Hey yaa: a Haptic Warning Wearable to Support Deaf People Communication

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Abstract. This paper investigates ***Hey yaa***, a haptic wearable interaction system that allows sensory-motor communication through vibration. The system allows users to call each other attention through haptic sensation, without using voice or vision. Hey yaa, thereby, meets the special needs of the hearing impaired and works as an assistive technological solution to call people when they usually wouldn't be able to do so. ***Hey yaa*** prototype consists of two waist belts. When a button is pressed in one, the other one vibrates, drawing the user's attention. We evaluated ***Hey yaa*** concept and prototype regarding usability, usefulness, usage learning, communication with interlocutor and appearance. As a result, test users confirmed its relevance and gave directions for further improvement.

Keywords: wearable, haptic interface, deaf communication, accessibility, assistive technology, hearing impairment computer aid

1 Introduction

Communication can be a difficult task for those who can't hear. They talk through hand gestures and therefore they depend on visual contact to have conversations. We usually use our voices to call someone's attention, but to do so deaf people necessarily need either visual or physical contact. For them, starting a conversation is difficult when the other one is not looking and it is not close enough to be touched. We focused in this particular problem, looking for an alternative way to call people through a tactile wearable.

Interpersonal communication technologies usually rely on audiovisual and text-based, e.g. mobile phones, while touch has been left largely unexplored in this field. However, we believe there is a huge potential in haptic wearables systems. Our goal in this work is to explore how we can provide support to deaf through wearable computing. In this paper, we describe a new way of establishing communication through haptic feedback in a wearable device. The intention was to enrich current real-time communication by opening a channel through touch.

We built a system called ***hey yaa***, composed by two waist belts that allow users to communicate with each other through vibration. The interaction occurs by pressing a button in one belt, which triggers a vibration in the other belt, drawing the user's attention and implying that another user wants his/her attention. After building the system, we evaluated it with potential users, both individually and in focus group research. The evaluation aimed at finding out how they interact with ***Hey yaa***, what

they think about comfort and appearance, and if they were interested in calling someone through vibration.

The remainder of this paper is organized as follows. In the related work section we discuss previous work on haptic and wearable communication. Next, we present ***hey yaa*** and the design principles behind the system. While, in the following sections we describe the usability tests and their results. The last section concludes this paper and provides several future work directions. In this paper, we use the term "deaf" following the orientation that the people interviewed wanted to be called this way and not "hearing impaired".

2 Related Work

The area of haptic communication hasn't been so much explored in commercial products but it can be found in many research ventures. Tactile devices present information to their users by stimulating the perceptual nerves of the skin. They can be really useful in situations where users are deaf, blind or when environmental factors don't allow audio or visual input and output.

The Tangible Media Group from MIT [1] explores the sense of touch in several areas. Regarding to interpersonal communication, they have developed inTouch [2], a system with two objects coupled in a haptic way such that each one receives other's movement. The project's goal was to explore a mean for expression through touch and not a practical application in daily life. Tactile sense has been also explored in wearable computing as a mean of navigation for the blind. Two popular forms of wearable tactile displays are a back array and a waist belt. The Wearable Haptic Navigation Guidance System, also from MIT [3], is a display consisting of a 4-by-4 array of micromotors for delivering haptic signals to user's back in order to provide navigation guidelines, together with a wearable computer to route planning.

An example of tactile display as a belt is ActiveBelt[4], a waist belt with GPS sensor and eight vibration motors spread around the belt that enables users to obtain multiple directional information. Both tactile displays – belt and array - have been compared in a posterior study, concluding that participants performed significantly faster and more accurately with the belt than with the array.

Physical contact is a channel whereby people achieve a sense of connection and affection. Some projects try to simulate this affective feeling through haptic wearable systems, creating the sensation of physical link between people separated by distance. HugMe[5], also a commercial product HugShirt™[6], is a system for hapto-audio-visual teleconferencing that enables people to exchange stimuli over a network. User must wear a haptic jacket that is embedded with arrays of vibrating motors. People can send hugs to a HugShirt user via mobile phones. Another project that exploits touch is SOS Stress Out Sourced [7], also from MIT. The networked wearable system allows users to receive body massages through haptic jackets anonymously.

Differently from these projects, in this work we focus on haptic wearables to support people in establishing communication when visual, audible and physical contact is not possible and in noisy environments or in places where speech is not allowed, e.g., libraries. In particular, we investigate the difficulties of the deaf communication.

3 Hey yaa

In this section, we discuss the development of ***Hey yaa***, including for which context it was developed, the design guidelines we set up and the prototype we built.

3.1 Context

Communication among deaf happens through sign language. Some hearing impaired develop the capacity of reading the movements of lips, understanding someone's talk only looking at the mouth. In both cases, message's decoding occurs through visual interpretation of movements. That means visual contact is of great importance for hearing impaired and their main communication channel.

Therefore, alert calls must be adapted for hearing impaired. For example, doorbells for deaf are usually connected to the house's light, in a way that a visual sign replaces the sound sign. Another alternative is Hearing Dogs for Deaf People [8] consists of training dogs to alert deaf people to specific sounds, whether in the home, workplace or public buildings. It is an interesting alternative way for deaf perception of the environment, but it depends on having a dog, which can be unpleasant or not possible to everyone. In order to protect deaf children from coaches running over while they were playing in the streets, Graham Bell gave them air balloons. The deaf children could feel when a coach was coming by feeling the balloon's vibration [9]. Deaf community also communicates via mobile devices. When using text-messages via cell phone, the vibrate setting was the alert mechanism for most users, even though it could be only occasionally detected [10].

In our project ***Hey yaa,*** we also investigate the use of tactile vibration for hearing impaired users. We suggest ***Hey yaa*** as a new medium for instant communication. Through a wearable device, one can send vibration to other as an alert mechanism. The metaphor is that vibration represents someone shaking or poking another person for attention, meaning "I want to talk to you". The main concept is to provide haptic communication between two people, in a linear reaction, where one calls another through vibration. This concept can be applied to several daily life situations, changing people's routine. Supposing one is in the kitchen and the other person is in the living-room. If one of them can't hear, they are not able to call each other. The use of ***Hey yaa*** would change this situation and they would just press a button to achieve the same goal, modifying the user's routine, as can be seen in Figure 1.

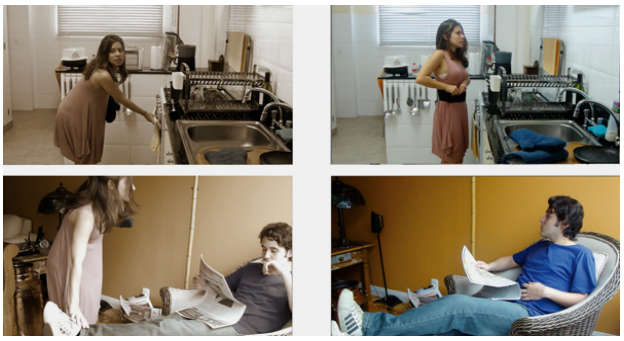

Fig. 1. ***Hey yaa*** changing deaf people's routine: calling someone in other room can be done without need of physical contact (the man uses the belt below his shirt).

Differently of mobile phones, ***Hey yaa*** is a wearable system, therefore it has the advantage of easy mobility and constant contact with the body, increasing the effectiveness of the call. Another scenario is when a person is sick in bed and need to call someone in other room or when two persons are working in bays and can't see each other. When walking on a street, deaf people can use ***Hey yaa*** when one person moves away some meters from the other. Besides peer-to-peer current communication, it can also bring other possibilities for improving deaf routine: they could be linked to systems such as doorbells. The system could be enhanced and integrated with other technologies, such as GPS, voice recognition or identification of sound direction so they could be notified, for example, when they pass by a specific address or when certain sound-alerts are triggered. It could also advice from which direction some defined word, e.g. a name, is being called.

3.2 Design guidelines

Hey yaa must create a haptic channel between two users. In order to achieve an adequate usability, several guidelines underlie the design of the system and the choice for being a wearable device. They are:

- The system must be ubiquitous, being present all time. However, while interaction doesn't happen, it must keep a peripheral position at user's attention.
- ***Hey yaa*** is a product to be used throughout daily routine: users must carry the system easily, maintaining the product next to their bodies all the time.
- Calling one's attention might be an urgent task. Easy handling must be provided.
- Vibration must be strong enough to draw user's attention. The vibe board needs to be as close as possible to user's skin, located in an area of high sensibility.
- Feedback must be provided to confirm the other user has received the call.
- Appearance: how a wearable should look like – computers or clothes? Impressions people have while looking for an enlightened interactive piece of clothing are totally different when looking for common clothes. It is important to let users decide which message they will be transmitting through the pieces they wear and if they want to show that they are wearing computers.
- It should be discrete enough to be used in public spaces without being heavily noticed by others. It should be seen as an ordinary accessory.
- It was chosen to be an accessory instead of a piece clothing to reduce, or even to eliminate, the need of washing.

3.3 Prototype

In this first prototype version, ***Hey yaa*** was built as a pair of 10 cm wide belts that allow 2 users to call each other's attention by sending vibrations. In our prototype, when a button in one belt is pressed, the other one vibrates. To provide feedback to the calling user, the sending belt also shakes to confirm the message was received by the called one.

To build our prototype we selected the Lilypad Arduino microcontroller and its accessories, specially designed for creating wearables [11], and added a transceiver/receiver module from Digi International, since the Lilypad family product doesn't include one. The components to set up one ***Hey yaa*** belt are: 1

microcontroller Arduino 328 board, 1 battery and its holder, 1 vibe board, 1 button and 1 Xbee 2.5 transmitter/receiver and its holder. All components were placed in the exterior side of the belt, except the vibe board, which was placed in the inner part of the belt to be closer to the skin. In order to provide choice for users, we designed a buckle that enables handling the belt in different ways: to hide or show up electronic components, as can be seen in Figure 2.

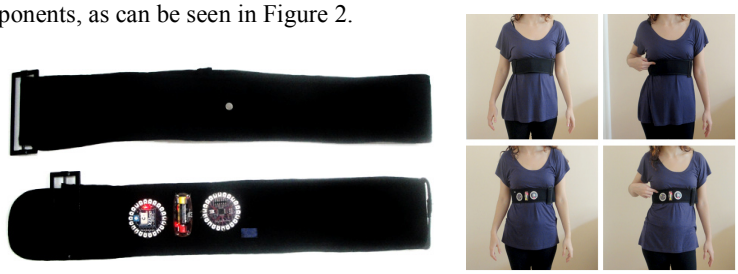

Fig. 2. ***Hey yaa*** belt in two different ways: hiding or showing the electronic components.

4 Evaluation

For evaluating our prototype, we performed usability tests with participants with whom we have direct communication through voice (individual tests) and a focus group conducted with deaf people and aid of translator (focus group).

4.1 Individual tests

Usability tests were performed with 5 people: 3 young people and 2 adults, 3 women and 2 men. Among them, there was only one hearing impaired person, a girl who was able to talk but hears partially and does lip-reading most of time.

Users had to accomplish the following tasks: to wear the belt, to turn it on, to make it work by sending and receiving vibrations to and from the interviewer's belt in the same room. Later, he/she was asked to walk around in other rooms or out of the building and return when he/she felt the belt vibrating. At first, no help was provided to them. When someone could not succeed in one task, a printed manual was given to help. After returning, users had to fulfill a multiple choice written questionnaire. Questions were about belt interface, learning to use the system, communication with interlocutor and appearance. Then, open questions were made orally in an interview and video recorded. The results were:

- All users, except one, have found the belt comfortable.
- All users considered the belt easy to dress and undress.
- All of them, except the hearing impaired girl, had difficulties to turn on the belts. They had to use the printed manual to accomplish the task.
- All complained about the switch button to turn on/off the belt. This button is from the Lilypad battery holder and it was considered too small and too discrete.
- They reported it was easy to locate other belt components, such as the call button, as well as to feel its vibration.
- Despite the initial difficulty of finding how to turn on the belt, all users have

learned quickly how to do it, registering the task of turning on the belt as easy.

- 3 of 5 were concerned about getting an electric shock. The same 3 also said they usually feel comfortable when using technological devices. Meanwhile, those 2 who were not concerned with electrical shocks reported they usually feel uncomfortable with technology.
- They considered easy to call another person through the belt, pressing the button once or twice in each call. A user compared the system to a walkie-talkie, suggesting people could create their own code for communicating.
- It was also considered simple to feel the calling. 4 of 5 users could strongly perceive the call's vibration, feeling it with ease.
- All interviewed considered feedback vibration really useful because they could be sure the call was received by other. 3 of 5 showed spontaneously interest in having different levels of vibration for users to choose from.
- 3 people said they would like to use it in daily life, pointing their home and work as main places where they would use it. From this group, 2 revealed they would buy the belt depending on its price and the hearing impaired one said she wanted to buy it, regardless of the price. In the conversation, she also asked for an implementation of the system in her home, creating an environment connected to the belt in order to be aware of the doorbell or the telephone.
- Aesthetically, all of them think the belt is neutral, neither pleasant or unpleasant.
- Concerning to the electric components, 3 of them were not bother by their appearance and size, saying that they understand it is necessary to function, while 2 said clearly that they preferred it to be smaller and more discrete.

As conclusion of the individual testing, people were interested in the product's concept, but they would only buy it if they had any specific need, such as hearing problems or living with elderly. The belts were considered good, but its on/off switch button could be improved in order to become bigger and more visible and it could be added the possibility of choosing vibration levels.

4.2 Focus group

For focus group evaluation we have selected as target deaf adults older than those of the previous test. We choose a deaf pastoral group from a church and communicated with them with the aid of a language translator that also takes part of this group. The decision for focus group evaluation was considered adequate both as a way to have insights, explore feelings and attitudes about a new product [12] and as a way to facilitate and provide a better communication with users that are not able to talk.

Before conducting the focus group, this pastoral group was visited for allowing us to be introduced and to evaluate receptiveness to the product concept and feasibility of a group research with them. They were receptive to the idea, imagining several situations they could use it in daily life.

In the second meeting, we conducted the focus group. The ***Hey yaa*** prototype was taken to them so they could experience it (Figure 3). There were 6 women and 4 men, all between 45 and 70 years old. This focus group took 40 minutes long and was video recorded. First, we presented the belt in a 3-minute explanation of its basic functionality - calling person by pressing a button and being called through a vibration on the belt - without showing how to operate it. This was accomplished with

the help of the translator. Then, they were allowed to try the system freely, asking for help to put it and handle it when necessary and avoiding any embarrassing situation. We didn't establish any rules, since we wanted to investigate what calls first their attention and if it was easy to learn how to use it.

Once they tried it on and felt the system working, the participants revealed to be very interested in knowing how far the system reached. In the space where the focus group was held, a classroom near the church and the paths around it, they reached up to 20m. They also helped themselves to wear and use the belts, when needed. Women were much more interested: all tried the belt. On the other hand no men tried it.

After testing ***Hey yaa*** functionality, open questions were asked to the whole group. They were asked about their perceptions, opinions and beliefs towards the evaluated system: comfort, appearance, scenarios in which they would use it. All of them enjoyed the project idea, even the men. They called it good and beautiful and indicated some improvements that could be done. The first and most emphasized was the vibration intensity. They considered it too low, as they would not feel it in daily use. It was a totally opposite result comparing to the hearing people results, which claimed vibration to be enough or sometimes too strong, even tickling (Lilypad vibe board has a frequency of 12.000 rpm and 0.8 G amplitude).

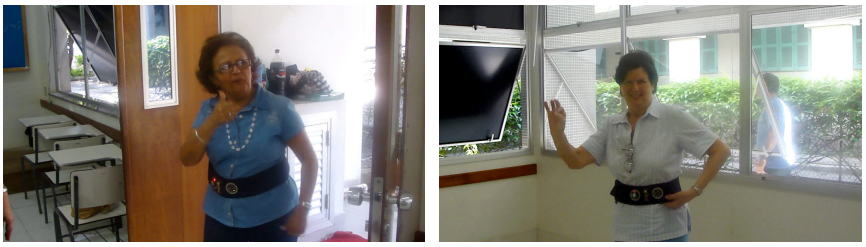

Fig. 3. ***Hey yaa*** focus group with Deaf Pastoral of Rio de Janeiro

Regarding to appearance, most of them were pleased, although one of them stated that she would like it to be thinner. Three participants tried it on under their clothing, but they didn't feel comfortable and reported that it was more difficult to press the button. Those also reported that using under their clothing could be very hot.

They considered using the belt in private places, such as home, work and parties. They mention a scenario in which an ill person in bed calls someone in another room or in which you need to call someone at work. They said it wouldn't be useful in public places, as in the streets: 2 women explained that in a street one might be very far apart from another and in this case they would use their cell phone instead.

5 Conclusion

We have presented ***Hey yaa***, a wearable interaction system for haptic interaction that creates a channel where information can be sent and received through touch. The system prototype was developed as two belt-type devices that enable users to draw each other's attention by sending vibrations. ***Hey yaa*** was evaluated in two different manners: individually, with people who hear and talk with us, and in a focus group of deaf people. It was largely accepted by users, independent of their ages, to the point

that 3 test participants revealed themselves interested to buy it. It has also brought up many situations in which ***Hey yaa*** could be applied to improve people's lives. Besides the results presented concerning the usability, easy learning, applicability of the system and appearance, this work provides a set of guidelines to be considered in the design of a peer-to-peer communication wearable.

Further development of this research are: improving the current system according to user's feedback and performing immersion tests to evaluate the belts in daily constant use. It is important to find out whether the vibration is noticeable at any moment, even when the system is in a peripheral spot of user's attention. We plan to implement ***Hey yaa*** prototype to be interactive for multiple users, in a way people could identify whom they are calling and who is calling them or send a broadcast call. We also plan to explore the use of codes through different ways to press the button, such as one person warning the other about urgency with a long press of the button or pressing it many times.

Haptic communication can bring several opportunities to wearable computing development, especially as an assistive technology. Although touch cannot replace vision or hearing, it can work as complementary aid, allowing different and innovative kinds of interaction, yet unexplored. Many are the possibilities of development for the ***Hey yaa*** concept. With this work, we hope to show some paths of how wearable computing together with haptic communication can bring improvements to deaf people's lives.

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