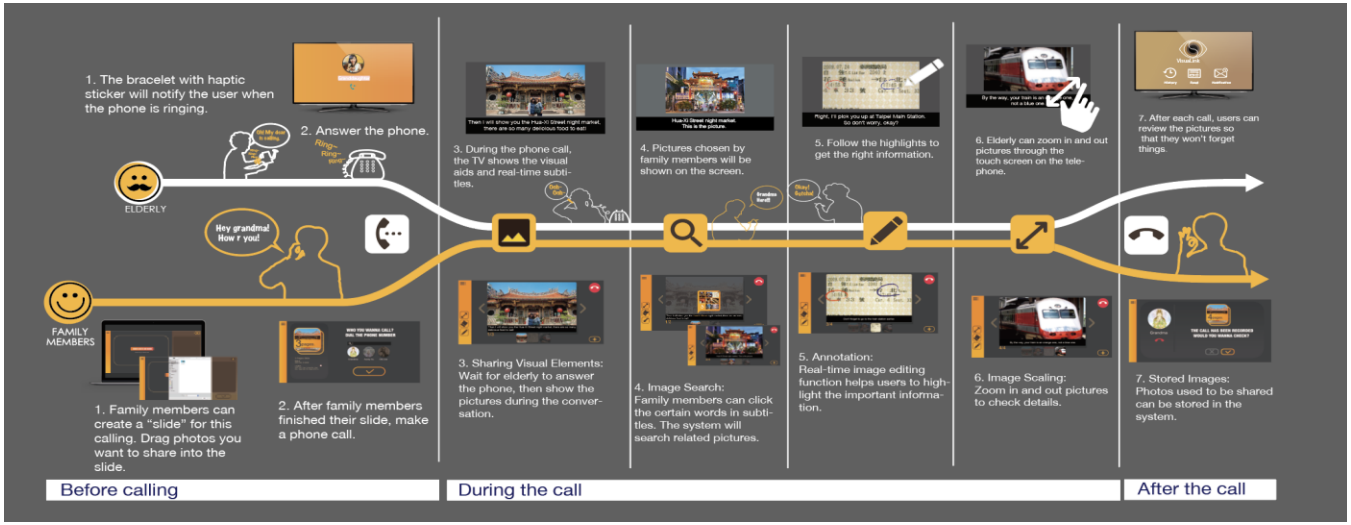

Figure 6: Journey map of VisualLink system. Before: The caller prepares slides, that is, authoring visual content what they want to talk about later. **During the Call:** Pictures and subtitles are shown on the screen, and both young people and elderly can highlight any information on pictures in time. **After:** Elderly can use a remote controller to review pictures had been shared so that they will not miss important information.

Iterative Design

The research results shed lights on important design directions. First, we need to use visual cues to help hearing-impaired elderly receive and understand the conversation. Second, we need to embed intelligence and computing into traditional electronics such as telephone and television so that the elderly would be willing to use them. Third, we need to use a non-auditory alert to get the elderly's attention of a call. The device for alerting is better not to look like new technology too. With these directions in mind, we ran through two iterations to reach our high-fidelity prototype. In the first iteration, we sketched our ideas separately for ideation and then gathered and refined our sketches to generate our low-fidelity prototype. Perceiving that family plays an important role for initiating a phone call, we invited people to give us feedback from the family side.

Our high-fidelity prototype had several improvements based on the feedback from the first iteration (Figure 4). For example, one of our original ideas was that the system captured keywords in a speech and extracted relevant photos automatically from the Web for the caller to choose. However, we received feedback that auto-searching keyword might not lead to accurate photos, which would mislead the elderly. We then

Figure 5 The VisualLink system

Figure 7: In-time subtitles will show on television screen through speech recognition while talking.

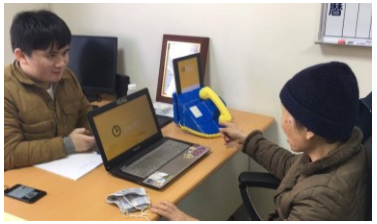

Figure 8: User testing with the hi-fi prototype.

decided to let the user manually select photos using the interface. Below we present our design of VisualLink.

VisualLink

VisualLink consists of three main components:

1. A conferencing system with a traditional telephone look and uses speech recognition to automatically caption the speech and directs the call, the subtitles, and received visual multimedia to the television during the call (Figure 4a).
2. A sticker attachable onto an elder's wearable such as a watch and bracelet and delivers haptic feedback when receiving a call (Figure 4b).
3. A call authoring interface enabling the caller to select visual multimedia to play later or currently in a call (Figure 4c).

The entire system is shown in Figure 5. Below we describe the interaction flow of the system (Figure 6):

Before calling

Family members author multimedia (e.g. adding photos) just as they make a slide show based on the content they want to talk about later in a call, (e.g. sharing life experience, teaching the elder how to take train, or even reminding the elder to take the right medicine)

During the call

The notification of an incoming call is shown on the television and the conferencing system screen. The sticker attached to the elder's wearable such as watch or bracelet will also vibrate to signal the elder of the call in case they are not on the telephone and television. After the elder picks up the call, the visual content authored by the caller will be shown on screen. The callers can play and control authored visual content or add new ones during the call. The system automatically recognizes the speech of the caller and produces subtitles on the screen (Figure 7).

Evaluation

We evaluated VisualLink with six hearing-impaired elderly to understand how they perceived the usefulness and usability of the system. The evaluation had two parts:

1. **Pre-study interview:** asking participants' degree of hearing impairment, technology acceptance, and prior communication experience.
2. **Main evaluation:** letting participants perform a series of tasks using our prototype, with our team members using a Wizard of Oz technique to control the content on the screen shown to the participants (Figure 8).

Participants

Most participants suffered from hearing impairment to some degree and they had medium (or above) technology acceptance, which means they would use telephone and watch TV (Medium). The table below shows our participants' characteristics.

Participant	Age	Degree of Hearing impairment	Technology Acceptance
1	78	High	Medium
2	62	High	Medium
3	71	Low	High
4	72	Low	Medium
5	65	Low	Medium
6	88	Medium	Low

Table 1: Participants' background information

The Study Procedure

We gave each participant the following instruction and tasks:

1 Introduction: We gave our participants a brief introduction to VisualLink and told them the goal of the study. We told them that "when there is a phone call, the telephone, TV, and the bracelet will notify you."

2 User Enactment: We invited our participant to play the role of a grandmother. One of our group members acted as her granddaughter. The screen on the display was controlled by the design team.

Note that we could not find a TV at the study site. Therefore, we used a laptop to show the call.

3 Tasks & Scenario: We told our participants that their granddaughter was calling. They had to pick up the call and have a conversation with her. In the scenario, the granddaughter shared wonderful memories of her trip recently and invited the grandmother to Taipei. Then, she taught the grandmother how to take the train on VisualLink.

Evaluation Result

Four out of six participants successfully completed the task. Two participants failed to complete the task because they didn't understand the task. The reasons were that one participant had never used a telephone, and the other had not had life experience similar to task scenario. Out of the participants who completed the task, they were able to perceive the alert from the system and understand the content and the context of the conversation shown on the screen. They reported that it was helpful and useful when there were pictures showing up during the call to enable them to capture key point. Our participants also thought the system was easy to learn. One participant especially appreciated the ease of use of the system and liked that they only needed to use a traditional phone, though in fact it only appeared as a traditional telephone. The participant commented,

"*The only thing I have to do is to pick up the phone, which is great. For some of the old generation like me, we have a hard time learning new things. For example, I always forget how to use a smartphone.*"

As a result, comparing with traditional telephone, VisualLink seemed to be able to help hearing-impaired elderly understand the conversation better. Meanwhile, because VisualLink preserves the look of a traditional phone, the elderly may have a higher acceptance of VisualLink than Facetime over a smartphone. In addition, our participants had no difficulty understanding noticing the haptic alert from the bracelet*, as one participant said, "The system is not complicated. I just noticed the vibration from this bracelet and then went to pick up the phone."*

Future Work

After evaluation, we identified improvements we had to make to make VisualLinks more effective. For example, there were occasions where participants had difficulty understanding an intended focus of an image. This made us realize that we needed to allow real-time annotation to enable both the caller and the elderly to explicitly refer to areas they want the other side to pay attention to. In addition, some participants could not understand the meaning of a specific word that was not accompanied with visual content. Therefore, we considered that the system can be improved by adding a feature of image searching by subtitle words on the caller side. We have incorporated these two features in our latest design shown in Figure 6.

Conclusion

We have presented VisualLink, a system aimed to help hearing-impaired elderly better receive and understand the conversation from their family in a call. VisualLink focuses on leveraging visual content to support communication, and it fits itself to the artifacts that hearing-impaired elderly is familiar with, including traditional telephone, television, and their own wearable for attaching the call-alert sticker. Our evaluation showed the perceived usefulness and ease of use from 4 out of 6 hearing-impaired elderly participants. We also identified areas to make improvements for our next version. Through VisualLink, our hope is to make a real impact by strengthening the hearing-impaired elderly's connection with their family, and even with more people to enrich their social life.

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