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Innovation of a Smartphone App Design as Used in Face-To-Face Communication for the Deaf/Hard of Hearing

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ABSTRACT

In recent years, our daily communication methods and behaviours have been transformed through new forms of communication media and technologies such as social media and smartphones. New communication technologies have opened new communication opportunities. On the other hand, communication is the main problem for Deaf/Hard of Hearing (D/HoH) people. Are new communication technologies able to address this problem? This study is a practice-based research project that aims to explore new communication opportunities for bridging the face-to-face communication gap between D/HoH and hearing people by developing a smartphone app. Creative practice (via interaction design)combined with ethnography (via interview)isthe primary research method utilised in this study. The results of this study propose a solution, which is a smartphone application (app) that can be used to assist face-to-face communication between D/HoH and hearing people. This smartphone app provides an innovative way of using computer-mediated communication (CMC) in face-to-face communication; this allows conductingand incorporating physical interaction with nonverbal messages. In addition, it provides various ways of inputting messages that facilitate communication process and it provides a specific mode for the elderly.

Keywords: Computer-mediated Communication (CMC), Deaf/Hard of Hearing (D/HoH), Face-to-face Communication, Interaction Design, Smartphone Application (App)

INTRODUCTION

The smartphone has become a popular digital mobile device in our daily lives. People use their smartphones anytime and anywhere for different purposes. Communication is one of the most significant purposes of using a smartphone. Digital mobile communication has been acting an important role in our daily communication.People are spending increasing time communicating with others through their smartphones, leading to a reduction in face-to-face interaction. In the meantime, the smartphonecommunication

technologies have opened new communication opportunities (Baym, Zhang and Lin 2004; Keating, Edwards and Mirus 2008; Pierce 2009; Turkle 2012).On the other hand, communication is a primary problem for D/HoH people due to their hearing loss. There is a communication gap between D/HoH and hearing people (Bouvet 1990). Digital mobile communication technology such as social media (e.g. Facebook) on smartphones has opened new communication opportunities and partly reduced the communication gap between D/HoH and hearing people (Chang 2014). However, most of digital mobile communication technologies (communication apps on smartphones) are mainly designed for non-face-to-face communication. There is still a further communication gap in face-to-face communication between D/HoH and hearing people even when they communicate via digital mobile communication technologies.The aim of this study is to explore a real solution through a creative practice of interaction design, the result is a smartphone app design that can be use to bridge the face-to-face communication gap between D/HoH and hearing people.

The primary research question in this study is:

How can digital mobile communication technology (a smartphone app) be used to bridgethe face-to-face communication gap between D/HoH and hearing people?

DIGITAL MOBILE COMMUNICATION

Digital mobile communication by definition is part of CMC but is specifically based on mobile devices. The rapid development of mobile technologies has brought new forms of communication. In recent years, a mobile phone is not just a communication device but is a multi-function device like a small computer. Goggin and Hjorth (2009, p.9) indicate that a ‘mobile phone increasingly becomes a platform for mobile media.’ Webb (2010, p.65) states, ‘The mobile becomes a portal and the networks become data pipes that enable the basic connectivity.’ Mobile devices include various digital devices, such as smartphones, tablets, laptops and so on. A smartphone is a type of mobile phone that offers more advanced functions than feature phones, usually with a bigger multi-touch screen, better camera, faster Internet connection and app support. An app is a programme specifically designed to be run on smartphones that offers a wide range of functions and services to smartphone users and is similar to software on desktop or laptop computers. Smartphone apps are gateways that people use to easily access online services (e.g. email and websites) without using a web browser.

Nowadays, people can convey information immediately available anytime and anywhere by using their smartphones (Dominick 2009). Digital mobile communication has advanced from a simple communication form to a variety of communication forms. Short message service (SMS) is a simple and basic text-based communication form specifically used on feature phones and smartphones. Smartphones can not only run standard SMS but also run various social networking service (SNS) (e.g. Facebook, Twitter and Linkedin) and communication apps (e.g. WhatsApp, LINE and WeChat), these provide advanced communication features and supportive functions. In addition, voice and video calls are two important ways of using smartphones. However, this study will not focus on it because of the limited speech capability of D/HoH people.

FACE-TO-FACE COMMUNICATION

Face-to-face communication is a type of communication via which people transmit information directly by using oral speech and gestural language. CMC is a type of communication via which people transmit information indirectly through digital devices by using text and multimedia messages. The different communication methods are the essential differences between face-to-face communication and CMC. Both face-to-face communication and CMC are multimodal communication with various communication methods that can be divided into verbal and nonverbal messages. Verbal messages include text and speech, whilst nonverbal messages include facial expressions and body gestures. CMC generally allows people to communicate by using a single form, such as text-only communication. Face-to-face communication generally combines more than one form in a conversation, such as speech involving eye contact and facial expressions (Dohen, Schwartz and Bailly 2010).Whittaker and O'Conaill (1997) also indicate that the main difference between CMC and face-to-face communication is the physical information used in face-to-face communication.

Nonverbal messages consist of physical information that includes eye contact, facial expressions, handshakes, head nods and smiles. Eye contact is an essential component of face-to-face communication, it is a ‘special stimulus’ in visual sense affecting communication (Bailly, Raidt and Elisei 2010). Jiang et al (2012) highlight the two major differences between face-to-face communication and other types of communication. First, face-to-face communication involves the ‘integration of multimodal sensory information.’ Sensory information includes facial expression and body gestures that can activate information during communication. Second, face-to-face communication involves ‘more continuous turn-taking behaviors between partners.’ Turn-taking is communication behaviour in a conversation that helps people decide who will speak next. Turn-taking

behaviours play a vital role in social interaction. Bailly, Raidt and Elisei (2010) indicate that eye contact plays a pivotal role in turn-taking behaviours.

Mehrabian (1972) explains that nonverbal communication is part of 'nonverbal behavior'.Nonverbal messages in face-to-face communication can sometimes be more powerful than verbal messages. Morris (2002) notes that nonverbal messages, such as body language, can help people understand other people much better.Okdie et al (2011) suggest that nonverbal messages combine richer and more abundant emotional information than verbal messages. Dohen, Schwartz and Bailly (2010, p.477) indicate that people integrate information in face-to-face communication 'not only from the speakers but also from the entire physical environment in which the interaction takes place.'

Speech in face-to-face communication is an easier and faster way to transmit information than text in CMC because typing messages takes much longer than spoken messages. The time issue is another significant difference between face-to-face communication and CMC. Face-to-face is real time communication via which speakers and listeners can immediately send and receive messages. CMC is not real time communication (except for video calls such as when using Skype), even though some CMCs provide near real time communication, such as IM, people still need to spend time typing messages and waiting for responses.

RESEARCH METHODOLOGY

This study is designed as practice-based research and aims to generate new knowledge through a creative practice of interaction design. The purpose of conducting the interaction design is to explore specific communication requirements in the target population and provide a possible solution to them. The target population (D/HoH people) will be involved in the designing process via ethnographic interviews, which includes user-centred design (UCD) and participatory design (PD) approaches in different design steps. UCD is a design approach of 'designing for users' and PD is an approach of 'designing with users' (Sanders 2002).

There are five design steps used in this creative practice to develop a smartphone app: a. Defining Requirements, b. Providing Alternatives, c. Alternatives, Testing and Deciding d. Prototype Development and e. Prototypes, Testing and Modification. See Figure 1 below.

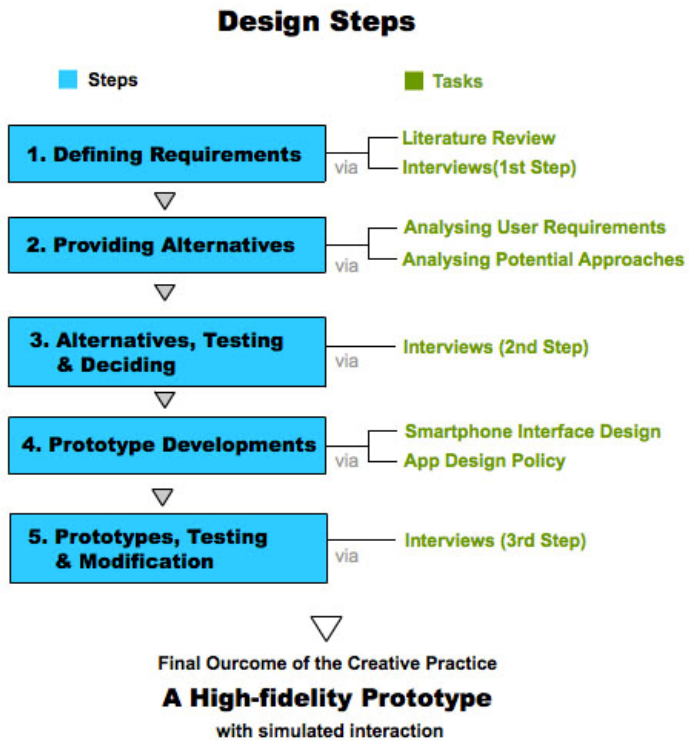


Figure 1.Design Steps

a. Defining Requirements

The first design step is to define user requirements via a literature review and interviews. The literature review will help understand face-to-face communication and how communication occurswithin the D/HoH community. The interviews will help explore the mmunication difficulties and requirements of the D/HoHthat are specific in face-to-face communication.

b. Providing Alternatives

The second design step will provide potential alternatives via analyzing user requirements and analyzing potential approaches. Analyzing user requirements will help in the design of the potential features of these smartphone app. Analyzing potential approaches will help explore relevant technologies that can be used to implement the design features.

c. Alternatives, Testing and Deciding

The third design step is to test and decide on the alternative potential features via the interviews. The interviews will help to evaluate original design concept and find bestdesign features for end-users.

d. Prototype Developments

The forth design step is to further develop prototype via the smartphone interface design and app design policy. The interface design process will help understand the specific requirements of interface on smartphones. The app design policy will help to understand basic design regulation of a smartphone app. Finally, the designed features will be presented via a visual-based prototype that will present a realistic impression of this interactive product to users for testing.

e. Prototypes, Testing and Modification

The fifth design step is to test and modify the visual-based prototype via interviews. The interviewswill help evaluate the visual-based prototype for developing a high-fidelity prototype (with simulated interaction), which will be the final outcome of the creative practice in this study.

Basing on the design steps, there were 9 interviewees (end-users) involved in the developing process of this smartphone app, with a total of 27 interviews in three different design steps (9 interviews per each step). The 9 interviewees were recruited from three specific groups: a. Experts, b. D/HoHPeople and c. Hearing People. The experts are professionals in the D/HoHfield. As an interview process is time consuming, the three interviewee groups allow for the precise and efficient collecting of data. Details of the 9 interviewees are shown in Table 1 below.

Table 1. Interviewee Details

Groups	People	Background / Details	Interview forms
Experts	Person 1	• A sign language interpreter (hearing person) • BSL degree awarded • More than 14 years of experience • Female / Age: 40-49	Face-to-face & Online Interview
	Person 2	• A communication development officer (hearing person) in the Action on Hearing Loss (a Deaf organisation in the UK), also a sign language interpreter • Issues in Deafness degree awarded • More than 17 years of experience	Online Interview

		• Female / Age: 50-64	
	Person 3	• A manager at the British Deaf Association (Deaf) • More than 32 years of experience • Male / Age: 50-64	Online Interview
D/HoH People	Person 4	• A university student • Male / Age: 18-29	Online Interview
	Person 5	• A university student • Female / Age: 18-29	Online Interview
	Person 6	• A college teacher • Male / Age: 30-39	Online Interview
Hearing People	Person 7	• A deaf child's mother • Female / Age: 40-49	Online Interview
	Person 8	• A designer who usually works with a Deaf/Hard of Hearing colleague • Male / Age: 30-39	Face-to-face & Online Interview
	Person 9	• A Deaf person's friend • Male / Age: 30-39	Face-to-face & Online Interview

SPECIFIC COMMUNICATION REQUIREMENTS

Understanding user requirements is the first step when developing an interactive product. 'A requirement is a statement about an intended product that specifies what it should do or how it should perform' (Rogers, Sharp and Preece 2011, p.355). Defining the target user and target activity are two necessary parts of understanding user requirements when developing this smartphone app. D/HoH people are the primary target users and hearing people the secondary users; and face-to-face communication between D/HoH and hearing people is the target activity.

According to the first design step, there is a main user requirement for developingthis smartphone app:

To provide a communication tool that can be used to assist face-to-face communication between the D/HoH and hearing people, particularly in common (informal) one-to-one conversations

The main user requirement contains the following two sub-requirements:

- **A solution to integrate and support different communication methods in an accessible communication channel that can be used in face-to-face communication between D/HoH and hearing people.**

- **A solution to conduct and incorporate physical interaction with nonverbal messages into communication when using this smartphone app.**

DESIGN FEATURES OF THIS SMARTPHONE APP

According to the second to fifth design stepfor concept testing, feature evaluating and prototype modifying (via sketching, visual-based, web-based and app-simulated prototypes), there are three significant features designed in this smartphone app for achieving the above user requirements: a. Various Ways of Inputting Messages, b. Rotating to Show Messages and c.Large Text Mode for the Elderly.

a. Various Ways of Inputting Messages

This feature is the basic feature designed in this smartphone app for users to input messages. It aims to facilitate the communication process (increasing the speed of inputting messages) when using this smartphone app by providing effective ways of inputting messages for both D/HoH and hearing users.It includes four ways of inputting messages.

- Text Typing (with predictive support)
  Test typing is a basic way of inputting messages in this smartphone app, which includes predictive text support that aims to increase text typing speed by giving suggestive words and sentences during the typing process.

- Emoticon
  Emoticon provides a quicker and easier way to input contextual emotional information, as well as enriching the content of messages by using various pictures.

- Stored Message (with categorising support)
  Stored message is an innovative way of inputting messages. This feature aims to increase speed of inputting messages by selecting existing messages from an archive (user creates archives in advance).

- Voice Recognition (with correcting support)

Voice recognition provides a way in this smartphone app that hearing users can use speech to input messages and the messages will be translated to text for D/HoH users.

Table 2 below shows interfaces of these four ways of inputting.

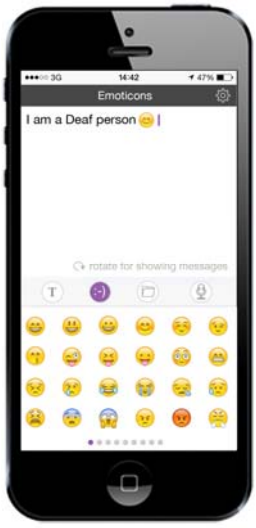
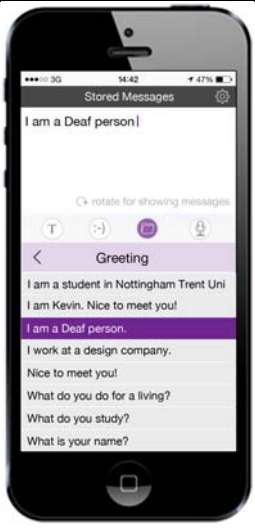
Text Typing	Emoticon	Stored Message	Voice Recognition
			

Table 2.Four Ways of Inputting Messages

The ways of text typing, emotion and stored message are designed to be mainly used by the D/HoH because of their limited speech capabilities. The way of voice recognition is designed to be mainly used by hearing people. Voice recognition includes basic text typing and emotions but does not include predictive and stored messages due to privacy issues.

b. Rotating to Show Messages

This is the most significant feature in this smartphone app, it prompts users to conduct and incorporate physical interaction with nonverbal messages when using this smartphone app during face-to-face communication. It integrates CMC and face-to-face communication in an innovative way during communication between D/HoH and hearing people. Rotating to show messages is activated via the accelerometer sensor. Users are restricted to inputting messages in the portrait orientation and shown messages in the landscape orientation. See Figure 2 below.

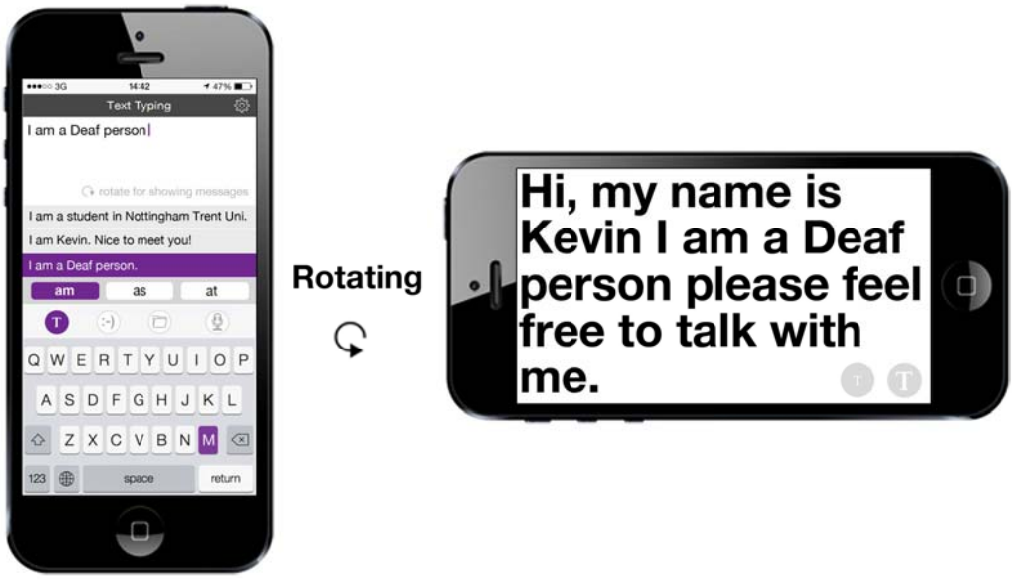
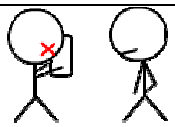
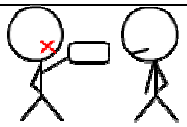
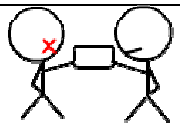
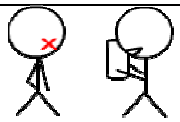
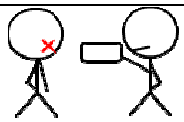


Figure 2. Rotation for Showing Messages 1

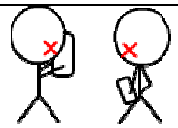
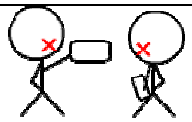
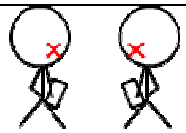
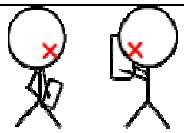
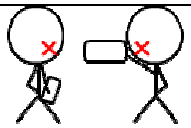
Showing messages via a single phone without connection technologies (e.g. GSM, 3G, Wifi & Bluetooth) is designed to be used between D/HoH and hearing people. It is the primary purpose for designing this smartphone app. A scenario showing messages via a single phone is presented in Table 3 below.

Table 3. Scenario for Showing Messages via a Single Phone

Step 1	Step 2	Step 3	Step 4	Step 5
				
A D/HoH person inputs messages via text.	The D/HoH person shows messages to a hearing person.	The hearing person reads messages and takes the phone.	The hearing person inputs messages via voice recognition.	The hearing person shows messages back to the D/HoH person.

Showing messages via two phones is designed to be used between Deaf and Hard of Hearing people. It is the secondary purpose for designing this smartphone app. A scenario showing messages via two phones is shown in Table 4 below.

Table 4. Scenario for Showing Messages via Two Phones

Step 1	Step 2	Step 3	Step 4	Step 5
				
A Deaf person inputs messages via text.	The Deaf person shows messages to a Hard of Hearing person.	Both the Deaf and Hard of Hearing people use their own phones.	The Hard of Hearing person inputs messages via text.	The Hard of Hearing person shows messages back to the Deaf person.

In addition, the text-to-voice (speaker) and flexible text size features are two further supports to increase the usability of showing messages. See Figure 3 below.

Figure 3. Text-to-Voice (Speaker) and Flexible Text Size

c. Large Text Mode for the Elderly

This feature is a further assistance designed in this smartphone app specifically for older users. The large text mode aims to reduce difficulties faced by older users when using a smartphone app by providing bigger text size and interfaces. The large text mode specifically focuses on increasing the size of message text and key feature buttons. See Figure 4 below.

Figure 4. Standard Mode vs. Large Text Mode

The standard mode (text size 17 pt and button size 68x68 px) is designed by following the Apple iOS Human Interface Guidelines. The large text mode (text size 25.5 pt and button size 130x130 px) is designed by followingthedesign guideline for older users proposed by Jin, Plocher and Kiff (2007).

A SCENARIO OF THIS SMARTPHONE APP

This section presents a typical scenario for using this smartphone app in face-to-face communication between a D/HoH person and a hearing person. See the Table 5 & 6 below.

Table 5. Scenario of Using this Smartphone App: Step 1-2

	
Step 1 The D/HoH person (right side) inputs a message via this smartphone app	**Step 2** The D/HoH person (right side) shows the message to the hearing person

(in portrait orientation).	(left side) via this smartphone app (in landscape orientation).

Table 6. Scenario of Using this Smartphone App: Step 3-4

	
Step 3 The hearing person (left side) inputs a message (voice recognition) via this smartphone app (in portrait orientation).	**Step 4** The hearing person (left side) shows the message to the D/HoH person (right side) via this smartphone app (in landscape orientation).

In addition, a video description of this smartphone app is available online at http://youtu.be/KJ1klK5aORM

CONCLUSION

This practice-based research has resulted in a real solution, which is a smartphone app that can be used to bridge the face-to-face communication gap between D/HoHand hearing people. This study contributes a new understanding in the integration of CMC and face-to-face communication and provides an innovative way of using CMC in face-to-face communication that combines physical interaction with nonverbal messages during communication.

There were three comments by the D/HoH interviewees that provided significant positive feedback on three specific features designed as part of this smartphone app: a. Various Ways of Inputting Messages b.Large Text Mode for Older Users and c.Rotating to Show Messages.

'The various inputting ways on this app are good, especially the text typing with predictive words/sentences and the stored messages.'

'The largetext mode is a very useful feature. I always feel text size is too small to read on my phone and the buttons are also too small for my stupid fingers sometimes.'

'I am really looking forward to using it. The rotating to show messages is a great idea and the messages shown using bigger text size with full screen display is very useful. Go for it! '

This smartphone app obtains very positive feedback from the end-users. This study has provided a solution to bridge the face-to-face communication gap between D/HoH and hearing people and a specific interface design for the elderly. However, there is a limitation in this study as a standard smartphone virtual keyboard brings difficulties for older users (Harad et al 2013). This issue would be a significant direction for future research.

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