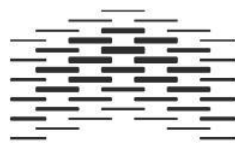


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Mobile Instant Messaging (MIM) for Elderly People

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Abstract

While the use of Mobile Instant Messaging (MIM) has been expanding vastly along with mobile technology, the needs of the elderly user group have not been addressed sufficiently in existing MIM applications. MIM applications have great potentials in supporting social interactions and thus contribute to the well-being of the elderly. However, user interface design features such as small font size, confusing icons and application flow in current MIM applications make them difficult to learn and use for the elderly. Furthermore, a preliminary study for this research found out that existing MIM applications are not compatible with speech recognition, such as Android's TalkBack, which causes difficulties for elderly who might need to utilize speech recognition due to certain disabilities. This research aims to provide a usable and accessible MIM application for the elderly user group. In this research a combination of user-centered and participatory action research principles was adopted. Both approaches aim to have co-developing research prototype with the people rather than for the people. This research was conducted through four main phases, which were (1) user requirement study, (2) design, (3) development, and (4) user testing. In user requirement study, six elderly participated in group interview and user testing to identify the usability and accessibility issues in current MIM solutions and requirements were collected. Based on the requirements and design principles in accessible design, a MIM prototype named *Your IM* has been designed and developed throughout eight iterations of design, development and user testing. Design, development and user testing were conducted in iterations to ensure the prototype meets the requirement of the end users. Last but not least, final user testing was conducted with the same six elderly from user requirement study in order to perform comparative study. Another user testing with a blindfolded elderly role-playing as visual impaired elderly was performed as well to test *Your IM*'s integration with Android's TalkBack. The user testing aimed to investigate if *Your IM* has helped to address the identified usability and accessibility issues faced by elderly when using existing MIM applications. The results showed improvement in usability and accessibility, especially in sending text, audio and picture messages. The participants also showed less confusion and made fewer errors when performing MIM tasks using *Your IM*. Overall, they demonstrated positive attitude in learning and using *Your IM* in the future.

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Countless thanks and appreciation are addressed to the elderly users who participated in the user testing, interviews and the iterations. Their feedback has helped in getting real inputs of how elderly users experience MIM applications, and contributed in shaping the prototypes from iterations to iterations so that it becomes more suitable for elderly users. It is hoped that *Your IM* can contribute in favor to these elderly users as a user friendly and accessible MIM application. Not to forget, numerous thanks and sincere gratitude are addressed to the helpful and kind supervisor, Professor Weiqin Chen. She has been sharing her expertise and valuable knowledge throughout the whole project. Without her assistance, clear guidance and useful suggestions, this research could never be succeed. Last but not least, sincere thanks are also expressed to the school, Oslo and Akershus University College of Applied Science for giving the opportunity to study this master degree. The overall learning experience is priceless.

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List of abbreviations

SMS	Short message service
MIM	Mobile instant messaging
IM	Instant messaging
HCI	Human-computer interaction
ICT	Information and communication technologies
dp	Density-independent Pixels
mm	millimeter
OS	operating system
iOS	iPhone operating system
AMCOSOP	Ambient Communication for Sense of Presence
ISO	International Organization for Standardization

1. Introduction

Mobile instant messaging (MIM) is messaging service that works on mobile devices and it is currently much more widely used as compared to before. Research conducted by Church and Oliveira (2013) has provided a deeper understanding of users' motives and perceptions of a popular MIM application called WhatsApp, thus gained insights in what this application offers above and beyond traditional short message service (SMS). Some of the benefits offered by MIM are the factors why people slowly switch from traditional SMS to MIM, e.g. cost saving, ability to have group chat, and unlimited text amount.

While the use of MIM has been expanding vastly along with mobile technology, the needs of elderly users have not been addressed sufficiently in current MIM applications. In year 2001, Meyer (2001) stated that in the coming 15 years, over 82 million people who belong to "baby boom" population (born 1946 – 1964) would join the older adult population. As of today, elderly people constitute big part of world population and it is undeniable that elderly population is likely to increase over the next three decades (Lutz, Sanderson, & Scherbov, 2008). As the result, it is essential to include them as a major group of MIM users.

There has been very limited research on usability and accessibility of MIM applications. A preliminary study has been conducted for this project. It was found out that currently existing MIM applications are not accessible for elderly users. Examples of problematic issues for elderly users include small font size, confusing icon and unintuitive application flow for navigating from one screen to another in the applications. As of today there has not been any attempts to develop an MIM application for elderly users.

In addition, another severe issue with instant messaging (IM) application is their incompatibility with speech recognition feature (Teixeira et al., 2012). The preliminary study conducted for this study also found out that current MIM applications have the same problem. Users who wish to use their MIM applications via speech recognition due to certain impairment, cannot utilize this accessibility feature because of the shortage in speech modality integration. Thus, it is crucial to ensure MIM application is compatible with speech recognition so that it is adoptable to the requirements of elderly users who might have disabilities and need of speech modality.

Ageism was also mentioned by Neves (2012) as a contributing factor to elderly people's lack of motivation and confidence in using these technologies. 78% of the study respondents suffered from active discrimination. These findings highlight the need of specially designed MIM application for the elderly users, so that they will feel that they are fit to use MIM, and MIM application can be adapted to as many elderly users with different kind of abilities and disabilities as possible.

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One of the usability principles is to have the product easy to use and easy to learn (Nielsen, 2005). Previous studies conducted by Prior, Arnott, and Dickinson (2008) aimed at producing a more usable and acceptable messaging solution for older adults by using metaphorical interface, e.g. exit door as an indication for exiting problem. Their results showed that the metaphorical interface performed better overall and majority of the participants preferred it for future use. However, their studies did not include touch screen mobile devices as they might not be so popular back then. Therefore, this study also targets to expand the previous metaphor icon with messaging solution study by including touch screen mobile devices for MIM used nowadays.

All in all, the goal of this research is to address the usability and accessibility issue in current MIM application faced by elderly users, and provide a usable and accessible MIM application for them. This research was designed to gather requirements from elderly users regarding the use of MIM, and then develop a prototype that overcomes existing problem faced by them when using MIM.

To achieve this goal, a combination of user-centered and participatory action research principles was adopted. Focus group interview and user testing have been conducted to identify the usability and accessibility issues in current MIM solutions and requirements were collected from elderly users. Based on the requirements, design, development and user testing were carried out in iterations. The feedback from each user testing was used to adjust and revise the design and development of the prototype.

Besides, different elderly users tend to have different requirements. Therefore, user profiling mechanism and speech modality integration have been incorporated while designing a better designed MIM application. Speech modality was valued by elderly users as second important modality after touch modality in the study conducted by Teixeira et al. (2012) while user profiling is required so that application can adapt to diverse needs of elderly, as suggested by Golemati, Katifori, Vassilakis, Lepouras, and Halatsis (2007).

In a nutshell, this research targets to expand previous studies and propose a specially designed MIM application to resolve issues stated earlier, thus ensuring elderly users able to use IM without much problem. Taking in the requirements of different elderly users, proposed MIM application is expected to be easy to learn, accessible and usable to them who have different abilities, disabilities and needs.

This thesis is organised as follows. After the Introduction, a review of related research is presented in Section 2. Section 3 describes the methodology being used, which are (1) focus group interview and user testing in user requirement study that have been conducted to evaluate existing MIM solutions, followed by (2) design, (3) development and (4) user testing. The results and discussions of user requirement study are presented in Section 4. Iterations of design, development and evaluation of prototype are presented in

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Section 5. Section 6 presents results from final user testing and suggestions from participants for future development. Section 7 discusses the results, which include comparative study, limitation of the whole study and summary of the design principles. In section 8 the process is reflected and conclusion and future plan are presented.

2. Literature review

2.1. *The need of MIM for elderly people*

2.1.1. Switch from traditional SMS to IM

Through interview study and large-scale survey, Church and Oliveira (2013) identified eight main factors that contributed to mobile user in choosing either WhatsApp or SMS. The eight factors are (1) cost, (2) social influence, (3) nature/intent, (4) community & sense of connection, (5) immediacy, privacy concerns & expectations, (6) reliability & guarantee, (7) choice of technology, and (8) coping mechanisms. Their findings can also be generalized to other existing MIM applications such as Viber and Facebook Messenger, since other MIM applications offer similar functions as WhatsApp.

Most interviewees and survey respondents found it more convenient to use WhatsApp, due to the fact that it is free as long as they have internet connection. WhatsApp also offered much more than SMS. With WhatsApp they can use group chat for keeping contact with large amount of people, have discussion for organizing group activities and have unlimited amount of characters or content which eliminate the need to fit all information into a single text message.

Besides, due to social influence, most people have to use MIM. The potential frustration faced by someone if he or she does not use WhatsApp can be seen from one of Church and Oliveira (2013) interviewees who expressed, *"I don't really use the latest things. I was using SMS and everyone had WhatsApp and everyone was saying, you are the last one and it costs money to talk with you so get WhatsApp"*.

Therefore, since the trend of communication nowadays is MIM and at the same time, the population everywhere is growing older eventually, there will be definite need of serving elderly people with MIM in near future.

2.1.2. Social inclusion of elderly people

Pensas et al. (2013) designed Ambient Communication for Sense of Presence (AMCOSOP), a social networking system for elderly users which consists of touch screen user interface and web-based solutions (AMCOSOP, 2011). Their goal was to enable the elderly people to stay socially included. It was implemented specifically to help reduce the loneliness of elderly people. Its target was to serve different end user technologies and experiences which could be classified into three different user groups. There were (1) primary, which was the elderly people; (2) secondary, which was their families and friends; and (3) tertiary, which was the stakeholders such as service providers or care givers. AMCOSOP further emphasized the need of technology tool for elderly communities to be

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socially connected to different important people. Thus, the importance of elderly people having MIM as a social inclusive tool is once again being highlighted.

Cornwell and Waite (2009) discussed about social disconnectedness (e.g., small social network, infrequent participation in social activities) and perceived isolation (e.g., loneliness, perceived lack of social support) in their research, with relation to elderly physical and mental health. Their finding showed the association between disconnectedness and mental health may operate through the strong relationship between perceived isolation and mental health; while lower levels of self-rated physical health had not much influence on both disconnectedness and perceived isolation. MIM can be used in keeping elderly people social connectedness, which helps in keeping them healthy as well.

Based on a random survey conducted by Telenor of 1000 persons in Norway, it was found out that people become more reluctant to send text messages to persons who are older (Ling, 2007). Respondents were asked if they would call or send text message to recipients aged 20, 40, 60 and 80 years old to inform them that they would be late for an appointment. 60% of them would text to the 20 year old person while only 3 % would send text message to the 80 year old person. Thus in order to eliminate this isolation issue, it is time to include elderly in the messaging culture in trend, which is MIM.

In addition, the European Union reported that the number of elderly people is increasing every year (Union, 2010). As the result, in order to achieve social inclusion for elderly people, MIM application that is particularly addressed to this user group becomes necessary. A well designed MIM application for elderly users can certainly help them to overcome social exclusion by reducing their gaps in information and communication technologies (ICT) usage, and directly also improve their quality of life through social participation (Teixeira et al., 2012). Moreover, good communication tool is also necessary for elderly people because they are likely to require additional healthcare and social services due to certain disability and diseases.

It can be debatable that MIM which is used at home can discourage elderly people to go out from home and be more socially active. Another related study about IM conducted by Koutamanis, Vossen, Peter, and Valkenburg (2013) examined if IM affected adolescents' ability to initiate offline friendship. It is crucial to ensure that elderly people do not rely only on MIM and stay home all the time while staying in touch with others. It is undeniable that communications made by elderly people with others should not only be limited to online and indoor.

Koutamanis et al. (2013)'s study showed that online communication can have a positive influence on the development of adolescents' offline social competence, specifically through IM. The skills they gain via IM can be applied in communication with people offline and thus increase their abilities to initiate offline friendships. Their research results imply

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that MIM can indeed encourage elderly people to be more socially included, both online and offline.

Some older adults think keeping in touch is worthy of time and dedication because they do want to be socially included. They also view communication as increasingly afforded by new technologies. Interviews with three focus groups with each including six elder participants were conducted by Lindley, Harper, and Sellen (2009). Group A consisted participants aged 55-64, group B was aged from 64-74, and group C was aged from 75-84. They were asked about different communication media, including non-technical and traditional methods such as letter writing and telephone. The scholars noted the small scale of participants but the findings were still worth being attended (Lindley et al., 2009).

The findings demonstrated clear differences between three groups. Group A, which was the youngest tended to favor new technologies. Stated by one of the participants, *"We're of an age where we sit in the middle of all forms of technology, we can dabble with perhaps texting, you know at the peripherals, we still do letters up to a point, but I think we only send letters to certain people."*

Hence, this again shows the great possibility of elderly people to utilize MIM in their social activities. Having similar findings as Church and Oliveira (2013), Lindley et al. (2009) pointed out that social influence had an impact on the usage of MIM to them:

We're using methods of communication that are appropriate for the people we're sending them to [...] if you have a friend who you know has an email address but hardly ever looks at it you'll ring them up or send them a letter, but if I'm communicating with my daughter it's often by text or I'll email.

This direct quote strongly demonstrates the need of MIM for elderly users in the future. In order to stay socially included, elderly users might find it hard to avoid themselves from using MIM applications. Another important fact is that elderly people value the importance of communication not only in writing, but also through talking with each other (Lindley et al., 2009). MIM is able to provide both of these interaction styles as there are text messages and also voice messages in MIM.

Lastly, it also requires enabling these features work with different modalities especially speech modality. It was found out that elderly people might require speech modality due to certain impairments (Teixeira et al., 2012). Nevertheless, MIM applications nowadays are not supported well with speech modality. More detailed findings about the problem and limitation of current MIM applications are presented in the next section.

2.2. Problems and limitations of MIM applications for elderly users nowadays

There has been very limited research conducted which focus on usability and accessibility area specifically on current MIM applications. However some other studies have been performed on elderly using mobile applications and their issues are discussed as below.

2.2.1. Incompatible in modality

Elderly users have the needs for using multimodal inputs for mobile application (Teixeira et al., 2012). According to the study done by Teixeira et al. (2012), touch modality for interaction was most preferred by elder people followed by speech modality. Due to aging which can lead to health problems, elderly might have vision impairments such as glaucoma, or motor impairments such as arthritis. However, current MIM applications do not have good interaction styles which address specifically towards elderly people, as found out in the preliminary study.

Besides, it was noticed that some desktop based IM applications such as Windows Live Messenger and Facebook Messenger, did not support speech modality as well (Teixeira et al., 2012). Five MIM applications were tested in the preliminary study for this research and none of them worked perfectly with iPhone operating system (iOS) VoiceOver and Android operating system (OS) TalkBack. Since speech modality is also preferred by some elderly people, this functionality must be taken into consideration when designing a specially designed MIM application for elderly.

2.2.2. Poor and confusing user interface

The preliminary study also reached the conclusion that current MIM applications do have problematic interfaces such as small buttons and confusing application flow, where users navigate from one screen to another while using the application. Not all elderly people have good control over their fingers and their visions might not be clear. Besides, some elderly users also had problem understanding the icons and application flow in current IM applications (Prior et al., 2008). Therefore it can be unpleasant experience for them to have overly small buttons and small font on a touch screen while using MIM applications.

Findings from Prior et al. (2008) clearly indicates the need for elderly users to have better icons when using IM applications. In their study, by using metaphor interface, the participants were able to link the features of the application to items they could related to, e.g. finding a photograph in their hand-bag to send to the other participant, or leaving the program by exiting through a door. This concept can be adopted to current MIM applications in terms of their icons to facilitate the need and understanding of elderly

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people. In addition, Prior et al. (2008) also commented that *“the use of fun and friendly metaphors may encourage such users to continue to use the technology after the initial learning period”*. The use of fun and friendly yet understanding icons is vital to encourage novice elderly users as they might be reluctant to accept and learn new technology.

Church and Oliveira (2013) stated that the ✓✓ symbol in WhatsApp (Figure 1) was often being misunderstood as read or seen but its actual interpretation explained by WhatsApp is *“message successfully delivered to the phone of your chat partner”* (WhatsApp, 2014). The preliminary study find out that other MIM applications such as Viber uses words *“seen”* and *“delivered”* (Figure 2) and these words indicators seem to be better understood by the users instead of symbols. Besides confusing interpretations, these kind of indicators also brought up privacy issues, as stated in Church and Oliveira (2013)’s study and they are further discussed in Section 2.2.4.

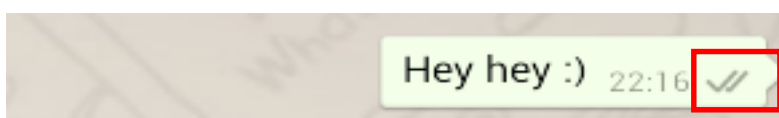


Figure 1: Double ticks indicator in WhatsApp

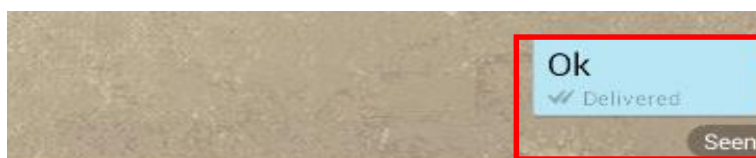


Figure 2: “seen” and “delivered” indicators in Viber

2.2.3. Complexity

Current communication and social media services such as Facebook were also commented as having too many functions by the elder users (Teixeira et al., 2012). Elderly people tend to use only simple functions for their communications, such as sending messages, sharing pictures and having free call. However, different elderly users with different educational background, or profession, or even experience with information technologies do have different perception on that. Novice elderly users might find a feature complicated while experienced users might find it fun and necessary.

The works from Teixeira et al. (2012) were only focusing on three different things, which were (1) IM task, (2) conferencing task and (3) Facebook task and these three tasks could be beyond the requirements and capability of the elder people. Elder participants commented that they enjoyed simpler user interfaces and functionalities. Thus this study also intends to eliminate what is not required and keep MIM application as simple, usable and accessible as possible. In addition, some elderly may have limited abilities. So, current

MIM applications which might be perceived as having too many unnecessary features can possibly confuse and burden the novice elderly users, thus demotivate them from using MIM.

2.2.4. Lack of privacy

The privacy issue identified by Church and Oliveira (2013) in their studies expressed that users' feeling about their access of WhatsApp was overly disclosed. WhatsApp was considered as disclosing too much users' information. First, user status could be read from WhatsApp and others could know when someone's last access to WhatsApp was (Figure 3). For this reason, users of WhatsApp might probably know if their messages were read but not yet replied by the recipients. This might upset them as they might not want to reveal too much information about what they do.



Figure 3: "last seen" indicators in WhatsApp

Double ticks (Figure 1) are another indicator that used by users to check if the message has been read. As the result, double ticks indicator (Figure 1) and users' last access time (Figure 3) were seen as revealing much information about them. These indicators are not limited only to WhatsApp, but other MIM applications such as Viber, Facebook Messenger and WeChat which also have such indicators. MIM application shall be used as communication tool and not monitoring tool. Thus, these privacy concerns shall be addressed accordingly in order to design a less intrusive MIM application not just for elderly people, but all.

2.3. Characteristics of elderly people

2.3.1. Ability to use mobile phone

Kurniawan, Mahmud, and Nugroho (2006) had a focus group with seven older women with median age of 67.5 years old, with the aim to study their usage patterns, problems, perceived benefits, desired and unwanted features of mobile phones. In terms of usage patterns, the participants only used it during emergencies. This is seen to be too limiting and the use of MIM can definitely extend the benefit of mobile phones to them.

Problems that they faced with their current phones, which were not smart phone or touch screen phone were

1. Buttons were too small and rubbery

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2. Menus with too many options that were often unnecessary
3. Functions that were difficult to understand, complicated and thus impossible to recall
4. Devices and screens that were too small to hold and read comfortably

The use of touch screen mobile can resolve problem 1 and 4 since touch screen is bigger than regular mobile phone with rubber keypad and soft keyboard can appeal bigger than rubbery buttons as well. Their frustrations with complexity and complicated functions are once again being highlighted and shall be resolved while designing MIM application for the elderly. Simplicity is the key to retain their interest in using the application and their requirements shall be prioritized. Buttons size should be big enough for them so that they feel comfortable “pressing” and touching them on touch screen.

While it came to desired feature, the elderly participants stated the importance of having large screen and text. They did not want a large screen if the screen cannot display large text. Therefore, text size becomes another important element while designing the application. Caller identification was also crucial for the elderly users to remind them who the caller was. This can be implemented by having the user inserting their own pictures during the set-up of MIM application.

2.3.2. Ability to use touch screen

It is important to know that elderly people do portray their own characteristics and diverse abilities which result in requiring specialized design of MIM. Studies have been conducted to find out if aging affects the ability of elderly subject in corrected and inhibited pointing movements by Rossit and Harvey (2008). The results showed same accuracy achieved by older subjects as compared to younger subject in performing same tasks. However older subjects required more time, which resulted from slowing and increased variability of movement planning, initiation and execution to both perturbed and stationary targets. Rossit and Harvey (2008) concluded that aging is not accompanied by a decrease in inhibition of motor control. Therefore, MIM which operates by using touch screen mobile device portrays no problem to most elderly people.

2.3.3. The need of multimodal input and output

On the other hand, Taveira and Choi (2009) who conducted review study on computer input devices and their adequacy to the elderly users, commented that touch screen devices offer poor typing accuracy to them. The buttons are too small for elderly users, especially to those who have poor control over fingers movements. As the result, besides having bigger size for buttons, the need of multimodal input and output also comes into picture while designing MIM for elderly users, specifically to those who speech modality feedback can improve their user experiences in computer tasks (Jacko et al., 2004). The

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similar conclusion was drawn by Teixeira et al. (2012) as they found out that other modalities such as speech recognition was also valued rather important by the elderly. Elderly who might have visual impairment can benefit from using the combination of touch and speech modalities.

2.3.4. Cognitive function

Zhu, Hu, and Efirid (2012) examined the relationship among demographic characteristics, such as age, gender, education, and chronic disease; with social support and cognitive function. Their findings suggested that elderly people who have more family support have better cognitive function levels. Better family support here refers to being married, living with their spouses or with children. This shows the importance of elderly people being socially connected to their families, which can lead to better cognitive function. MIM can be used as social connecting tool by elderly people to maintain or improve their cognitive functions despite of aging.

Besides, Alzheimer's disease and other dementing illnesses are proved to be strongly associated with age. As found out by Evans et al. (1989), of those 65 to 74 years old, 3.0% had probable Alzheimer's disease; while 18.7% of those 75 to 84 years old and 47.2% of those over 85 years old had probable same disease. Stern (2006) recommended that different life exposures including leisure impart reserved against Alzheimer's disease in epidemiologic studies. An elder's cognitive reserve could be increased through some set of systematic exposures or interventions. With functionalities such as sharing photos, sending text and voice messages, group-chatting, MIM is a good non-pharmacologic approach for reducing risk of having Alzheimer's disease.

2.3.5. Ability to learn

The use in ICT is increasing but there is still a significant age-based digital divide. Therefore, it is important to understand the elderly attitude and perceptions when it comes to their usage of ICT. Neves (2012) surveyed random samples of 500 individuals over 64 years of age who lives in Lisbon. 72.4% had a mobile phone and used it regularly, 13.2% used a computer and 9.8% used the internet regularly. The lack of functional literacy in ICT was identified as the main factor not to use a computer or internet. Thus, the need to learn ICT has been highlighted by Neves (2012).

The respondents were mostly positive about learning new technologies. One of the interviewees said, *"I know I am old but I think I could learn how to use the computer... I don't know, maybe not because I'm so old. But sometime I think, if my little grandchildren can learn it, why can't I?"*.

While designing MIM for elderly users, their ability to learn to use it must be taken into consideration. Craik and Jennings (1992) identified cognitive abilities that differed

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between older and younger adults. They were (1) discourse comprehension, (2) reasoning, (3) inference formation, (4) the acquisition of new information, and (5) the subsequent retrieval of such information from memory. As the result, implying these five cognitive abilities into design principles, in order to make MIM easy to learn, it needs to (1) use simple words or instructions, (2 & 3) intuitive in design and (4 & 5) limit the amount of information (both new and old) so that elderly are not overloaded with information at a time.

The preliminary study conducted for this thesis also showed that features in existing MIM are too complicated for elderly and the user interfaces are confusing too. Some unnecessary functions even demotivated them from using MIM. This justifies the need of having simple and accessible yet effective and usable interface of MIM to the elderly users.

Besides, MIM shall also be intuitive in use so that the time required to learn to use it can be minimized. As elderly people have lower cognitive ability to learn, intuitive approach like metaphorical icons can be helpful for them to understand (Craik & Jennings, 1992; Jones & Bayen, 1998; Prior et al., 2008). Easily understandable and intuitive icons can help them reducing their time and effort learning new thing, thus encourage them to engage themselves more in new technology such as MIM.

2.3.6. Self-isolation

As discussed previously, elderly do not have much problem to learn, as long as the application does appear intuitive and simple to them. On the other hand, elderly's self-isolation is a serious issue when they psych themselves out even before they start to try out something new.

In Ling (2007)'s study, he interviewed Reidun, an elderly woman who had received a mobile phone from her children. *"I have been opposed to mobile telephones because I think there have been too many of them but on my 75th birthday, my children and grandchildren gave me one even though I wasn't so excited about it. I didn't know what I was going to use it for."*, told by Reidun.

Reidun only had it with her when she is out driving and spending time at cabin. She did not like having phone around her. When asked about her last time using her phone during the interview, she said, *"I don't know, it was a long time ago. I turn it on every once in a while but there are so few that call so I don't have much use for it, but it is security, if something should happen."*

From Reidun's attitude towards using mobile phone, it can be concluded that she was not annoyed with using mobile phone. Instead, she did know that having a mobile phone around her could provide her more security. Therefore, to address the problem of elderly's self-isolation, it is important to get the elderly come out from their regular comfort

zones. MIM can be then introduced to elderly to use as social connecting tool, not just using it with their elderly friends, but with families. When children and grandchildren also use MIM with them, they would not isolate themselves anymore and in fact, they would feel more interested in using new technology to stay socially included.

2.4. Other needs for elderly people

2.4.1. Electronic family newspaper

It is noted that elder people sometimes live alone without their family members. In Mexico, 10% of the elderly people lived with no close family members around them, as found out by Santana et al. (2005). One possible reason mentioned was migration of family members or relatives to the United States of America. They who lived far apart from others would like to know what was happening in their hometowns, or with their families. Challenges faced by these lonely elderly people in visiting or being visited by their families were lack of proper documentation such as visa or residency permits, cost, and distance. Santana et al. (2005) proposed a web-based system named as electronic family newspaper to resolve the above mentioned problems. This related issue of elderly people might able to be addressed using MIM as a solution as well.

The electronic family newspaper aimed to provide adequate interfaces for different kind of elderly users. Meanwhile, it served the purpose of enhancing the level of interaction beyond synchronous, which means occurring together for two parties as in real time; and also asynchronous form, which they could participate whenever they wanted to. The electronic family newspaper improved the social networks between elderly people and their families.

Although this electronic family newspaper could resolve the problem of social exclusion of elderly people, it focused more on digital photos and narrations accessible through a repository of information. What MIM can offer beyond electronic family newspaper is the ability to chat fluidly, sentence by sentence because electronic family newspaper was only limited to photos and more news-like. Similar to Prior et al. (2008), Santana et al. (2005) used the metaphor of newspapers to convey the concept of picture messages or information to elderly people. This is an important feature as it is perceived as easier to be understood by elderly users, especially for those who are more inexperienced with new technologies.

2.4.2. Ambient concept for elderly people

Kleinberger, Becker, Ras, Holzinger, and Müller (2007) conducted research in an ambient assisted living laboratory for elderly people that functioned to train them to use modern interfaces. They listed three major requirements in order for ambient assisting elderly living to be met, which were

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1. They had to be ambient and unobtrusive to reach a high acceptance.
2. They had to adapt themselves to changing personal situations or capabilities of the individual and the environment to fulfill individual needs.
3. They had to provide their services in an accessible way to enhance usability.

Since proposed MIM application is not designed to be ambient, the first criterion is not required. Nevertheless, criteria 2 and 3 are closely related while achieving personalized design of MIM application for elderly users. MIM application should have user profiling feature where elderly people and other users can choose certain preferred settings which suit them the best. These preferred settings should be changeable anytime whenever the elder users require new adaptable settings. Through this way, it can provide MIM application user experience which is more accessible with enhanced usability. Elderly might feel more motivated as well since personalized settings can help eliminating their problems in using MIM.

2.4.3. Elderly health care

As mentioned by the European Union's report, the need of health care for elderly people has rapidly increased (Union, 2010). Suliman (2014) proposed to send digital data, especially radiological images through MIM since it is much faster and convenient than other internet-based applications such as email. They do not need to compose an email, attach image in the email and so on. MIM can provide the instantaneous and immediate sharing between physicians. This point can certainly be seen usable and beneficial for elderly people.

Those who require extra attention in their health care can stay closer connected with their doctors by using MIM (Pensas et al., 2013). Elderly people can send instant messages or images whenever their doctors ask for them. Doctors on the other hand can have better control over their elder patients due to the ease in using MIM and its immediacy. Any required treatment or medical actions can be facilitated with the use of MIM.

Ferrer-Roca, Cardenas, Diaz-Cardama, and Pulido (2004) conducted a trial system using SMS for diabetes management. 23 diabetic patients used this service in an eight-month period to transmit data such as their blood glucose levels and body weight to a server. Then the server processed the data, calculated a monthly result and sent to patient via SMS. They concluded that SMS was particularly useful for elderly persons that have difficulty in controlling their diabetes, as it provided simple, fast and efficient way to the management of diabetes. This can be seen to be used on MIM platform as well.

Besides, Scanail, Ahearne, and Lyons (2006) developed a telemonitoring system which used SMS to remotely monitor the long-term mobility levels of elderly people in their natural environment. Their mobility levels were measured and summarized, then

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transmitted as SMS message hourly to remote server for long-term analysis. Using the analysis generated, the appropriate medical personnel were informed if an alarming trend was observed in the elderly patients' mobility levels.

This low-cost, operational remote monitoring system has helped elderly people to have independent lifestyle while still being monitored. Even though the system was automated and required no one to operate it, it did not provide immediacy in monitoring. It was also limited to only text messages due to the nature of SMS. Therefore, to complement this shortage, MIM can be a good option. MIM does provide platform for immediate communication at lower cost than SMS. Besides, MIM can be used to send out images, which tells more information when it comes to monitoring. Thus MIM can be seen to be a good tool for tertiary users, such as doctors and caretakers to monitor the elderly patients.

2.4.4. Interactive messaging and reminder display for elderly

A study done by Van Veldhoven, Vastenburg, and Keyson (2008) designed an asynchronous interactive communication system based upon a bulletin board metaphor. They highlighted the low acceptability of new technology might be partially caused by usability problems. Since most of the ICT-based products require minimum level of computer literacy, it is important to have elderly people involved in the process of designing the ICT-based products which target on them, especially when many elderly have little experience with ICT-based products.

They involved a panel of end-users in various stages of the design process and this user-centered design approach was successful in their study. It showed a high degree of user acceptance. Having the similar metaphorical concept as Prior et al. (2008), Van Veldhoven et al. (2008) implemented bulletin board metaphor where traditional bulletin board mapped into the interactive bulletin board and this concept was easily accepted. Two realistic messaging services have been linked to the bulletin board and they were (1) families and friends adding messages, and (2) context-aware reminder service.

All in all, their studies concluded that new technology can be presented to elderly individuals in a more accessible and usable way, by understanding the context of use, their needs and requirements, knowledge and experience and lastly, by leveraging existing interaction metaphors. Despite of their positive feedbacks, they had the doubt concerning the issue of elderly users with reduced motor skills and limited cognitive abilities. This problem can be addressed by having not only one touch modality, but also input substitute of other modalities such as speech recognition, which has been discussed previously in Section 2.3.3.

2.4.5. Gesture-based application for elderly people

W. Chen (2013) highlighted the need of simplicity while designing applications for elderly people and therefore she examined gesture-based applications which allow direct manipulations for them. For the elderly people, advantages of gesture-based interfaces are beyond simplicity. They are also more natural, attractive, intuitive, and easier to be learnt. In this MIM for elderly research, gesture-based interfaces shall be taken into account because the advantages offered by them are suitable in addressing elderly people's need. Touch screen is a good gesture-based device for elderly users as it can offer the above-mentioned benefits.

Touch screen performance study by K. B. Chen, Savage, Chourasia, Wiegmann, and Sesto (2013) investigated the effects of button size and gap size on performance by individuals with varied motor abilities. Button size ranged from 10 to 30 millimeter (mm) while gap size was either 1 or 3 mm. They concluded that there was decrease in misses, errors and time to complete tasks as the button size increased. At the same time, the disabled group also performed better as button size increased. Gap size did not have any influence towards user performance, both abled and disabled group. Thus, since MIM heavily uses touch technology, accessibility is believed to be improved by having users to select their own preferable button size.

Mobile devices nowadays are designed with touch screen and therefore, using MIM as social communication tool can be perceived as easier and more accessible to the elderly users since gesture-based interface can be intuitive. On the other hand, multimodal input and output, which is non-gesture based, are undeniably important with regards to accessibility of elderly people. As mentioned before, due to different kind of elderly's abilities and disabilities, they might need application to able to work with speech synthesis and voice input as well, besides touch screen gesture-based interaction.

2.5. Design principles and techniques

2.5.1. User profiling

It is vital to have user profiling feature while developing specifically designed MIM application. User profiling helps to ensure there are customized designs which can adopt to users' preferences (Golemati et al., 2007). A number of studies related to user profiling have been conducted, and they showed the importance of having user profiling to improve users' experiences while using certain product (Alberto, 2010; Balduzzi et al., 2010; Golemati et al., 2007; Hildebrandt, 2008).

User profiling is the process of building a profile based on a set of data (Alberto, 2010). There are two main types of user profiling. One involves automated data while another one is non-automated (Hildebrandt, 2008). Automated data user profiling can use

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data cleansing, data aggregation and data mining. These are done without having users to directly provide their 'profiles' data. Therefore, this kind of user profiling provides more of a kind of prediction, based on past behaviors of users.

On the other hand, non-automated user profiling requires user to input their data, which is what MIM can do. A list of preference setting questions can be asked before the elderly users start using the MIM application. By combining the preferences, the users can create their own profiles and the setting suits the best for them will be generated for them. This will ensure the user profiling is done more accurately than prediction in automated user profiling.

To ensure the user profiling questions do not annoy the elderly users when they start using the application, it is important to ensure the questions are not lengthy (Lazar, Feng, & Hochheiser, 2010). As the result, stereotyping can be adopted as the user profiling has to be done brief and simple. Turner and Turner (2011) defined stereotype as typically comprising abstract knowledge about a group of people. They suggested stereotypes to arise from the cognitive processes involved in categorization and are useful heuristic for dealing with everyday situation. So, while integrating stereotyping in user profiling approach, MIM application has to make assumptions that a number of preference settings can address all of its elderly users, by grouping them into all different stereotypes and cover all the user groups.

2.5.2. Design principles

To design a specially designed MIM application where elderly users interact heavily with the mobile devices, Human-computer interaction (HCI) principles can never be overlooked. Hinze-Hoare (2007) reviewed and analyzed many rules and principles developed for interface design in HCI. Eight fundamental were found by him to be most weighted and they are discussed as below.

1. *Recoverability*. Some elderly users are expected to be new or unfamiliar with MIM. Therefore, if errors occur while they are using the application, there should be ability of users recovering from their errors. Recovery can occur both forward, which is the prevention of error; and backward, which concerns the easy reversal of erroneous actions. For MIM, one of the errors which user can perform and shall be prevented is sending text messages, audio messages or pictures to wrong recipients. In terms of sending pictures, they can be asked to confirm their actions before sending selected images. In terms of text and voice messages, name of the recipients appearing on the menu bar should be in sufficient font size in order to prevent the error of sending message to wrong recipients.
2. *Familiarity*. Referring to familiarity, elderly users' experience with MIM shall be surveyed and the layout of the proposed MIM application shall refer to the most

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commonly used MIM applications, or other mobile applications which they are using. This can also be achieved by including the elderly in the design and development process so that the design is inspired by them and easy to learn for them, thus achieve the aim of familiarization to them.

3. *Consistency*. To ensure consistency can be achieved, perceptual grouping concept can be used to ensure the same kind of functionalities are grouped together (Rosenholtz, Twarog, Schinkel-Bielefeld, & Wattenberg, 2009). For example, having the camera and gallery buttons near to one another (Figure 4) like in WhatsApp. Besides, the functions shall be performed in similar way so that the elderly users can behave similarly in performing similar tasks.



Figure 4: Camera and gallery functions in WhatsApp for photo sharing

4. *Substitutivity*. Hinze-Hoare (2007) summarized the need of having input substitutivity to contribute towards an overall flexible HCI structure, which allows the users to choose whichever input method he considers most suitable. As suggested by Teixeira et al. (2012) as well, this is where the need of multimodalities comes in. It is expected that with the support of speech modality, more elderly users will find it convenient to use MIM as they have speech modality as substitute for input modality besides touch modality.
5. *Task migratability*. Task migratability concerns about the transfer of control for executing tasks between the system and the user. This feature can be implemented by incorporating camera function or direct to gallery while sharing images. Current MIM applications, such as WhatsApp has this type of feature (Figure 4) and this shall be included while designing MIM application as well.
6. *Synthesizability*. Synthesizability emphasizes the ability of the interface to allow users to construct a predictive mental of how it operates (Hinze-Hoare, 2007). This can be implemented with status and notification mechanism. For example, when the message is not delivered, notification will be prompted. The same goes to messages being sent successfully. However, these kind of information shall also be handled carefully due to privacy concern, which has been previously discussed in Section 2.2.4.
7. *Predictability*. MIM's predictability can be improved through the use of metaphorical icons in interface design. Besides making the interface more

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interesting and attracting the elderly users' attention to learn, metaphorical icons also help the users to understand the interfaces easily by providing intuitive meaning. Thus, they achieve the goal of MIM application works as users' expectations are.

8. *Perceptual ergonomics*. Perceptual ergonomics shall also be taken into consideration while designing MIM application interface to ensure more efficient interface can be created. For example, the icon size cannot be too small and must at least fulfill the required size in Android accessibility testing checklist (Android, n.d-b).

Furthermore, in order to make elderly feel effortless while learning and using MIM application, it is crucial to make the application appears easy and simple to them. As mentioned by Rosenholtz et al. (2009), "*understanding and exploiting the abilities of human visual system is an important part of the design of usable user interfaces and information visualizations*". There are a few Gestalt laws that are found usable and applicable in designing the user interface of MIM application for elderly (Graham, 2008). They are:

1. *Law of proximity*. Items that are spatially located near each other seem part of a group, while items that are apart are perceived as separate. Other than soft keyboard on the bottom of touch screen, all other functions can be placed together, and near to each other on the top part of the screen, where they look like the menu bar of the mobile application.
2. *Law of similarity*. Items that are grouped together are expected to have similar functionalities. This can apply on grouping picture message and voice message together as multimedia message.

Last design principles are from Norman (1988). As mentioned by Abras, Maloney-Krichmar, and Preece (2004), "*Telling designers that products should be intuitive is not enough; some design principles are needed to guide the design*", thus they recommended the seven principles of design, which were proposed by Norman (1988, pp. 189-201) for facilitating designer's task. They are

1. Use both knowledge in the world and knowledge in the head. By building conceptual models, write manuals that are easily understood and that are written before the design is implemented.
2. Simplify the structure of tasks. Make sure not to overload the short-term memory, or the long term memory of the user. On average the user is able to remember five things at a time. Make sure the task is consistent and provide mental aids for easy retrieval of information from long-term memory. Make sure the user has control over the task.

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3. Make things visible: bridge the gulfs of Execution and Evaluation. The user should be able to figure out the use of an object by seeing the right buttons or devices for executing an operation.
4. Get the mappings right. One way to make things understandable is to use graphics.
5. Exploit the power of constraints, both natural and artificial, in order to give the user the feel that there is one thing to do.
6. Design for error. Plan for any possible error that can be made, this way the user will be allowed the option of recovery from any possible error made.
7. When all else fails, standardize. Create an international standard if something cannot be designed without arbitrary mappings.

Not all principles from Norman (1988, pp. 189-201) were found applicable. However there are some similarities found between his principles and Hinze-Hoare (2007)'s HCI design principles. For instance, by adopting "design for error" (principle 6 from Norman), it is expected to achieve good design for recoverability (principle 1 from Hinze-Hoare), since design for error will provide good fundamental for designing good recovery methods in the system, both forward and backward recovery.

Making things visible and getting the mappings right (principle 3 & 4 from Norman) are vital to achieve predictability (principle 7 from Hinze-Hoare). The elderly users should be able to predict and figure out the use of button by seeing how its metaphorical icon looks like. When functions cannot be represented well using metaphorical icons, then it is recommendable to use text to convey the message instead, so that the functions can appear visible and understandable to the users. Not to forget, mappings are also crucial to make sense of things. This is why application flow has to be logic and reasonable for users to navigate from one screen to another.

Lastly, simplifying the structure of tasks (principle 2 from Norman) can help to achieve familiarity, consistency and predictability (principle 2, 3 & 7 from Hinze-Hoare). In order to make elderly users feel familiar with the MIM application, it is important to simplify the tasks and not overload them with remembering too many things. While tasks are being simplified, the way to perform the tasks can be ease by making the interfaces consistent so that the elderly do not have to remember a lot. When the interfaces are consistent, the way of performing the tasks can be more predictable to them as well.

2.5.3. Usability principles

While designing a new MIM application for elderly users, usability is another important aspect to determine if the elderly will continue using it or give up and live without it. Through literature review focusing on papers published between year 2008 and 2010, Harrison, Flood, and Duce (2013) identified three main attributes, which were (1)

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effectiveness, (2) efficiency and (3) satisfaction for measuring mobile usability. These principles were included as the usability attributes in more than 50% of the relevant papers studied by them. Besides, these three principles are also proposed by International Organization for Standardization (ISO) as usability model.

Other common attributes of usability are errors and learnability, which were described by Harrison et al. (2013) as not that often being used in research studies. These two principles are considered least in accessing usability because they require to be evaluated over periods of time. However, in order to ensure elderly people can use MIM application without any barrier, all the above mentioned five usability principles are vital to be incorporated during design and development of MIM application.

1. *Effectiveness*. To ensure MIM application is perceived as effective to the elderly people, it must provide the necessary functionalities that elderly users use them to achieve their desired outcomes, which is being socially included in an easier way. The required functionalities shall be identified through user requirement study.
2. *Efficiency*. This principle can be achieved via less effort required by elderly users while using MIM application. Appropriate size and space are required to be provided for easy approach, reach, manipulation and use regardless of the users' body size, posture or mobility. Size of buttons on interfaces shall be appropriate and sufficient to the users so that no extra physical effort is needed. The appropriate button size shall be minimum of 48 dp or approximately 9 mm in length and width (Android, n.d-b). User profiling mechanism can be included for elderly to choose suitable size of buttons for them in order to enhance this accessibility issue. The design of MIM application should also be able to communicate necessary information effectively to the elderly users, regardless of ambient conditions or their sensory abilities. This principle is extremely crucial while designing the "touch to speech" Android's TalkBack functionality because every single touch shall convey audio information which is perceptible to the elderly or visual impaired users.
3. *Satisfaction*. To get users feeling satisfied with the MIM application, it is important to ensure that they are not facing any kind of barrier while using it. This can definitely be achieved similarly as principles of effectiveness and efficiency. However, in addition to that, it is also important to make the elderly feel special and unique while using the MIM application as in the application has taken consideration of their needs. Therefore, personalized user profiling can increase their satisfaction level.
4. *Errors*. Hazards and the adverse consequences of accidental or unintended actions shall be minimized while designing the MIM application. Same as recovery principle in HCI design, error handling can be achieved by having

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prevention mechanism such as sufficient font size displaying names of recipients to avoid messages sent to wrong recipients. Button size cannot be too small as it might cause the users pressing and touching on wrong buttons. If they do press wrongly, undo or back button shall immediately bring them back to the previous screen. Since the primary target group of users are elderly people, they are expected to be tired easily after using mobile phone for some time. Thus, MIM application has to be designed to be used effectively, efficiently, comfortably and with a minimum of fatigue. Button size that is too small can lead elderly to tap wrongly while tapping on it, and this might require additional focus and effort from elderly users who possibly suffer from muscle control problem. This goes the same for motor impaired users.

5. *Learnability*. Elderly users should find the MIM application easy to understand and learn, regardless of their experience, knowledge, language skills or current concentration level. Thus, the design of interfaces and functionalities shall be kept simple and the application flow shall also be easily understood. Learnability can also be improved by having metaphorical icons that seem intuitive to elderly users. If the feature cannot be represented well using metaphorical icons, text shall be used instead to provide clearer information.

Last but not least, to maximize usability, the set of seven principles of Universal Design, which was developed by The Center for Universal Design at North Carolina State University, can never be overlooked (Connell et al., 1997; Story, 1998). These seven principles can help to ensure the MIM application can be extended to as many user groups as possible as well.

1. *Equitable use*. *The design is useful and marketable to people with diverse abilities*. MIM should be designed in such a way that it can be used by people with diverse abilities. As suggested by Story (1998), “*Provide the same means use for all users*”, implementing multimodality integration can support different needs of the elderly. While touch modality is easy to be used and it is the main interactive modality for MIM, speech modality shall also be integrated as alternate modality to support people who might have visual impairment.
2. *Flexibility in use*. *The design accommodates a wide range of individual preferences and abilities*. This principle aims in accommodating wide range of audiences by providing choice in methods of use and adaptability to the user’s pace (Story, 1998). By implementing user profiling, elderly users can choose the settings that suit best to their needs. Thus they have the adaptability in using the MIM application the way they want.
3. *Simple and intuitive use*. *Use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level*. To achieve this, unnecessary complexity has to be eliminated while the MIM

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application has to work consistently with elderly's expectations. As found by Teixeira et al. (2012), elderly do not like complicated features especially those that they feel like they do not need. As the result, it is important to remove unnecessary functionalities that have been identified in existing MIM applications.

4. *Perceptible information. The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.* According to Story (1998), this principle can be achieved by differentiating elements in ways that can be described (i.e., make it easy to give instructions or directions). In MIM application, metaphorical icons can help to make the functionalities to be perceived easily (Prior, Arnott, & Dickinson, 2008). Besides metaphorical icons, simple text can also achieve the same results. It is always better to provide clear and simple text, than difficult to understand and confusing icons.
5. *Tolerance for error. The design minimizes hazards and the adverse consequences of accidental or unintended actions.* Same as in HCI's recoverability principles (Hinze-Hoare, 2007), it is always crucial to ensure the elderly users are able to avoid doing mistake and recovered fast from making mistake. Sufficient font and button size, together with confirmation message can be used to prevent elderly users from making errors.
6. *Low physical effort. The design can be used efficiently and comfortably and with a minimum of fatigue. Applicable guidelines recommended by Story (1998) are minimizing repetitive actions and minimizing sustained physical effort.* In current existing MIM applications like Facebook Messenger and WhatsApp, in order to record voice message, users require to tap and hold the recording button while recording takes place. This kind of "sustained physical effort" is what should be avoided while designing MIM application so that elderly are not worn out while sustaining their physical effort. Furthermore, sustaining physical effort can also be a problem for the elderly as they might have muscle controlling problem due to aging.
7. *Size and space for approach and use. Appropriate size and space is provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility.* Size is vital in providing good accessibility to elderly while using MIM application. Size for touch target like icons and buttons shall be designed based on Android (n.d-a)'s accessibility guidelines. Not to forget, providing user the option to choose their preferred size is also a good way to adopt this principle.

2.6. Summary

All in all, these surveyed literature aim to point out the importance of better design MIM application particularly for elderly people, how MIM can be used by them to socialize with others, and also design principles and techniques while designing mobile application for the elderly. Main issues of MIM applications to users are its incompatibility with speech recognition, poor and confusing user interface, complicating and unnecessary features and lack of privacy.

Elderly users have their limitations in terms of learning new technology. Nevertheless, this new technology is what helps in making them more social connected, active and thus, physically and mentally healthier as well. Despite of aging, elderly people still have the ability to use touch screen devices. However, the need of multimodal input and output cannot be overlooked. Speech modality is highlighted in this literature review and it is another modality that is considered important requirement by them. These elements can be significantly important to secondary and tertiary users for elderly people, and other user groups as well because these requirements are not limited to elderly but other people with variety of abilities and disabilities.

As the result, it is crucial to include the concept of accessible and usable design while designing mobile application for elderly in order to make them feel included. User profiling can provide more personalized user experience. Stereotyping can be used as a simpler method of user profiling, to ensure specially designed MIM application can achieve personalized user experience for different elderly users with different abilities and disabilities. Last but not least, HCI design principles, usability principles, perceptual grouping principles and principles of universal design shall be applied as well to ensure elderly can have good experiences using and interacting with the simple yet effective and efficient MIM application.

As found out in the preliminary study, the current MIM applications have many issues limiting elderly people to use them. Therefore resolving these problems has become significant so that the elderly are not discouraged from using MIM and thus, not being excluded socially as they grow older. Even though this specifically designed MIM application is targeted to elderly people, there are still other people who will use this MIM application with the elderly users, such as elderly' families, friends, and caretakers. Thus it is important to ensure elderly users with variety of abilities and disabilities can be addressed while the needs of secondary and tertiary users are also covered.

By presenting this literature survey, it is also hoped that MIM's potential contribution to elderly people can be highlighted. It is no doubt that with a better accessibility and usability MIM, elderly people can benefit from being socially included with their families, friends, and whoever they want to keep in touch with.

3. Design, development and evaluation

The research started with a preliminary study on the existing MIM applications. User testing were conducted with two users who were age 51 and 56. They were asked to perform a few MIM tasks, which were (1) sending text messages, (2) sending voice message, (3) sending picture messages and (4) setting contact as favorite. The findings were both of them did face some issues while using the current existing MIM applications. They had problem identifying the correct buttons to perform certain MIM tasks and one of them even mentioned that using PC could be much easier as the buttons on touch screen mobile phone were too small. The tested MIM applications were WhatsApp, Viber, WeChat, LINE and KIK.

Using the five above-mentioned MIM applications, another user testing were conducted with a blindfolded user to test if they could work well using speech recognition. It was found out that current MIM applications were incompatible with speech recognition both in iPhone OS and Android OS. For instance, VoiceOver could not read add others button of Wechat, Viber (Figure 5) and Kik which caused user not able to send pictures. MIM should be compatible with speech input and output to improve elderly user experience while using MIM, especially for those who have certain impairment and need to rely on speech recognition

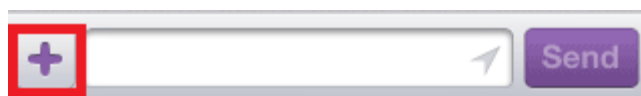


Figure 5: Viber's add others button

After the preliminary study, the study was planned and designed to adopt user-centered design and participatory action research approach, where primary targeted user group, which is the elderly users influence the design of prototype takes shape (Abrams et al., 2004; UPA, n.d.). Many studies prove that user-centered design approach can result in valuable input while ensuring the end users being able to make use of the end product (Meiland et al., 2014; Prior et al., 2008; Santana et al., 2005; Van Veldhoven et al., 2008; Vermeulen et al., 2013) . The elderly users should be able to use MIM application as intended and with a minimum effort to learn how to use it.

Norman (1988) suggested four basic suggestions on how a design should be, based on his opinion about user-centered design concept. They are (1) make it easy to determine what actions are possible at any moment, (2) make things visible, including the conceptual model of the system, the alternative actions, and the results of actions, (3) make it easy to evaluate the current state of the system, and (4) follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state (Norman, 1988, p.

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188). These suggestions were adopted during the user requirement study, design and development process.

Same as user-centered design approach, participatory action research is suitable for researchers who are committed to co-developing research outcome with participants rather than for participants (McIntyre, 2007). Participatory action research seeks to understand and improve the world by changing it (Baum, MacDougall, & Smith, 2006). In this study, it also aims to eliminate e-exclusion and improve elderly lives. Using participatory action research approach, it was targeted that the elderly participated by reflecting their inquiry through user testing and interviews.

The study was conducted through four main phases, which were (1) user requirement study, (2) design, (3) development, and lastly (4) user testing. Their interrelationships are illustrated in Figure 6. The processes were iterated back and forth until the tested outcome met as desired by the elderly participants, and these processes were considered as iterations of the prototype. Since this study aims to deliver prototype that is desired by the elderly participants, so combination of user-centered approach and participation action research was found suitable.

According to Chevalier and Buckles (2013), there are three challenges within participatory action research. They are (1) social plane, which means participation (life in society and democracy), (2) plane of experience, which means action (engagement with experience and history), and (3) plane of mind and thought, which means research (soundness in thought and the growth in knowledge). These three challenges are crucial to be integrated into research work, in order to practice participatory action research.

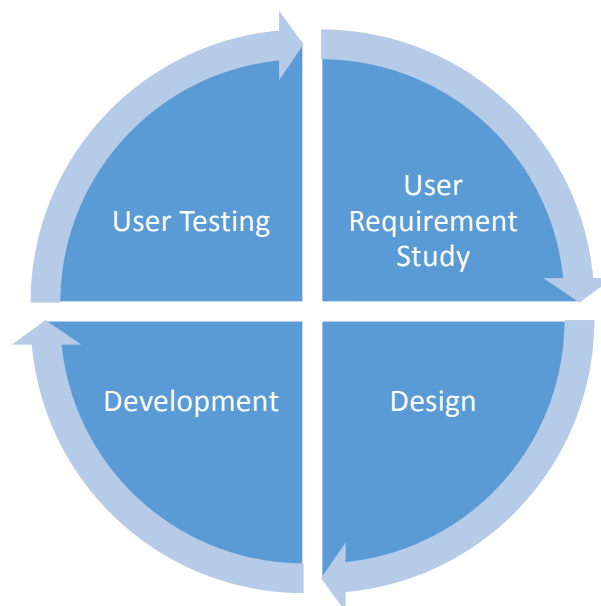


Figure 6: Interrelationships of project phases

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While adopting combination of user-centered design and participatory action research approach, having elderly participants to engage starting from user requirement study until user testing had them participating, experiencing, learning and gaining knowledge in using MIM. As the result, it was expected to deliver an end product that users would have feeling of self-belongingness in it.

3.1. User requirement study

The objectives of this phase was to gather user requirement, since the need of primary target users, elderly people shaped the design of specially designed MIM application. The user requirement study consisted of two main techniques, which were (1) focus group interviews and (2) user testing. Focus group interviews was conducted to collect data related to the needs and expectation of elderly users while user testing was designed to have them performing MIM tasks so that they could be observed in order to provide deeper insight on what could be improved while using MIM (Abrás et al., 2004; Lazar et al., 2010).

There were three main aspects that were focused while conducting user requirement study. They were (1) functionalities that elderly users would like to have in MIM, (2) interface design of MIM that they could interact easily and (3) application flow of MIM that they could understand easily. These three elements were inspired by Norman (1988)'s four suggestions on how an user-centered design end product should be like. They were important to ensure elderly users find MIM application easy to be used and therefore, do not demotivate them from using it. They were also crucial since they provided the input for the next phase, which was the design phase.

First, elderly people whose age ranged from 60 to 80 years old were identified and invited to be research participants. The age of elderly people was defined by WHO (2014) based on a combination of chronological, functional and social definitions. The concept of "pensionable age" was also remained. In Norway, the general age limit for retirement is 70 years old but for some professions, employees have their right to set their retirement age lower than 70 years old. (Veland, 2013).

Before the sessions started, they were briefed about their roles and rights as participants, and then asked to sign the letter of consent (Appendix A). According to Lazar et al. (2010), having informed consent means that they are

1. "Informed". The participants must understand the reason for conducting the study and the procedures that are involved;
2. "Consent". The participation in this research study is entirely voluntary and free from any implied or implicit coercion.

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They were then interviewed, based on a set of semi-structured interview questions (Appendix B). These questions were inspired by Software Usability Scale (Brooke, 1996) and adopted semi-structured format with mostly open-ended questions to have flexibility in prompting more feedbacks from the participants (Lazar et al., 2010). As suggested by Lazar et al. (2010), "*This freedom invites the respondent to answer in depth, exploring any aspect of the issue that may be of interest.*", it was hoped that this approach could stimulate more insights that literature reviews and other interview sessions had not covered.

During the semi-structured interview, their opinions, attitudes about MIM were also be gathered to see if they would have the interest to use MIM now or in future. They were also asked if they could understand the proposed metaphorical icons (Appendix C). These metaphorical icons were referenced from some currently existing MIM applications. If they did not understand them, they were asked to propose their own metaphorical icons.

After that, they were told to perform a few MIM tasks (Appendix D) and the whole process was observed to see if there was any difficulty faced by them, any features that they liked or disliked and so on (UPA, n.d.). This list of MIM tasks were generated based on the feedback from the preliminary study and also other IM related studies such as Prior et al. (2008), Teixeira et al. (2012) and Church and Oliveira (2013). Time required to accomplish these tasks were recorded.

The above mentioned semi-structured interview and observations themselves had some limitations. Since interview's data collection was separated from MIM tasks, it suffered from the problem of recall (Lazar et al., 2010). In order to avoid this potential issue, participants were also asked some related questions while they were performing the MIM tasks. It was important to ensure that those questions were asked under the circumstance that they would not affect the participants' speed for completing the tasks.

Furthermore, "*Observation is harder than it sounds*", as observer might tend to only observe what is expected to be observed, and then filter out what is not in his or her expectation (Lazar et al., 2010). Thus, as suggested by Lazar et al. (2010), combination of interview with observation helps to understand the relationship between what interviewees say and what they do. This can also help to avoid the missing of filtered inputs from interviewees.

Last but not least, they were debriefed before the user requirement study were ended. Debriefing provides the opportunity to share any thoughts that do not seem to fit earlier in the interviews, but they can still be related to the topic and contribute to more insights (Lazar et al., 2010).

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The findings from user requirement study were then compiled and analyzed. At this stage, the user requirement was then generated. The deliverable of user requirement study reflected in a list of objectives that specifically designed MIM application should achieve.

3.2. Design

Design phase was divided into three main parts. They are discussed in the following sub-sections accordingly.

3.2.1. Designing user profiling

Using the analysis from user requirement study, user profiling was designed accordingly. Based on findings, one main element has been identified to be included in developing user profiling and that was the size of font. To achieve user profiling of font size, elderly users shall be asked to select their preferred font size while they start using the MIM application for the first time. This aims to give the options to personalize their own MIM application with font size setting.

Stereotyping was used as a simpler mode of user profiling. It was targeted to have three different font sizes, which were (1) medium, (2) large and (3) extra-large. Small font size is not encouraged to be used by elderly users (K. B. Chen et al., 2013; "Making Your Printed Health Materials Senior Friendly | National Institute on Aging," 2008). A low fidelity paper prototype (Figure 7) was created at this stage to realize the idea of the design.

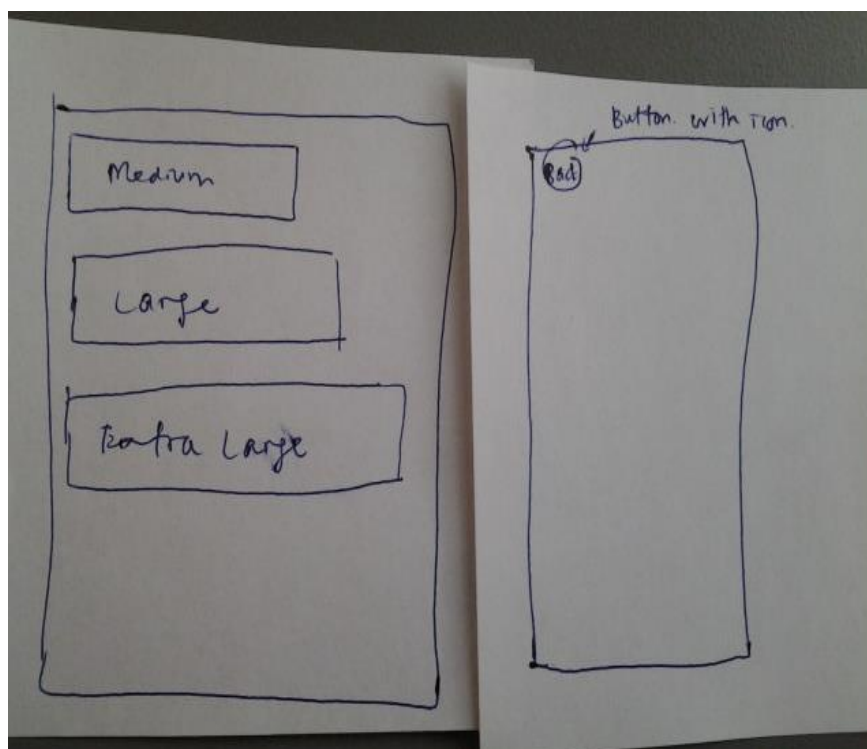


Figure 7: Low fidelity prototype

3.2.2. Designing interfaces, functions & application flow

The low fidelity prototype (Figure 7) was further designed with interfaces and application flow. While designing the interfaces and buttons, metaphorical icons were taken into consideration as they were easier understood by elderly users (Prior et al., 2008).

Accessibility testing checklist was used while designing the interfaces, in order to ensure the interfaces were accessible to elderly users with varying abilities. In terms of touchable control sizes, all controls where a user a select or take an action must be minimum of 48 dp (approximately 9mm) in length and width, as recommended by Android (n.d-b).

From literature review and preliminary study, there were already a few MIM functions which have been identified as important and must be included in the prototype. They were (1) sending text message, (2) sending voice message, (3) sending image and (4) having group chat. These were the same features that were later then identified as important by the elderly participants from user requirement study. It was expected the MIM application to have minimal yet necessary functionalities, work as easy and effortless as possible, by adopting the concept of both HCI and usability principles (Harrison et al., 2013; Hinze-Hoare, 2007; Nielsen, 2005; Rosenholtz et al., 2009).

3.2.3. Designing multimodal input and output

The user requirement study was limited to elderly users without much disability problem. Thus, other than inputs from user requirement study, studies from literature study and the preliminary study also shaped another important requirement for the MIM application, which was integration with other input and output modality in order to support elderly users with different kind of disabilities, particularly speech recognition.

Existing studies have shown that the current IM applications are not compatible with speech modality (Teixeira et al., 2012), which was aligned with the finding in preliminary study. Besides the interfaces, modality to use the MIM application is also extremely crucial to bring convenience to elderly users. Therefore, the objective of this phase was resolving the incompatibility issue with speech modality in at least one mobile OSs, which was Android's TalkBack.

Since MIM shall be fully compatible with speech modality, it is crucial to ensure the application can operate, and be read and understood via speech input and output. The interfaces should be voiced-over to elderly users while they touch the elements on the screen. All output should be voiced-over as well, except images message that the MIM application cannot read. The terms voiced-over to elderly users have to be simple and not jargon that elderly users cannot figure out their meanings.

3.3. Development

After having the design specification and paper prototypes from design phase, development phase took place to convert the design from low fidelity prototype into end product. The overall development process was divided into three main modules. As shown in Figure 8, they were (1) interfaces, (2) application flow and (3) functionalities.

Interfaces modules included five main interfaces, and they were (1) main application screen which displays the list of contacts, (2) install screen where users have to answer their user profiling question, (3) settings screen where users choose their application settings, (4) chat screen which involves from sending messages to displaying messages, and (5) add new contact and create new group chat screen. Three types of messages are (1) text messages, (2) picture messages and (3) voice messages.

Application flow here refers to the flow of navigating from screen to screen. These three modules are interrelated, as functionalities are performed on interfaces and interfaces are linked one to another through application flow.

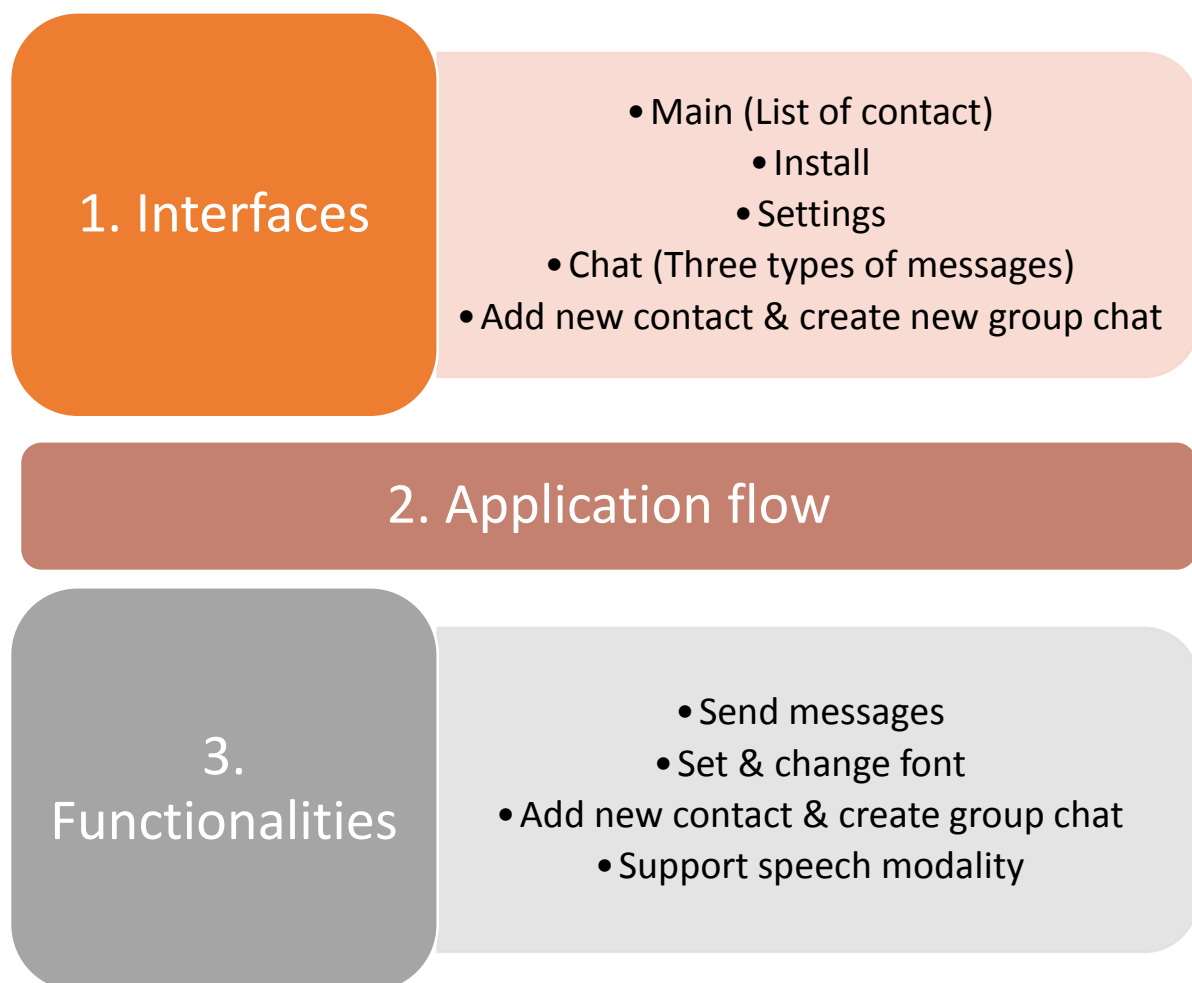


Figure 8: Development modules

3.4. User testing

There were two types of user testing throughout the research. They were (1) the user testing during design and development and (2) the final user testing after final iteration of design and development.

3.4.1. User testing during design and development

These user testing are also considered as usability testing. They were conducted as soon as any features were developed. Providing great user experiences is an ongoing process, therefore usability testing are conducted when any outcome from the study is ready (UPA, n.d.). There were a few iterations of the prototypes where each iteration was tested by at least one elderly participants from the initial user requirement study in order to get feedback about the prototype. The one basic goal of usability testing is to improve the quality of interface by finding flaws in it (Lazar et al., 2010).

Asking the elderly people to evaluate and test partially completed product could be troublesome and tiring to them. Besides, they were not always available. Therefore, to ease the usability testing during development phase, persona and stereotypes were used (Turner & Turner, 2011) to overcome this shortage. Initial design and testing were performed by assuming how general elderly people who were new in using MIM application would want a MIM application to be like.

The elderly were asked to test out features that were developed and then interviewed to ask their opinions about the currently developed prototype. Whenever there was issue or comment after usability testing by elderly participants or personas during development stage, the issues were fixed before moving to the next development. That was to ensure feedback were taken into real design and development in order to fulfill the essence of user-centered design and participatory action research approach.

3.4.2. User testing after design and development were completed

After the design and development have completed for the last iteration, the final user testing was conducted. As mentioned previously, since it was expected to be difficult to test and evaluate unfinished or partially ready prototype with all elderly users in every iteration, thus only the final user testing was conducted with all elderly users from the user requirement study. This phase of thorough user testing aimed to gain more constructive and thorough user feedbacks of the whole end product for MIM application.

Similar to user requirement study, they were briefed at the beginning of the user testing session. However, the flow was different this time as performing MIM tasks were conducted first while focus group interview were held afterward. MIM tasks performed by

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the elderly participants were listed in Appendix E. Time required to complete the tasks were recorded as well.

Interviews questions were different in this final user testing since the aim was not to get their background and initial experience of using existing MIM, but to prompt their feedbacks about using the specially designed MIM application for elderly. The focus group semi-structured interview questions were listed in Appendix F.

After the final user testing, the test results were analyzed to see if the objectives set from literature study and user requirement study were achieved. Besides, the quantitative and qualitative test results were compared as well. Lastly, one user testing with a blindfolded elderly playing the role as elderly with visual impairment was conducted. This was to ensure the MIM application could function smoothly with speech modality, as it was identified earlier in design requirement that supporting with speech modality is also important.

4. User requirement study

Six elderly people were identified and they have agreed to participate in the user requirement study. Their demographic information are presented in Table 1. Pseudonyms are used to protect anonymity.

#	Age	Gender	Job
P1	76	M	Retired
P2	62	M	Manager
P3	65	M	Retired
P4	64	F	Retired
P5	68	M	Retired
P6	67	F	Retired

Table 1: Demographic information of elderly participants for user requirement study

4.1. *Semi-structured focus group interview*

All participants have knowledge in using smartphone or even tablet. Except P1 who does not own a mobile phone, all of the other actually use their smartphones at daily basis to stay in touch with friends and families. However, P1 did use Facetime with his iPad to talk to with his children and grandchildren before, especially when he was spending his winter vacation abroad and away from his family.

Other than communication purpose, they also use their phones for other purposes. P2, who is still working as a manager, uses his iPhone for both work and leisure purposes. For work, he uses it to check email and manage appointments or meetings. In terms of leisure purpose, P2, P3 and P4 mentioned that they play mobile games and check Facebook using their mobile phones. Besides that, both P5 and P6 also pointed out their use of checking email via mobile phones.

All of them showed positive attitudes towards learning new mobile application, as long as its functions are really beneficial to them. The technologies used by them to stay connected with others are different and they are summarized in Table 2. P4 was previously

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using Viber with her friends. However, she realized that people who were using it became lesser and lesser. *“Perhaps it was because it was not user friendly enough to elderly like us. My friends stopped using and so did I,”* mentioned by P4.

	P1	P2	P3	P4	P5	P6
Regular phone calls and messages	No mobile phone.	Yes	Yes	Yes	Yes	Yes
Facebook messenger	Yes but only using web version.	Yes	Yes	Yes	Yes but not anymore.	No
Skype	Yes but not anymore.	No	No	No	No	No
WhatsApp	No	No	Yes	No	No	No
Viber	No	No	No	Yes but not anymore.	Yes	No
Other	Facetime	Facetime	No	Facetime	No	No

Table 2: Different communication technologies used by the participants

Similar to P4, P5 was using Facebook Messenger before. The reason he quitted using Facebook Messenger is because he was overwhelmed with the information he could possibly expose to others through Facebook Messenger. He had privacy concern where he felt there was no such need to tell so much. For example, when was he last online, when was his location and so on. This kind of privacy issue is not only faced by P5, but also P1 and P6.

Another privacy concern was when they were added as messenger contact without permission. Most of the messengers such as WhatsApp and Viber use registered mobile

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phone number to sign up the users. So the contact will appear automatically or be suggested to add as messenger contact as long as it is saved as a phone contact list. P5 does not like when he can be searched up by anyone who has his mobile numbers in a messenger.

In addition to that, P5 mentioned that he was annoyed when he was added into contact list, or group chat without obtaining his permission. *“I don’t like when I was added suddenly. Maybe I don’t know that person so well. And there was one time into a group also. I don’t feel like I want to be in that group chat, but if I just leave, it will look strange to my friends or whoever that adds me into that group.”*, said P5.

When asked about learning and using new MIM, all six of them showed positive attitudes as long as the MIM application is really beneficial to them. A MIM application that can be used easily to stay connected with friends and families was seen as very useful and practical by them. When asked about necessary functionalities, the features that they certainly wanted in a MIM application were text and audio messaging, while image sharing could be rather useful to them as well.

In terms of recognizing metaphorical icons (Refer Appendix B question 14 & Appendix C), all participants had no problem identifying them. They could either point out the functions accurately, or at least named some related features. For instance, some of them identified voice message button as volume or speaker. Those were considered as related features as they were still related to sound (voice message). So overall all of them could understand the metaphorical icons.

4.2. User testing

In order to limit the time spent on the user testing, each participant was asked to test only one application, which was chosen randomly (Refer Table 3). All six of them were asked to perform a series of MIM tasks (Appendix D). The same text message (writing “Hi”) and voice message (saying “Hi”) were asked to be sent so that these results were not influenced by the length and content of the messages. It was noted that these results from the user requirement study must be able to be compared fairly with the results at final user testing.

Observation of their performances were summarized as below, based on the tasks carried out by them.

1. Find a contact
 - ✓ All participants had no problem finding the contact name and tapping on it.
2. Send a text message

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- ✓ All participants had no problem finding and using soft screen keyboard except P1 and P6. Both of them were not familiar with touch screen smart phone.
 - ✓ P1 and P6 had problem identifying send button at application.
 - ✓ The send button seemed too small for P1 and P6 to tap on it precisely.
3. Read an incoming text message
- ✓ No one had problem reading. They either had their reading glasses with them or had no vision problem at all. However, P1 commented that the font could be larger.
4. Share an image from gallery
- ✓ P1 was confused between camera and gallery buttons.
 - ✓ P2, P3, P4 and P5 had no problem. However they did spend some time searching for the gallery button.
 - ✓ P6 was clueless as she did not even know what it mean by gallery in mobile phone and what she supposed to do.
 - ✓ P1 and P6 continued to struggle with tapping precisely on the right button, as the buttons were too small for them.
5. Send an image by taking picture
- ✓ P6 was the only participants having problem while the rest performed it smoothly.
 - ✓ P1 learned quick from previous task while P6 was still confused with what picture message mean.
 - ✓ P1 and P6 still had problem with the small size of button.
6. Read an incoming picture message
- ✓ All had no problem.
7. Send a voice message
- ✓ All 6 participants struggled with sending voice message task. They had problem either understanding what voice message was supposed to mean, or identifying voice message button.
 - ✓ Another issue that they had was using the voice message button. They did not know that they had to press the button while talking as recording was being done at that time.
 - ✓ Same as previous messaging tasks, the audio recording button was also too small for P1 and P6.
 - ✓ Lastly, P1, P3, P5 and P6 also had problem pressing the button for long when the recording was being done. They slipped their fingers and they were not sure if the recording had succeed.
8. Read an incoming voice message
- ✓ No problem for all of them as they only needed to tap on the message.
9. Find other contacts and create a group chat with minimum of 3 members
- ✓ All 6 participants were able to complete the task, but with a lot of guidance.

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- ✓ P1, P3, P5 and P6 did not know where to start. They were given step by step instructions from searching for create group chat button to adding contacts.
- ✓ P2 and P4 were aware of the function but required some time and effort to find the create group chat button.

At the same time, their time used to conduct these MIM tasks were also recorded and they are presented in Table 3. Tasks for reading incoming text, audio and picture messages were only observed but not recorded their time since they were difficult and fairly pointless to be quantified.

# Time in minute (m) and second (s)	P1	P2	P3	P4	P5	P6
MIM application that was tested	Facebook Messenger	Facebook Messenger	WhatsApp	Facebook Messenger	Viber	WhatsApp
1. Find a contact	2s	1s	2s	1s	1s	3s
2. Send a text message that says "Hi"	1m 6s	6s	10s	9s	13s	1m 23s
3. Share an image from gallery	2m 34s	15s	20s	16s	19s	2m 15s
4. Send an image by taking picture	20s	18s	21s	18s	20s	3m 21s
5. Send an voice message that says "Hi"	2m 8s	1m 15s	1m 14s	1m 5s	2m 1s	2m 7s
6. Find other contacts and create group chat with	2m 8s	1m 5s	2m	1m 9s	2m 16s	3m 2s

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minimum 3 members						
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Table 3: Time required to complete MIM user testing tasks

To summarize the user requirement study, four main issues were identified during the focus group interview and user testing sessions. They are discussed as below.

1. Font size. Though it seemed like none of them had problem reading what was on the screen, some of the elderly participants mentioned that they do have bad vision and prefer to have bigger font which appears clearer to them. Thus, there should be user profiling mechanism to allow them to choose their preferred font size.
2. Back button at the right of application icon. It was too small and the elderly participants only recognized the application icon (Figure 9). This was considered as a confusing icon to them.

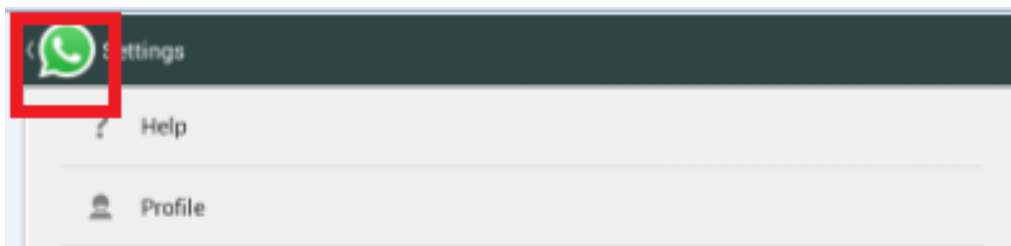


Figure 9: Back button for WhatsApp at settings screen

3. Create group chat. It was too confusing for both WhatsApp and Facebook Messenger as the participants confused between creating group chat and adding a new contact. For instance, P3 and P6 had problem identifying add new contact icon and create group chat (under more button in WhatsApp) as illustrated in Figure 10. Besides, they also had problem navigating from adding new contact to creating group chat since create group chat was placed under more button. This application flow was problematic to both of them.

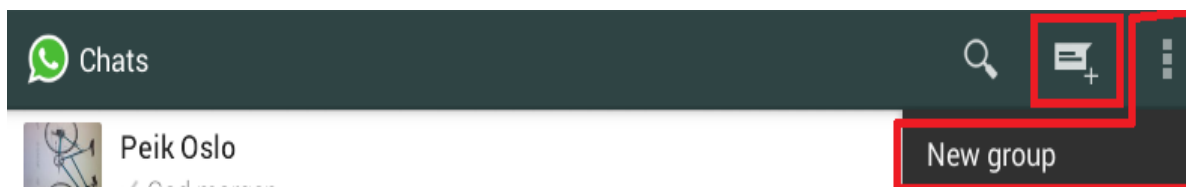


Figure 10: Add new contact (small red box) & create new group chat buttons in WhatsApp

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4. Sending image and voice messages. These icons were confusing and hard to be identified by some elderly participants as well (Figure 4 for WhatsApp and Figure 5 for Viber).

Based on focus group interview, user testing and inspection of existing MIM applications, the following initial requirements have been gathered. Users should be able to

- ✓ Send text messages, voice messages and images
- ✓ Start group chat
- ✓ Configure their preferred font size

In addition to these basic functions, the issues identified were taken into consideration in the design, such as privacy concern, confusing icons and application flow. Buttons indicating add new contact, create group chat, send voice message, send picture message, and back to previous screen are important because the users would interact heavily with them and most participants from user requirement study were having problem identifying them. Moreover, the application flow with regards to how users go from one function to another would also affect their satisfaction of using the application.

5. Prototype design, development and user testing

A prototype named “*Your IM*” was designed and realized into working prototype. Existing MIM applications such as WhatsApp, Facebook Messenger, Viber and Spika were referred while designing *Your IM*. There were in total of eight major iterations of design, development and user testing, and they are discussed as below.

5.1. Iteration 1

In the first iteration, design was made based on the initial requirements and design principles. For instance, by adopting Gestalt’s grouping by similarity theory, the adding new contact function and creating new group chat function (Figure 11) were considered as similar functions and they were grouped together while designing and placing them at the application interface (Figure 12). Human tend to perceptually group the similar functions together by their positions and this can provide good design for quick and easy usage for the users (Rosenholtz et al., 2009).



Figure 11: *Your IM*'s original add new contact and create new group chat buttons

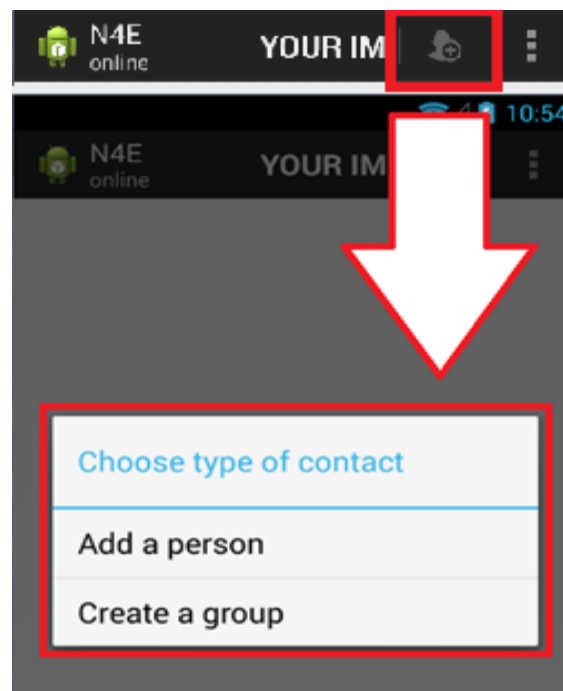


Figure 12: *Your IM* prototype in iteration 1 (Add new contact & create new group chat buttons after applying grouping principles)

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This was actually also one of the issues identified during user requirement study as some of the elderly participants had problem finding create group chat button. They were confused with adding new contact button since creating group chat button was separated from adding new contact button like in WhatsApp (Figure 10) or placed in different tab like in Facebook Messenger (Figure 13). Thus, the idea of placing both related functions under the same button would be a good design for them.



Figure 13: Add new contact (red square box) & create new group chat buttons (red rectangular box) in Facebook Messenger

The first iteration also included user profiling feature where the elderly users would have to choose their preferred font and button size prior to installing the MIM application, as illustrated in Figure 14. The button size is actually dependent on font size. The bigger the font size, the bigger the button size has to be in order to have the words fitted into the button.

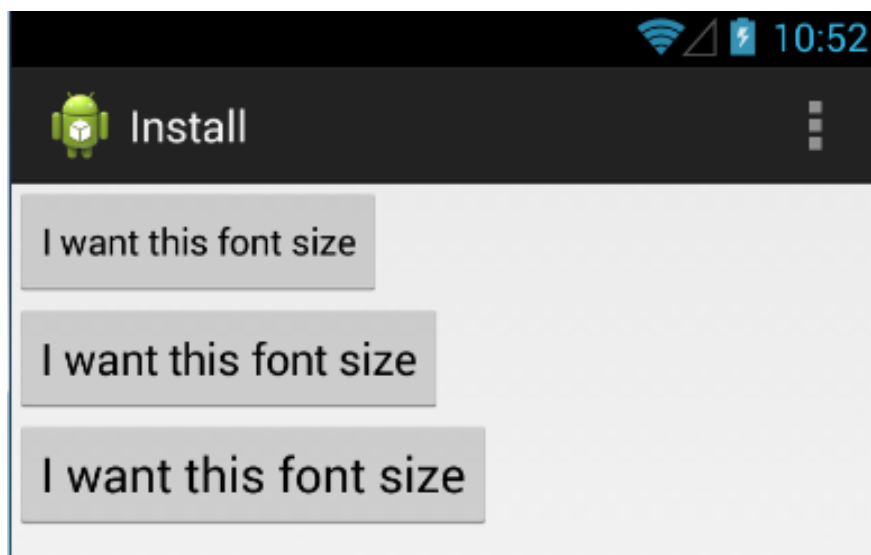


Figure 14: *Your IM* prototype in iteration 1 (User profiling to set preferred font and button size)

This font preference could also be changed after installing the MIM application. User could go to settings screen to change it again if the chosen font size during installation was not suitable for them (Figure 15).

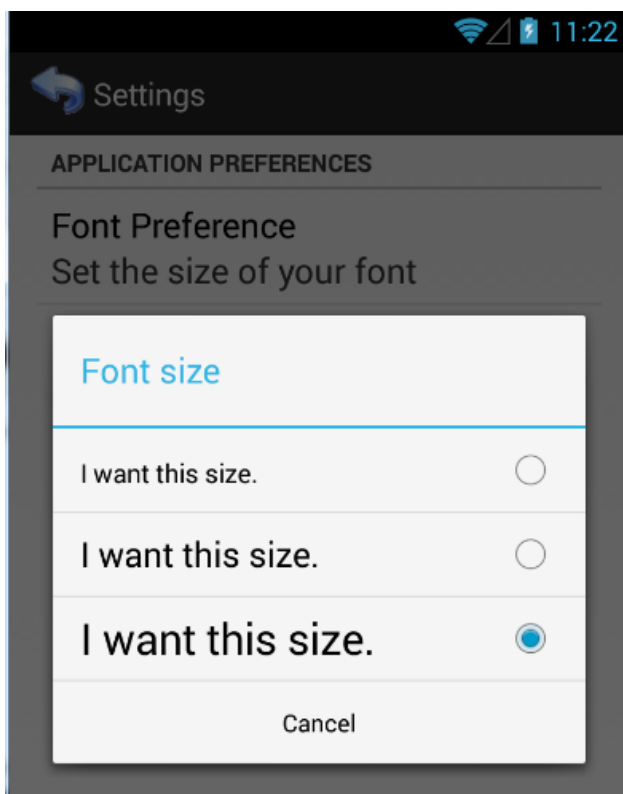


Figure 15: *Your IM* prototype in iteration 1 (Settings screen for choosing preferred font size)

Last but not least, for iteration 1, the back button was also redesigned to make it clearer and more understandable for the elderly users. Instead of having just a regular application icon and a tiny back arrow button at the left like in WhatsApp (Figure 9) and other MIM applications, the prototype used a big and clear back button (Figure 16). This issue was identified during user requirement study as a few elderly participants had the problem to return to the previous screen in application as they did not know or able to see the tiny back button at the left of application icon.

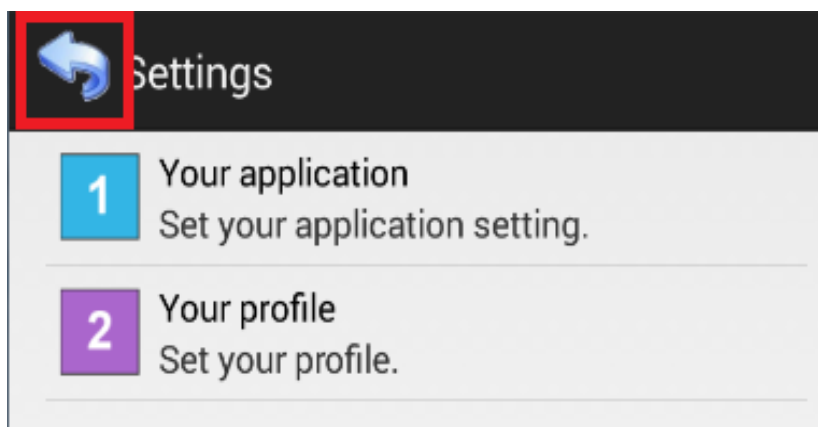


Figure 16: *Your IM* prototype in iteration 1 (Redesigned back button at settings screen)

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Elderly participant P5 was asked to test the prototype of iteration 1. He liked the concept user profiling design when he was asked for preferred font size, as he thought that the messages in some regular MIM applications could appear too small. P5 said, *“Yea, I like the font setting part and I think it is nice to set the size I want. Then maybe I wouldn’t need my glasses anymore if I just want to read messages.”*

He had no problem with setting font size during installation and resetting it again at settings screen. When asked about his experience with the back button with bigger metaphorical icon, he commented, *“I think I can understand better with this icon now. And now I know what I should do if I want to go back to main page or previous page. Before that I thought it was just the icon of the application appearing there for us to see!”* This new redesigned back button seemed to work better visually for elderly users.

P5 also did not face much problem in testing feature of adding new contact & creating group chat. He found it much easier to create group chat as it was placed together with adding new contact. However, he commented that the button looked inactive due to its color (Figure 12). *“At first I was not sure if I should press it, because it looked like it is disabled or inactive. Maybe you can change the color to make it looks like active or can be used.”*, mentioned by P5.

Last but not least, P5 also suggested that after adding contact, it would be better if user themselves could set the profile picture or avatar for each contact. This was because profile picture in current MIM applications are set by the contacts themselves and some contacts choose to use pictures that are not representing themselves or the pictures are not clear enough to tell who they are. As the result, P5 were confused sometimes by just looking at the profile pictures. P5 expressed, *“The display pictures should tell who they are, but some of them are too small, or they put their family pictures or with friends, then we cannot tell who is who”*.

5.2. Iteration 2

In iteration 2, the color for the adding contact & creating group chat button was changed to light blue (Figure 17) based on the recommendation from P5 in user testing iteration 1.

The new feature developed in this iteration was sending media message, which allowed users to perform two tasks. One was to choose image for picture message by taking a new picture or choosing an existing picture in the phone gallery. The other was to choose voice message. This design was also based on grouping theory from Gestalt (Rosenholtz et al., 2009). Image and voice messages were both considered as media messages so their functions were grouped under one button.

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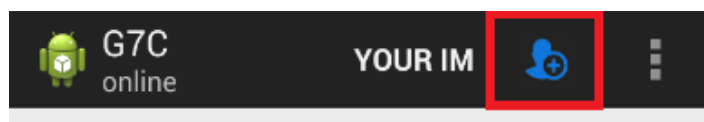


Figure 17: *Your IM* prototype in iteration 2 (Change of color for adding new contact & creating group chat button)

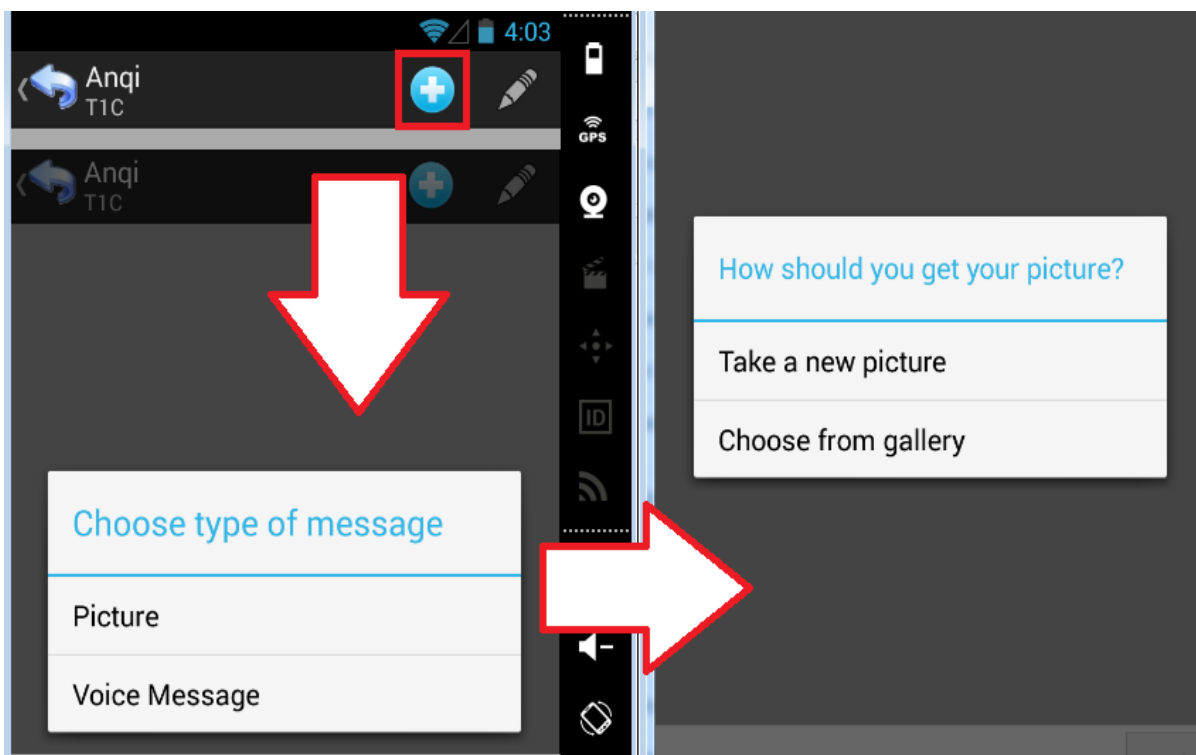


Figure 18: *Your IM* prototype in iteration 2 (Add media message button & choosing picture message screen)

P1 from user requirement study was asked to test the prototype of iteration 2. He found it rather easy to choose font preference during installation, change font preference at settings screen, add new contact, create group chat and send media message. As shown in Figure 18, after the P1 tapped on the add button on menu bar, a prompt box would pop out to ask user to choose between picture message and voice message. After choosing picture message, another prompt box popped out to request for the source of image, which was either taking new picture using camera or choosing existing picture from phone gallery.

P1 commented that this interface and application flow seemed easier to him as the text and button were clear and meaningful to him. He could understand it right away without wondering much about what to do, as compared to Facebook Messenger that he tested in user requirement study. Using Facebook Messenger he was confused between camera and gallery functions, and took some time to recognize voice message button (Figure 19). Facebook Messenger was commented by P1 as having complicated interface

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with too many different buttons and icons, thus making him used more time trying to understand them. In comparison with *Your IM* prototype in iteration 2, he could recognize add media button within few seconds.

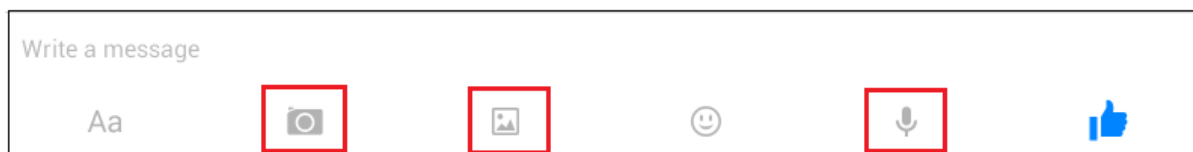


Figure 19: Add image & voice message buttons in Facebook Messenger

5.3. Iteration 3

Since there was no negative feedback received in user testing iteration 2, there was no amendment done to the prototype from iteration 2 in iteration 3. New added feature in iteration 3 was sending text message (Figure 20). P3 was asked to test all existing features in prototype iteration 3.

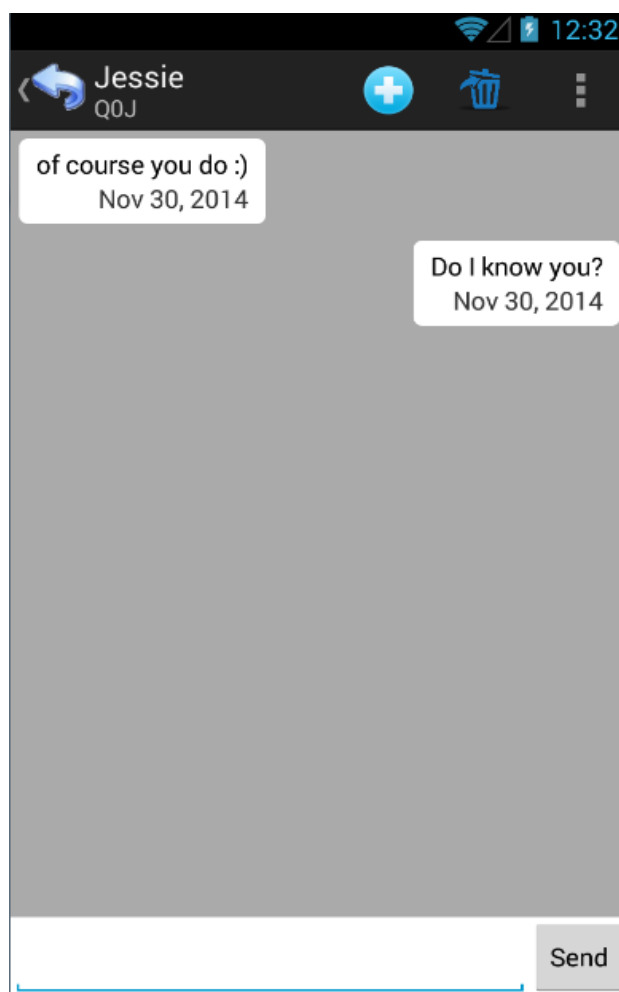


Figure 20: *Your IM* prototype in iteration 3 (Sending text message screen)

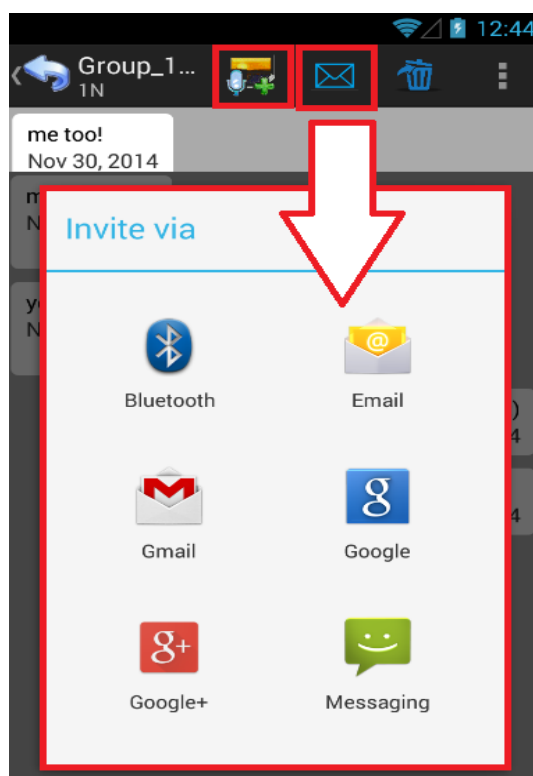
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Same as P1, P3 found it easy and useful for setting font preference during installation and changing it again at settings screen. Adding new contact and creating group chat were no issues for him as well. However, when it came to sending media messages, he had difficulty identifying the right button as he claimed that the cross button did not seem meaningful to him (Figure 18). *"I don't know that it is add button. I only see it like a cross so I really don't know I should press it to add image or audio,"* commented by P3. Lastly, he also managed to perform sending text message with no problem (Figure 20).

Other than not understanding the add media message button, P3 did not have other difficulty with prototype iteration 3. He did like the interface of *Your IM* because he was a user of WhatsApp. He thought the sending text message function was similar to WhatsApp and regular SMS message. He only emphasized that the add media message button was really confusing and perhaps it should convey metaphorical meaning as an add media message button instead of an add button.

5.4. Iteration 4

Comments and recommendations from P3 were considered valid and helpful. They were then taken into the change for icon of add media message button in iteration 4. As shown in Figure 21, it has changed from just a cross add button (Figure 18) to metaphorical icon consisting (1) a picture representing picture message, (2) a speaker representing voice message and (3) an add symbol.



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Figure 21: *Your IM* prototype in iteration 4 (Add media message button & Share group chat ID screen)

Besides that, the share group chat ID feature was completed as well. When user tapped on the envelop button on the menu bar (Figure 21), a window would prompt to ask him/her to choose the way how s/he wanted to share the group chat ID. This mechanism was adopted due to the privacy issue mentioned by some elderly participants in user requirement study. They prefer to be asked for permissions before being added into a group chat. With this design and mechanism, *Your IM*'s users who receive group chat invitation can decide if they want to join a group chat by adding the group chat ID which is sent to them.

P5 was invited to perform user testing for prototype iteration 4. Positive comments were received from him as he found the prototype was easy to use. He had no difficulty using all the existing features. He liked that the add media button was easy to be identified and understood. In terms of creating and joining group chat, he found it simple and good that his privacy concern about being added to group chat without asking permission has been addressed accordingly. All in all, he was impressed with *Your IM*. *"Now that I see that this application is so easy to be used, maybe I can recommend to my other friends around my age who don't like this kind of stuff to try it out!"*, expressed by P5.

5.5. Iteration 5

Iteration 5 implemented the design of sending voice message. First the user clicked on the add media message button, and a dialog box popped out to ask the user to choose between picture and voice message (Figure 22). After choosing voice message, the recording voice message interface would appear (Figure 23).

In order to start the recording, the user had to tap on the screen where it said "TAP TO RECORD". When it started to record the voice message, the image of microphone on the screen changed its color from two grey lines in the middle to two pink lines (Figure 24). It was assumed that this could help the elderly to notice that the recording has been starting. In addition, the word also changed from "TAP TO RECORD" (Figure 23) to "RECORDING..." (Figure 24). The duration of recording appeared below the microphone while recording was in progress (Figure 24).

The user had to stop the recording by tapping on the screen again. When the recording has ended, four changes occurred on the recording voice message screen. They were (1) the "SEND" button appeared, (2) the word changed from "RECORDING..." to "RECORDING DONE", (3) the color of the two lines in microphone image changed from pink to grey and (4) two other buttons appeared below the microphone (Figure 25). One of them was a stop button while the other one was a play button. Play button functioned to play the

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recorded voice message while the stop button functioned to stop the playing of the voice message.

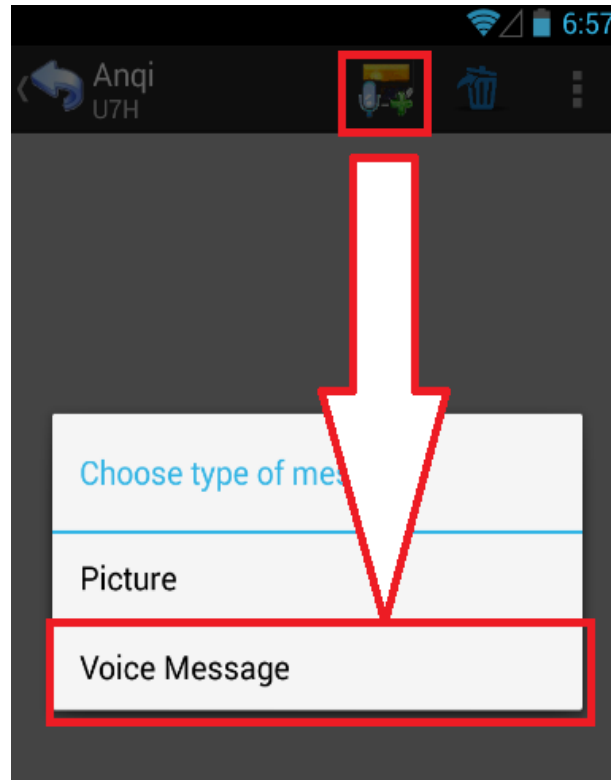


Figure 22: *Your IM* prototype in iteration 5 (Adding voice message)

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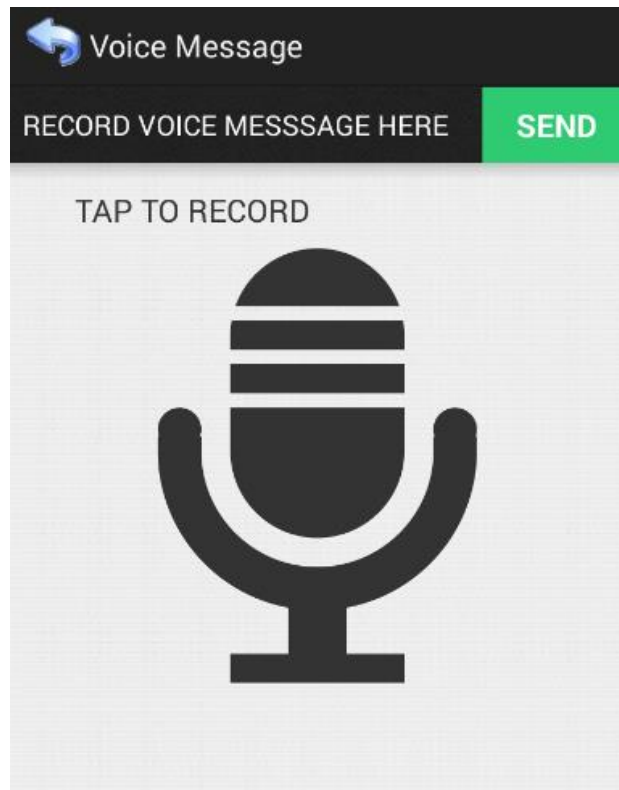


Figure 23: *Your IM* prototype in iteration 5 (Recording voice message screen)

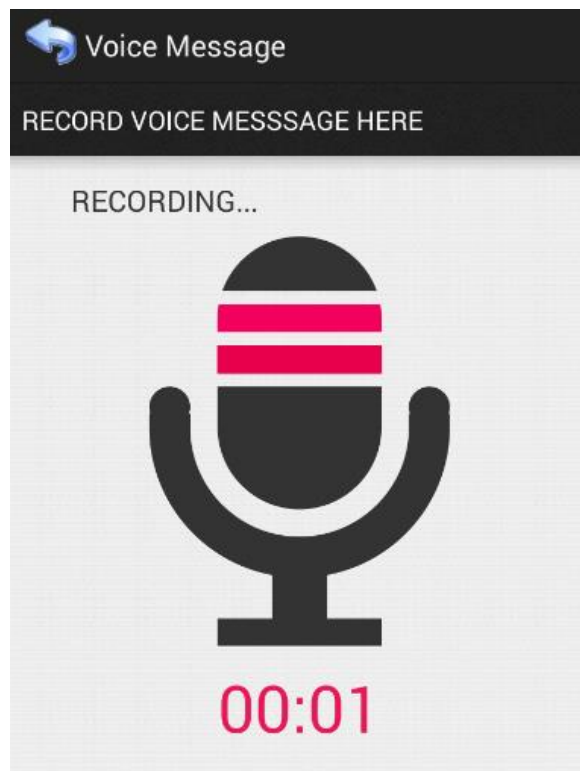


Figure 24: *Your IM* prototype in iteration 5 (Recording voice message screen while recording takes place)

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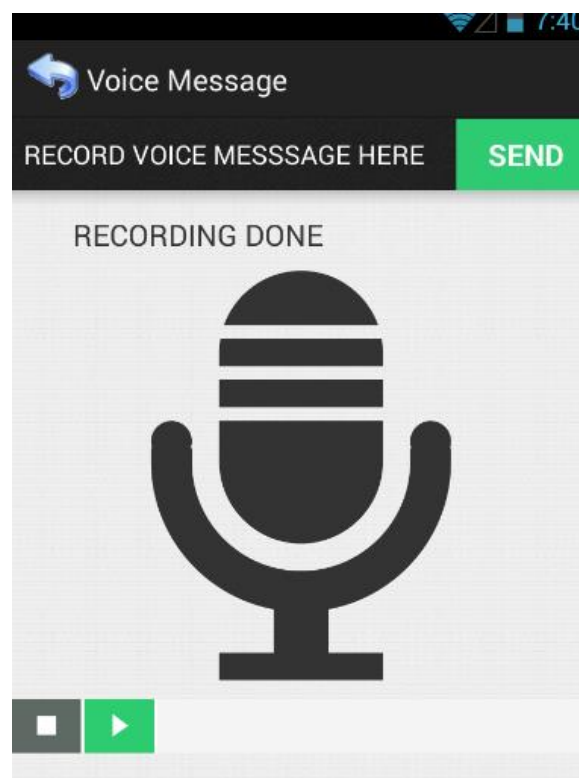


Figure 25: *Your IM* prototype in iteration 5 (Recording voice message screen when recording is done)

P3 was invited to test iteration 5 prototype. He had no issue finding the way to get to sending voice message screen and starting the recording. However, he had problem when he had to end the recording. *"I don't see where I can or what I should do to stop the recording. Is it possible to give more information or instruction to tell me how to do it?"*, P3 pointed out.

P3 liked the rest of the design for recording voice message as it was simple and easy to be used. P3 used WhatsApp before and he had two main problems recording voice message. First, the button was too small for him to press. Secondly, it was difficult for him to press and hold the button for long while recording the voice message (Figure 26). Now with the redesigned recording voice message screen in *Your IM*, user does not have to hold recording button while voice message is being recorded. Thus P3 felt that it was much easier to send voice messages.

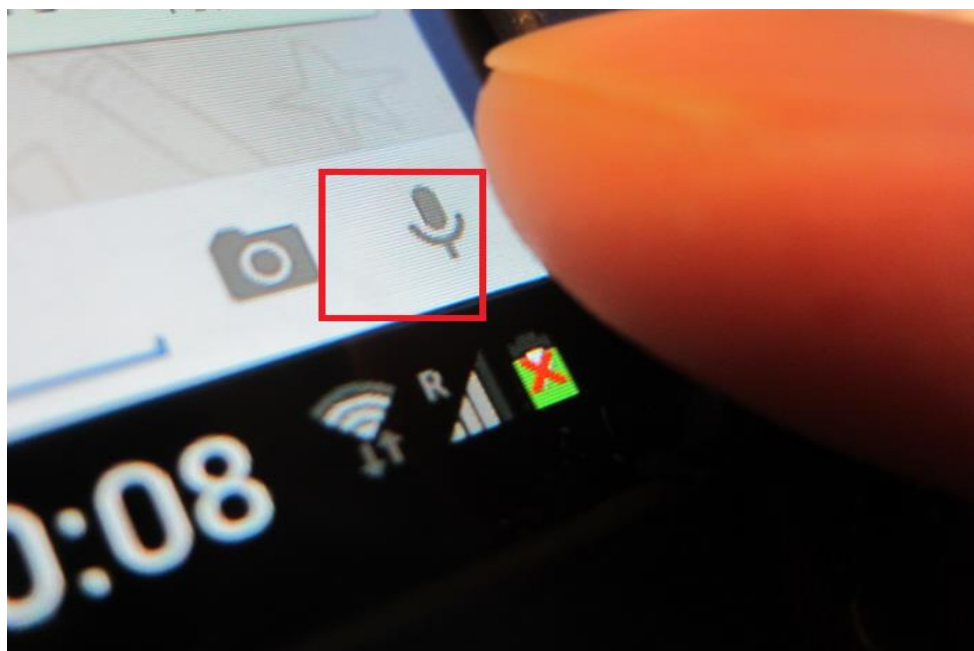


Figure 26: The audio recording button in WhatsApp

5.6. Iteration 6

In Iteration 6, the text “RECORDING...” in recording voice message screen was amended to “RECORDING... TAP AGAIN TO END RECORDING” (Figure 27). This change aims to guide the elderly users with clearer text instructions in stopping their voice message recording activity.

Iteration 6 completed the design for sending picture messages as well. After choosing the way to get the image for picture message (Figure 18), choosing “Take a new picture” brought the application to camera screen (Figure 28) while choosing “Choose from gallery” brought the application to user’s phone gallery (Figure 29).

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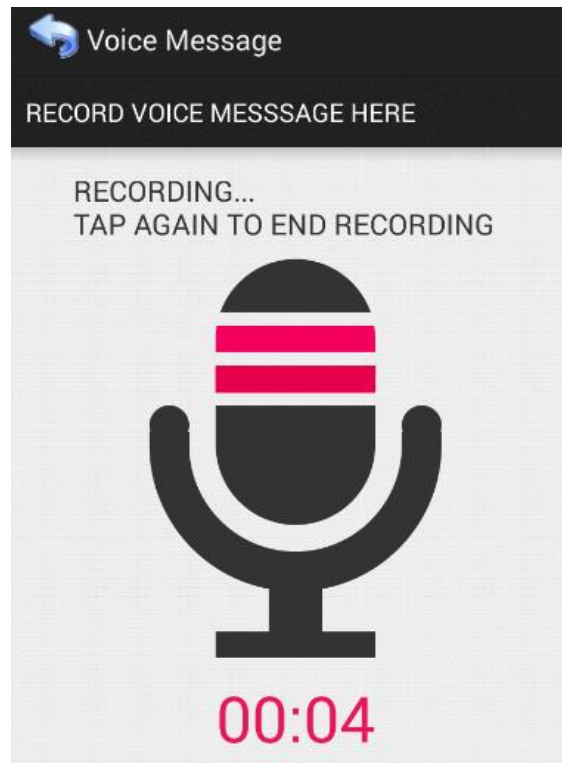


Figure 27: *Your IM* prototype in iteration 6 (Recording voice message screen when recording takes place)

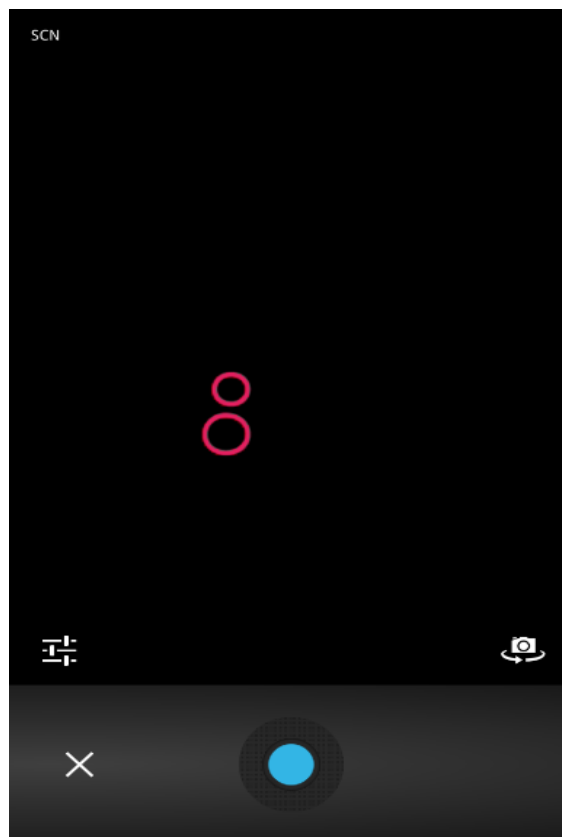


Figure 28: Camera screen while taking picture

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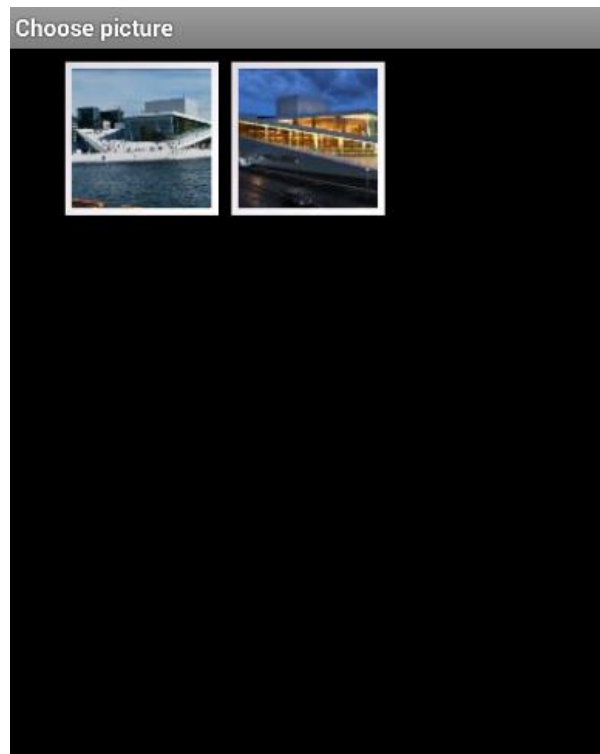


Figure 29: Gallery screen

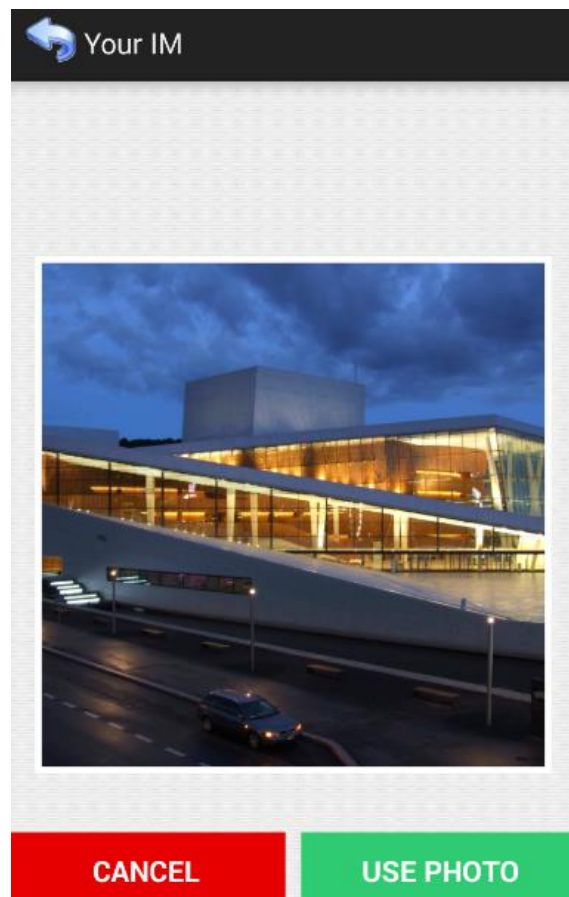


Figure 30: *Your IM* prototype in iteration 6 (Confirmation for use of picture as picture message)

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After taking a picture or choosing a picture from gallery, the screen went back to *Your IM* where user would be asked to confirm the use of picture selected or taken as picture message (Figure 30). “CANCEL” button was in red while “USE PHOTO” button was in green as inspired by the color indication for traffic light. This confirmation design was also inspired by Hinze-Hoare (2007)’s “forward recovery” HCI principles and “tolerance for error” in universal design principles as it is important to prevent users from sending wrong picture messages.

P1 was asked to evaluate prototype iteration 6. He tested all features, from installation to sending text message, picture message and voice message. He found it easy to perform all the tasks because the interfaces and instructions seemed clear to him. He commented that as a user who had no smart phone, he would give it a try if applications in smart phone could be as simple and intuitive as *Your IM*.

While he was asked opinion about sending multimedia message, he liked the part where sending voice message did not require long tapping on the screen. He had slight problem when it came to muscle control. So, the elimination of long tapping was very helpful to him. Regarding to sending picture messages via taking new picture and selecting from gallery, he had no problem understanding them and performing the tasks smoothly.

However he had a few suggestion. Referring to Figure 30, the suggestions were (1) changing the word “USE PHOTO” to “YES”, (2) indicating the use and send of photo with an instruction that appears on top of the image, and (3) changing the interface of sending audio so that it could have the same consistency in terms of design with sending picture screen. All three suggestions were considered good and very reasonable, and thus they were taken into iteration 7 to improve the interface design.

5.7. Iteration 7

Your IM in iteration 7 changed the confirmation screen of image selection for picture message. As shown in Figure 31, a question “DO YOU WANT TO SEND THIS PICTURE?” was placed on top of the preview of the image while two action buttons “YES” and “CANCEL” were placed below it.

Besides, combining the feedback from P1 in previous user testing and design principle such as consistency principle from Rosenholtz et al. (2009), recording voice message screen was changed to have a consistent layout as sending picture message screen. “SEND” button, which was originally placed on top (Figure 25) is now placed at the bottom of the screen (Figure 32). This was believed to provide better predictability (Hinze-Hoare, 2007) for elderly users as well.

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Furthermore, to make the interface less confusing and more reasonable, both “SEND” and “CANCEL” buttons would only appear after recording was done (Figure 32). This is considered a more sensible and reasonable design as the previous layout had “SEND” button appears even before any recording has been made (Figure 23).

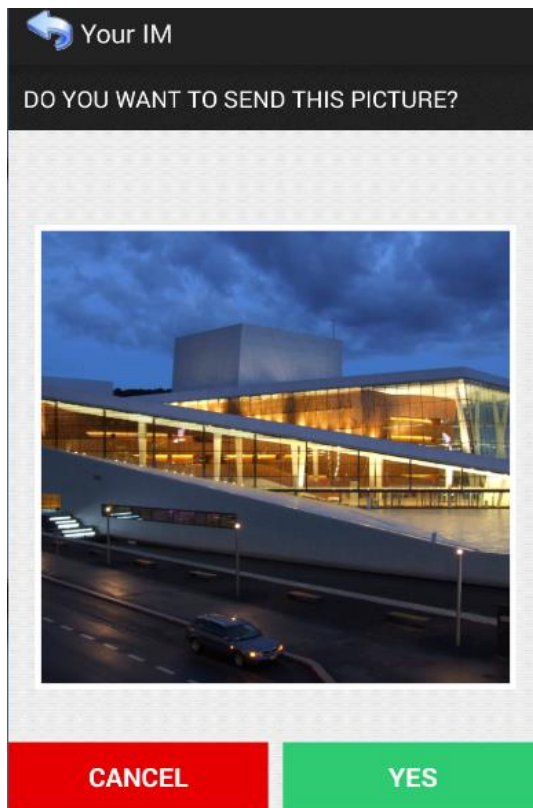


Figure 31: *Your IM* prototype in iteration 7 (Confirmation for the use of image as picture message)

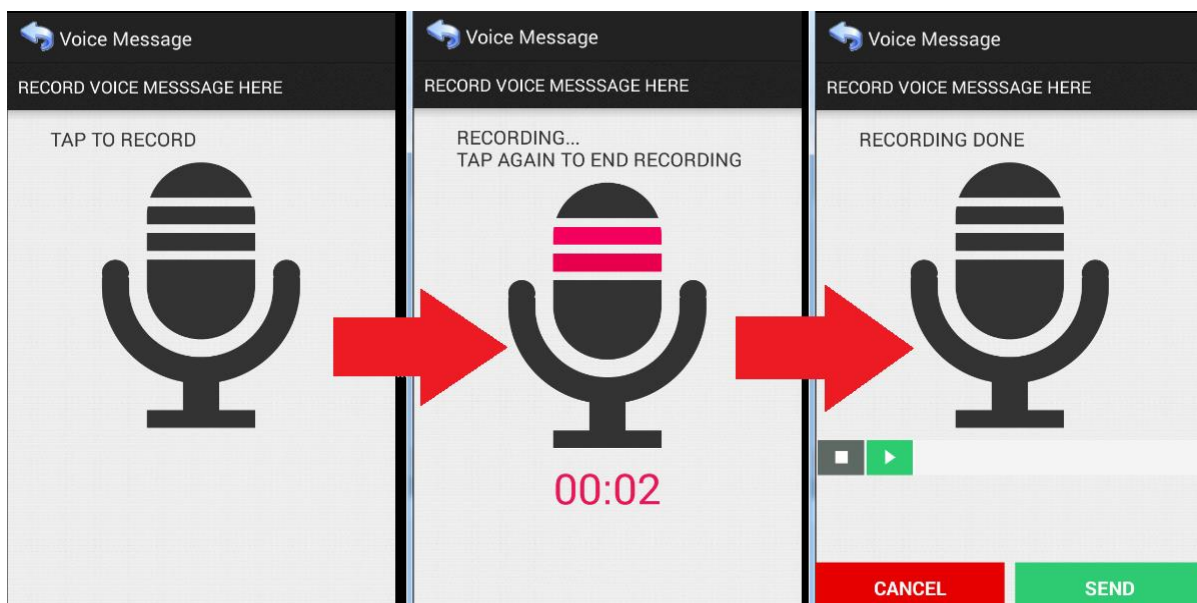


Figure 32: *Your IM* prototype in iteration 7 (Recording voice message application flow)

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For the user testing of this iteration, P6 was invited to participate. She was asked to test all functions, from installing and setting preferred font size to changing preferred font size settings, adding a contact to creating a group then invite others to join, and also sending all three forms of messages.

When she was asked about user profiling for preferred font size settings, she did not comment much as she did not face much problem performing the tasks. However, she voiced out her opinion about this feature and commented, *“I don’t know if this really help because I think my problem is the size of buttons, and the phone, or the screen, but not the size of word I see here.”*. After clarifying to her that the font size affects the button size, she said, *“Then I see the point here. That’s really important because I always think the button is too small for me to tap.”*.

She did not have any difficulty in performing the rest of the user testing tasks. The part where she liked the most was the user interfaces. As an inexperienced user in smart phone, she thought that it was much easier to understand *Your IM* than WhatsApp, which was tested by her previously in user requirement study. She commented that she could know how to use *Your IM* without much learning and effort required. *“Yes I remember it was more difficult to use the previous thing that you gave me. This is easier I think, for me,”* told by P6. Overall, she was very satisfied with this prototype.

5.8. Iteration 8

Last iteration implemented the speech modality for users’ input and output interactivity. This was to ensure TalkBack feature in Android could be supported to ease the users who are blind or have vision impairment. Android accessibility guidelines were referred while implementing this feature. *“I should always know where I am”* is Android’s key design principle when it comes to accessibility concerns (Android, n.d-a). Besides clearly informing users where they are while using *Your IM*, it is also crucial to make sure they know what they should do.

In addition to that, in order to make the screen clearer to be understood with only using speech modality, the speech describing the screen elements was designed to focus on explaining the functions of the screen elements, instead of what were the texts displayed on the elements. For instance, pressing *“SEND”* button on recording voice message screen (Figure 32) would prompt Android’s TalkBack to provide speech feedback that said, *“Yes, send this audio”* instead of just *“Send”*.

In order to implement this feature, user interface element’s *android:contentDescription* attribute was added to all elements that user would interact with. Below demonstrates one of the user elements, which is the *“SEND”* button explained in the above paragraph.

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```
<Button
```

```
android:id="@+id/btnSend"
```

```
...
```

```
android:contentDescription="@string/yes_audio_button"/>
```

(In strings.xml)

```
<string name="yes_audio_button">Yes, send this audio</string>
```

Same as previous iteration, one user testing was conducted to get feedback on the prototype for this iteration. However, none of the elderly from user requirement study has vision impairment. Thus P3 was invited to play the role as elderly user that entirely relied on touch and speech modality. P3 was blindfolded and a Samsung tablet was used to test *Your IM* instead of regular smart phone because P3 was not familiar with using TalkBack in Android (Figure 33). Thus, a bigger screen could assist him to perform user testing tasks in this role playing.



Figure 33: Role playing as visual impaired elderly by P3 in user testing

P3 had a hard time adapting to use TalkBack voice over in Android at the beginning. He found it difficult to understand what had been voiced over. Nonetheless, he got used to it after spending some time familiarizing it. All features were tested including sending picture message because it was assumed that users who have visual impairment can still send picture message even though they might not be interested in receiving one.

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There were some user interface elements in *Your IM* of iteration 8 that were not labelled properly with Android content description attributes. They were noted down and taken into next iteration to be improved. When it came to photo taking using camera task, it was found out that camera itself was not tagged precisely. As illustrated in Figure 34, cancel button on the left was voiced over as “button 43 unlabeled”, and yes/proceed button on the right was voiced over as “button 88 unlabeled”. These created confusion to P3 who was blindfolded. However, camera itself was only a build-in application to *Your IM*, thus there was no authority to overwrite the content description attributes of camera.

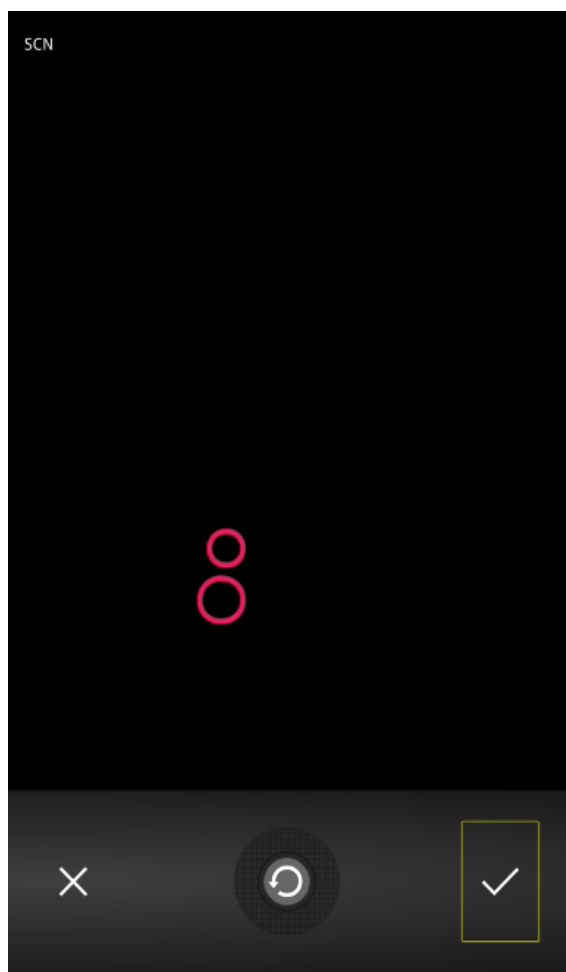


Figure 34: Camera screen after picture has been taken

All in all, although much time was required, P3 was still able to perform all the user testing tasks provided with some guidance. The biggest challenge for him was his frustration with using TalkBack because some voice over were too fast to be listened and they were also difficult to be captured due to its monotone way of voice over. Thus, he highlighted the need to have simple yet informative voice over in the informal interview conducted after the user testing. As mentioned by P3, *“If it speaks this fast and like machine all the time, it is better to have the words simple but clear with its instructions.”*. Some voice over such as *“Tap to send this voice message”* was suggested to change to *“Yes, send this audio”*.

6. Results (Final user testing)

After eight iterations of design, development and evaluation, the prototype *Your IM* was considered complete in achieving all its necessary user requirements. The research was then moved to final user testing phase.

6.1. User testing with elderly

The final user testing were conducted with all six initial participants from the user requirement study using revised and finalized prototype after iteration 8. They were first briefed about what they would be asked to do. User testing then started with performing MIM tasks using *Your IM*.

Observation was done throughout the process to obtain qualitative data while quantitative data, which was the time to complete certain tasks were recorded to see if *Your IM* was really more accessible, usable and easier to be used. Below summarized the observation of their performances, based on the MIM tasks performed by them. It was then followed by the quantitative data for their user testing performances which is presented in Table 4.

1. Install *Your IM* and set the preferred font size
 - ✓ None of them had problem to choose preferred font size during installation. Instruction and interface seemed clear to them.
2. Change font size
 - ✓ They were not told where they could change the font size. This was to test if they could find it out by themselves.
 - ✓ P2 and P4 took a bit more time to figure it out as they never involved themselves in the design, development and user testing process in any iteration. However, they still managed to find where to tap within five seconds, and they only took additional three seconds as compared to the elderly who completed this task the fastest. This was considered acceptable as they were totally new to *Your IM*.
 - ✓ The rest of them performed it without much hesitation.
3. Add a new contact
 - ✓ All of them knew where to find the icon to add a new contact and had no problem completing this task.
4. Find a contact
 - ✓ P4 moved her finger around the avatar of contact first, but then realizing there was no personalized avatar for all contacts (Figure 35).
 - ✓ Overall, all of them could find the contact easily, including P4.
5. Send a text message that says “hi”
 - ✓ All of them managed to send the text message.

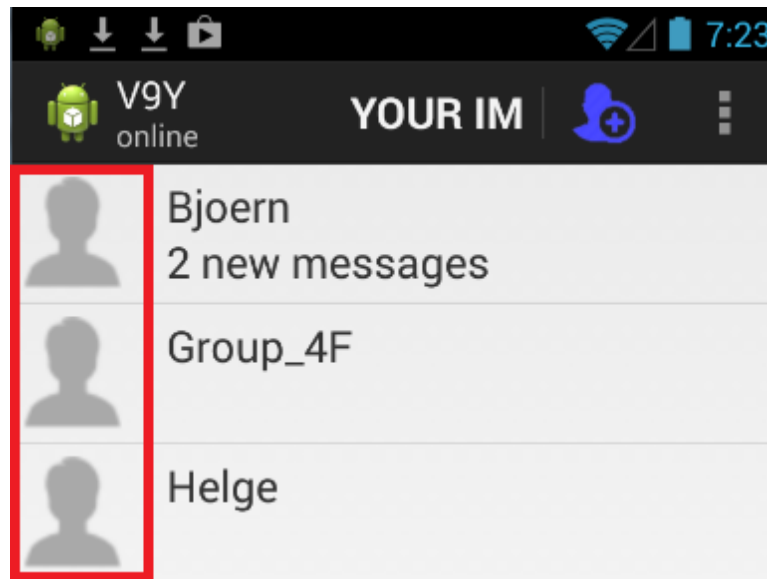


Figure 35: Contact list on *Your IM* with blank avatar and name

6. Read an incoming text message
 - ✓ Time was not recorded.
 - ✓ All of them managed to read the text message. It also seemed that the preferred font size had helped P3 and P5 to read better without reading glasses.
7. Share an image from gallery
 - ✓ Same as task number 2, P2 and P4 did take a bit more time to learn the interface as they encountered this for their first time.
 - ✓ All in all, all of them did not have much problem performing this task. They spent some time reading the instructions from the pop up dialog box (Figure 18 & Figure 22). However, it was still less time spent as compared to not knowing the icon and where to tap which resulted in having the need to try and error several times.
8. Send an image by taking picture
 - ✓ In this task, both P2 and P4 showed that they were already familiar with the interface. Thus they did not spend as much time as before.
 - ✓ No participants had problem completing this task.
9. Send a voice message that says “hi”
 - ✓ It was also new feature to both P2 and P4. However, they did not take much additional time to complete this task as compared to others.
 - ✓ All participants completed the task without any issue.
10. Create a new group chat and invite one friend to join
 - ✓ This was another new feature to both P2 and P4. Though P2 have encountered “choose type of contact” dialog box while performing task 3, he forgot the “create a group” option was just right below “add a person” (Figure 12). Thus, P2

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clicked on settings button on main screen first while being asked to perform task 10, as he thought it could be there.

- ✓ P4 on the other hand, same as other participants who seemed rather familiar with *Your IM*, did not encounter any issue completing this task.
- ✓ All of them did ask what to press while dialog box asked about the method to invite a friend to join (Figure 21). After being told to choose “messaging”, they completed the tasks.

# Time in minute (m) and second (s)	P1	P2	P3	P4	P5	P6
1. Install Your IM and set the preferred font size	6s	8s	5s	7s	4s	9s
2. Change font size	6s	8s	6s	8s	5s	13s
3. Add a new contact	8s	7s	7s	8s	10s	8s
4. Find a contact	1s	1s	2s	2s	1s	2s
5. Send a text message that says “Hi”	5s	6s	8s	8s	5s	8s
6. Share an image from gallery	19s	20s	16s	21s	19s	22s
7. Send an image by taking picture	18s	14s	15s	14s	14s	19s
8. Send a voice message that says “Hi”	18s	19s	14s	17s	13s	19s
9. Create a new group chat and invite one friend to join	1m	1m 17s	50s	1m 10s	46s	52s

Table 4: Time required to complete MIM user testing tasks using *Your IM*

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To summarize all tasks, all six participants did not have many issues using *Your IM*. For P2 and P4 who never involved in any user testing throughout design, development and design iterations, they did not spend much time and effort to learn to use *Your IM* as well. All of them completed the tasks without any guidance or assistance. The user testing were then continued with semi-structured interview. The list of questions is presented in Appendix F.

When they were asked about general opinion and experience of using *Your IM*, most of them said that the application was easy to use, in particularly compared with the MIM application that they had used previously during user requirement study. P6 had the most difficult time completing the MIM tasks using WhatsApp during user requirement study. After using *Your IM*, she commented, *"Before that I really don't like this kind of mobile phone thing. Or maybe I think that I don't know how to use them. But now I feel like it is not so difficult!"*.

Most of them mentioned that they liked the simplicity of *Your IM*. *Your IM* did not have too many features that they did not require. *"It is just like regular SMS with a bit more fun....If it has more features, maybe I won't use it because I don't like too many things. This is what I need to contact my friends, and this is just enough."*, mentioned by P1.

The simple user interface of *Your IM* helped the elderly users to explore the application with minimal time and effort. P3 commented, *"There is not so many icons for me to press. So I can just press all of them and try and error you know...I think this simple design is really nice."*

However, *Your IM's* simplicity was not valued the same way by P2 and P4. Since P2 is a manager, he suggested that this application could be extended to include what he needs for his works. For example, outlook email, reminder and LinkedIn. P4 who is an experienced user in social media, expressed that, *"It will be better if I can have my Facebook combined because I want to use Facebook but I don't want to chat in other messenger other than Facebook Messenger. I don't want to use too many apps so if it can combine then it will be great you know... or else why should I use it when I already have Facebook?"*

Selecting preferred font size was considered helpful to P1, P3, P5 and P6. P1 and P3 require reading glasses while they read. So with the biggest font size set in *Your IM*, they could read the text in *Your IM* without the use of reading glasses. P4 mentioned that there was already font setting in the phone itself. So she did not really see the significance of having preferred font size setting in *Your IM*. P2 had no opinion on that and he just said, *"Not helping much to me I think..."*.

In terms of the feature of user profiling, P4 recommended the setting of contacts' avatar by herself, which was same as suggested by P5 in user testing iteration 1. This feature

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of user profiling has not been implemented since there were more basic yet crucial features to be implemented. Contact' avatar or user profile picture is now considered a must-have feature in the future version of *Your IM*.

When asked about adding contact, most of them agreed that it was easy to be done. P2 and P4, who were both experienced user in MIM, thought otherwise. They preferred if *Your IM* could use contacts' phone numbers to add them automatically into their messenger list, instead of adding by a chat ID. On the other hand, P5 and P6 responded negatively with the idea of adding automatically via phone numbers. P6 said, *"I don't think I want everyone who has my phone number to use this thing (Your IM) with me. How if my hair dresser or cleaning maid also appear on the list...you know...I don't need to use it with them."*

When further asked about why P6 would mind to use MIM with her hairdresser or cleaning maid, she pointed out her concern with privacy. She felt like there is still significant difference in the usage for MIM and SMS. MIM seems more suitable to be used with closely related friends and families; while SMS is for more formal messaging usage with other not so close contacts. This finding is actually similar as found out by Church and Oliveira (2013) when they investigated the practice and behavior of users in choosing between WhatsApp and SMS.

Regarding to group chat feature, all of them agreed that it was better to have people inviting and they could choose if they wanted to join the group, instead of they added others or others added them without permission. They did not like the feeling like they were "forced" to be part of a group when they were not being asked first. *"Of course it depends on who is inviting... but I prefer if they can get my permission first, or yes let me decide,"* P5 mentioned.

When asked about features that were unnecessary, none of them stated any current feature in *Your IM*, except P4, who commented, *"Perhaps the installing part to decide the font size?"*. However, when further justified with her the reason, she answered, *"May be it is just for me, because I don't use any kind of glasses you know. My family is lucky with good eye sight. But yes may be like my uncle, I believe he might need that help!"*. This shows she actually still believed that font size setting could help someone who has that kind of need.

In term of size of buttons, all agreed that there was no problem with the current button size. Unlike previously in user requirement testing, P1 and P6 did not struggle anymore due to the size of buttons was too small for them. P1 said, *"Yea I agree. This button size is more suitable for me. I don't feel like I need to try so hard to press on the small icon like before."*

When discussed about sending media message, once again they pointed out that it was easy to send them, especially in voice message. In sending voice message, a few

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features were highlighted as improved design as compared to WhatsApp, Facebook Messenger and Viber, which they used previously in user requirement study. First, the recording has been made easier by tapping to indicate start and end of recording, instead of holding it while recording took place. Secondly, the application flow to get to recording voice message screen was also commented as more intuitive. They did not have to spend much effort and time to look for add media button (Figure 22). Then the pop up dialog box also provided clear options between choosing picture message or voice message.

The same simplicity concept was praised by the elderly participants when they were asked to send picture message. It also used pop up dialog box instead of icons, which provided clearer instructions to them (Figure 18). Besides, they liked the confirmation screen design for both picture and voice message, which used green and red color for yes/send and cancel (Figure 31 and 32), just like in traffic lights. P5 commented, *“I could instantly relate the colors indication to the traffic lights. So if I don’t read the text on the buttons, I guess I still understand what to do. This kind of simple design is what we need!”*

All in all they liked the prototype *Your IM* and four of them would definitely use it in the future. P2 and P4 would only use it if their friends and families were going to use it too. Lastly, all of them were asked to rate *Your IM* based on their satisfaction level after using it, in a scale of 1-10. Their ratings are presented in the table below.

	Rating
P1	8
P2	6.5
P3	8
P4	7
P5	9
P6	9
Average Rating	7.9

Table 5: Rating from participants based on satisfaction level after using *Your IM*

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Your IM received an average rating of 7.9 out of 10. In summary, it received positive feedbacks from the elderly participants. It is definitely a MIM application that they can use to keep in touch with others. Nevertheless, there are certainly room for improvement. It also received good suggestions from the elderly participants which could be considered in its future work, which are presented in Section 6.3.

In addition to that, a comparative study has been done to compare both the qualitative and quantitative results, in order to see if *Your IM* has resolved usability and accessibility problems faced by elderly in the context of improving their task performance in time and effort. The comparative study is discussed and presented in Section 7.1.

6.2. User testing for integration with Android's TalkBack

One final user testing with a blindfolded elderly user role-playing as visually impaired elderly was conducted as well. It is important to include another modality, such as speech recognition so that the application can support more diverse elderly with different abilities and needs (Jacko et al., 2004; Teixeira et al., 2012). Speech modality was chosen to integrate into *Your IM* as the alternative modality besides touch, since it was the second most preferred modality ranked by elderly in Teixeira et al. (2012)'s study. As the result, this user testing was conducted to ensure the MIM application could support Android's TalkBack.

A new volunteer aged 62 (namely P7) was invited to role play as an elderly with visual impairment to test *Your IM* using only touch and speech modalities. P7 has basic knowledge in using smart phone and mobile applications. He uses Android phone so he was familiar with the OS, but not with Android's TalkBack. The reason why a new elderly user was asked to be the participant is because elderly users from user requirement study have tested *Your IM*. Thus they had already initial idea about how the user interface was and how to use the prototype already.

This user testing used the same list of tasks as in Appendix E, expect task number 7, sharing image from gallery. It was assumed that visual impaired elderly would take pictures and send them to others, but not selecting existing pictures from gallery since they had visual impairment and not able to see the pictures from gallery clearly. Similar to user testing in iteration 8, P7 was firstly blindfolded. He was also explained the purpose of the user testing and what he would be asked to do. A Samsung tablet was given to him to perform the user testing as a device with bigger screen was assumed to be easier to use for a new user to TalkBack like him.

Time to complete the user testing tasks were recorded while observation was done throughout the process. Results from observation are presented below.

1. Install *Your IM* and set the preferred font size

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- ✓ P7 could not see the size of buttons for font preference. He was first told by TalkBack that it was an installation screen (Figure 14). Then he explored by touching what was on the screen. He found out that there was three buttons for font size selection, so he just selected the biggest size.
 - ✓ Overall, this task was completed without any problem.
2. Change font size
- ✓ At the main screen, he realized that there was no voice over indicating where to tap for changing font size. He seek guidance if it was “more options” button. After being told yes, he managed to continue to navigate to settings screen (Figure 16) and then font changing screen (Figure 15).
 - ✓ At the selecting font size radio button pop up screen, he did not understand what it mean by “checked” and “unchecked” by TalkBack. After being explained, P7 managed to complete the task.
 - ✓ All in all, this task was completed with guidance.
3. Add a new contact
- ✓ P7 had no problem performing this task. The only confusion was when TalkBack voiced over the example Chat ID in the input field (Figure 36). Given the explanation to him that it was just an example Chat ID, he continued the tasks and completed it.

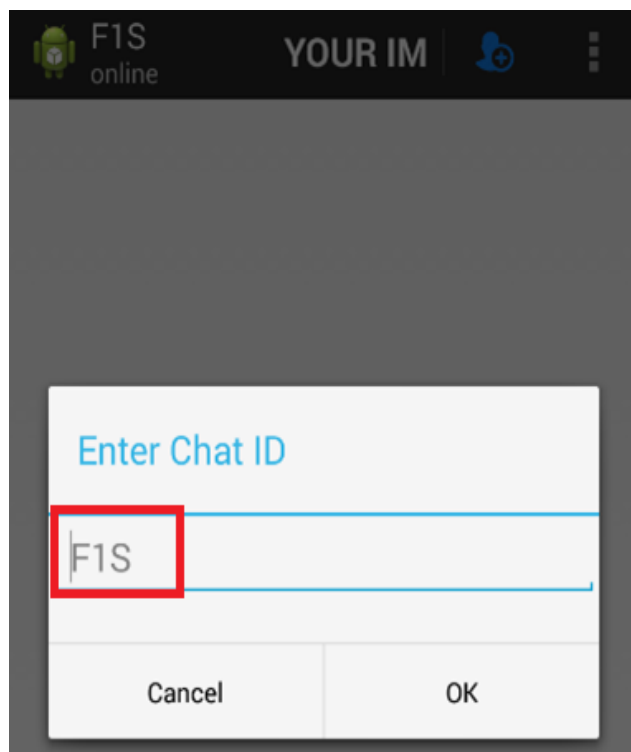


Figure 36: Example Chat ID in input field for adding new contact in *Your IM*

4. Find a contact

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- ✓ He managed to find the contact without problem as TalkBack voiced over the name of contacts in the contact list at main screen (Figure 37) when he tapped them.

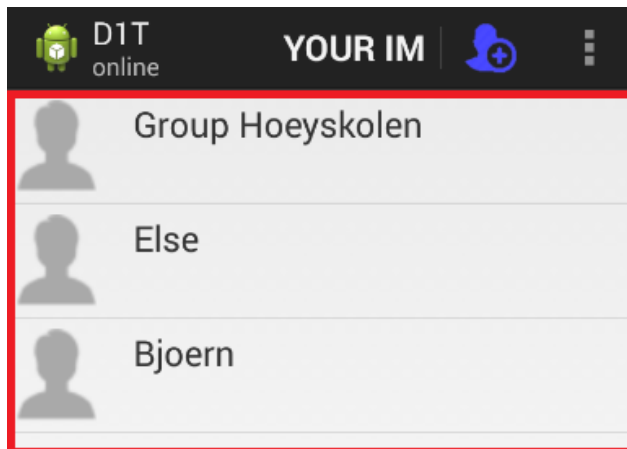


Figure 37: Contact list at main screen of *Your IM*

5. Send a text message that says "Hi"
 - ✓ P7 was guided clearly with voice over "edit box, enter your text here" when he tapped on the insert text bar (Figure 38). As the result, he also accomplished this task with no problem.

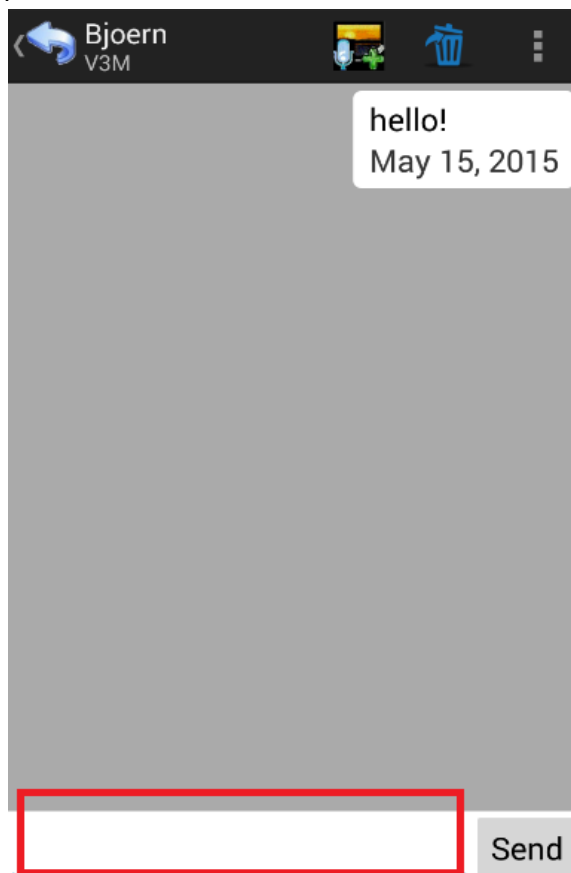


Figure 38: Insert text bar at chat screen of *Your IM*

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6. Read an incoming text message

- ✓ P7 firstly heard the sound notification of new incoming message. He tapped around the main screen around contact list. TalkBack voiced over the name of contact and indication of “two new message” (Figure 39). After tapping and navigating into the contact chat screen, he tapped around the message list (Figure 40).

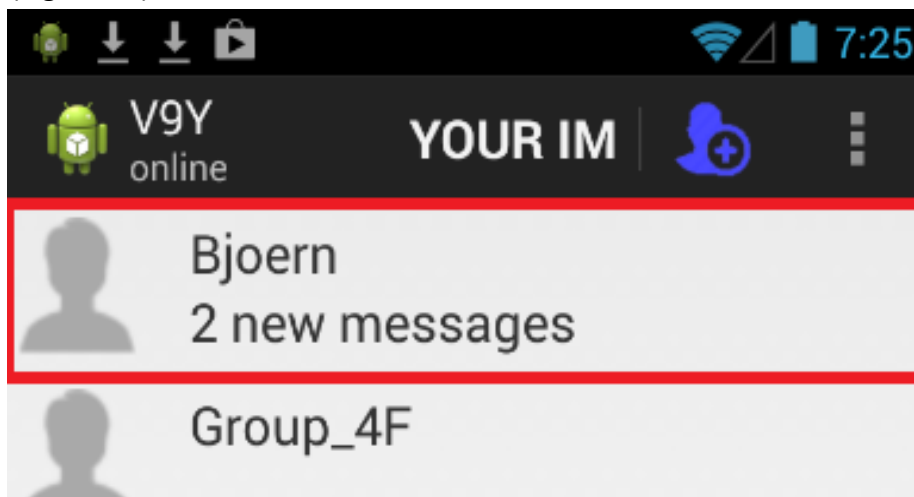


Figure 39: New message indication in *Your IM*

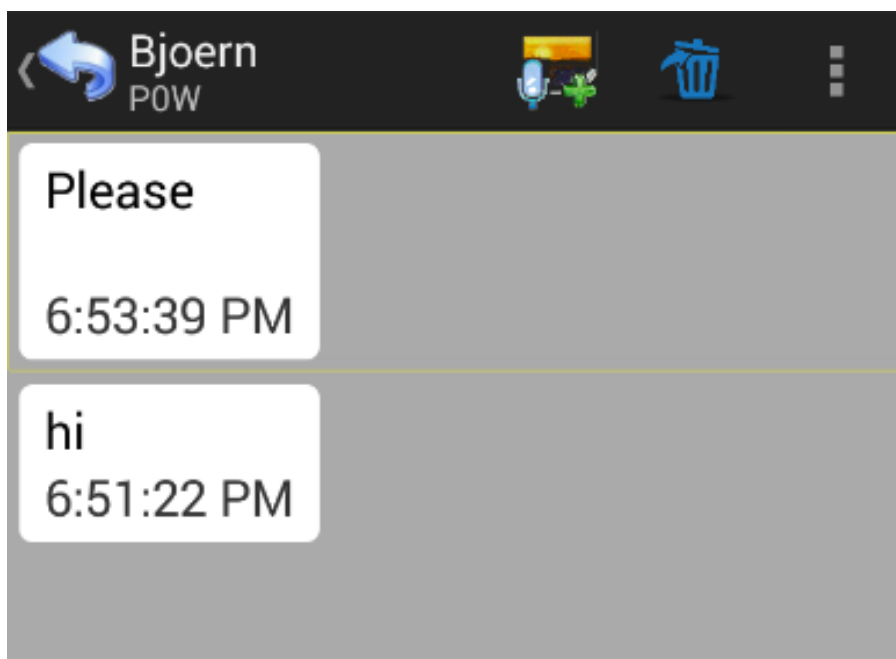


Figure 40: Message list in *Your IM*

- ✓ As he tapped on the text message, TalkBack voiced over the content of the text message and the time. Thus he knew that which message was the incoming message.
- ✓ As a whole, he completed this task successfully.

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7. Send an image by taking picture

- ✓ He did not encounter any issue until he reached the camera application. Same as P3 in user testing iteration 8, he had problem when the buttons were not being voiced over precisely. He turned panic then seek for guidance as he heard the word “unlabeled”. He then received the required guidance so that he could proceed in the task.
- ✓ He did not encounter any other issue after that. He commented, “Those buttons that say unlabeled are totally not usable to people that use this voice over...If I wasn’t guided by you, I think I would be stuck there!”.

8. Send a voice message that says “Hi”

- ✓ P7 encountered a big problem while performing this task. He managed to navigate himself to voice recording screen. He tapped on the recording screen (Figure 39a) and heard the voice over guidance said, “double tap to record, then double tap again to stop button”. He double tapped it to start the recording, and then double tapped again to finish his recording. Then he encountered the problem. He continued to tap around to find the way to send the voice message, but when he tapped on the same area (Figure 39b), the voice over still said “double tap to record, then double tap again to stop button”, even though the recording had been completed.
- ✓ As the result, he was confused if the recording was successful. He was then told to ignore that voice over since his recording had been succeed. He continued to search the way to send the voice message. He then found the send button at the bottom of the screen (Figure 32) and completed the task.

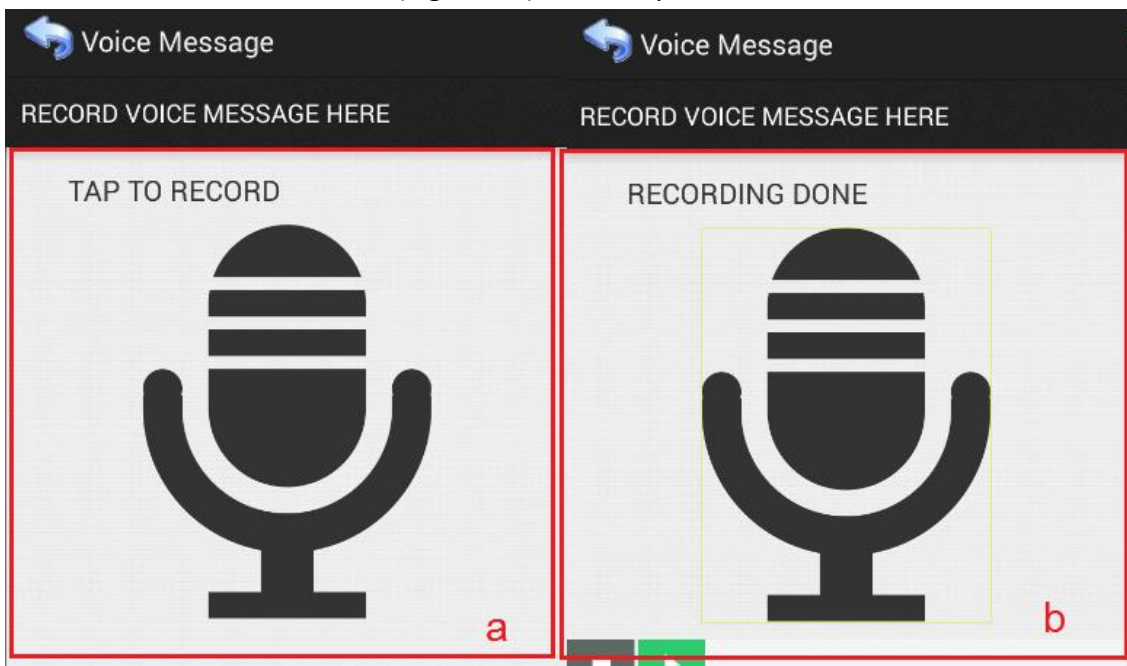


Figure 41: Voice message recording screen in *Your IM*

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9. Create a new group chat and invite one friend to join
 - ✓ P7 managed to complete this task as well. However, the only problem he had was when he clicked on inviting button and the voice over was saying “share your group”. He hesitated for a while and then asked to confirm if that was the same meaning as inviting a friend.

Table 6 summarizes the quantitative data from this user testing. There was no comparative study could be done as there was no such user testing with blindfolded user done previously.

# Time in minute (m) and second (s)	P7
1. Install <i>Your IM</i> and set the preferred font size	57s
2. Change font size	1m 55s
3. Add a new contact	2m 10s
4. Find a contact	10s
5. Send a text message that says “Hi”	2m 4s
6. Send an image by taking picture	3m 42s
7. Send a voice message that says “Hi”	5m 36s
8. Create a new group chat and invite one friend to join	2m 28s

Table 6: Time required by P7 to complete MIM user testing tasks using *Your IM*

P7 was interviewed after conducting the MIM user testing tasks based on the semi-structured interview questions in Appendix F. In summary, the main problem faced by P7 throughout the user testing was he did not manage to follow when TalkBack was voicing over. Similar to P3 in user testing iteration 8, it was considered too fast to P7. *“I don’t know what it is saying sometimes, so I have to press a few times,”* commented P7. When asked if it can be improved by changing the text to be shorter, he said, *“I don’t think it can help...I don’t know. Because I think the problem is the lady is speaking too fast...and may be something with her tone as well. She is speaking like a robot....flat tone...and fast!”*.

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Another problem that P7 faced in sending voice message task was when the user interface was referring to the same element, as the result the content description contained the same description. The user interface element did not change from before recording was started (Figure 39a) to after recording was done (Figure 39b), thus the voice over did not reflect accordingly as well, though the text on user interface element had been changed visually. This was considered an important issue to be fixed in the future as it can misled and confuse the elderly users.

When asked about his feeling using *Your IM* with TalkBack, he stated that it was voiced over clear in all screens and most user interface elements, except the recording and sending voice message screen. Other than that, all functions and instructions were told in easy words that he could understand. Furthermore, P7 pointed out that the amount and size of user interface elements on screen seemed just nice because he did not have to tap on too many things and hear too many of them when he tried to explore what was on the screen through TalkBack.

P7 rated *Your IM* 8 out of 10. He commented, *"It is quite easy to use actually, at least to me because I don't have any experience using this voice over on a tablet and I still can understand when I tap on it. If the lady can speak a little bit slower that would be perfect already!"* He mentioned that he could recommend this MIM application to his visual impaired friends to chat with friends and families, because it was simple and fulfilling what was needed to keep contact with others.

Lastly, P7 requested to try using *Your IM* again without being blindfolded as he was interested to know how it worked visually. This was done after the semi-structured interview was completed and rating was given, in order to ensure his feedback and rating were not affected by his experience of using *Your IM* without being blindfolded. After seeing and using it visually, P7 was even more confident that he would use it and recommend it to others in the future. All in all, *Your IM* received positive feedback from the blindfolded participant, which means it was really usable and accessible since normally a blindfolded person tends to perform worse than blind or visual impaired person.

6.3. Suggestion from elderly participants

As mentioned previously, *Your IM* received good and welcoming feedback from the elderly participants. They expressed their interest in using in and also provided some valuable recommendation to improve *Your IM* in the future.

1. **Deleting message feature.** P3 and P5 suggested that the deleting message feature could be implemented and it shall not require long pressing on the message or much effort to learn how to do it like in WhatsApp and Viber.

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Currently *Your IM* does not have deleting messages function, and deleting messages in WhatsApp and Viber have to be done by long pressing the message. In WhatsApp, the delete button only appear after long pressing on a particular message. Other messages can be then selected to be deleted together with the first selected message when the delete button appears (Figure 42). Viber requires the same long pressing, but it only allows deleting one message at a time if user presses on the message (Figure 43). In order to delete more messages at a time, user has to press on the blank screen instead, and not a single message (Figure 44).

As mentioned by P5, the main problem was the deleting messages function does not seem intuitive to him. He did not know that the delete message function in Viber would only appear after long pressing on messages, or the screen. *“It is difficult to understand something that doesn’t appear there...we cannot learn if we don’t see it. For us with not so much knowledge or experience, it has to come to us instead of us going to it (the function). Before we go to it, we already throw it out from the window you know...if it is that hard to be understood.”*, said P5.

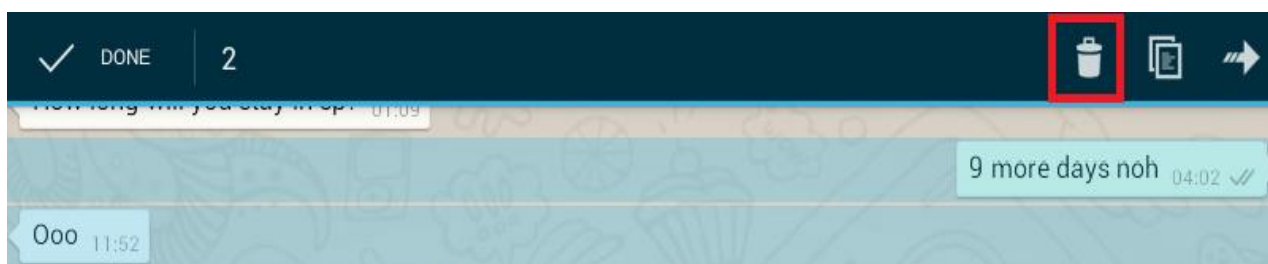


Figure 42: WhatsApp chatting screen after long pressing on message



Figure 43: Viber chatting screen after long pressing on message

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Figure 44: Viber chatting screen after long pressing on the screen

- User profile picture with the option of user editing their contacts' profile pictures.** P4 and P5 both mentioned that user profile picture is a must have feature in MIM application as it helps to identify the contact. *Your IM* currently does not have that feature. As mentioned previously in the finding of observation during final user testing with P4 (Section 6.1), P4 relied much on user profile picture in her Facebook Messenger (Figure 45) to identify her contacts. User profile picture could be helpful if there were clear pictures of the face of the contact.



Figure 45: Contact list on Facebook Messenger with profile picture and name

Not to forget in user testing iteration 1, P5 voiced out his concern with bad user profile pictures as many of his friends did not choose pictures that represented them. *"I got confused sometimes with their pictures. I have a friend uses a picture of his when he*

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was really really young. Then you also have people who use some scenery pictures that they took when they had vacations. How can I know who they are if they use these kind of pictures? ”, remarked by P5. Thus, in future Your IM should have user profile picture feature that allows user to choose and edit their own contacts’ profile pictures as well.

- 3. Integrating with other applications and having the option to exclude them.** Nowadays more elderly are more experienced and knowledgeable in using mobile applications, such as P2 and P4. P2 who is a working elderly, does require to use other applications regularly such as outlook, reminder, calendar and notes. *“I am still working and I need to check emails, set meetings every day. If I can do all these and combine with this messenger tool, I think it will be very useful then. For now I only see that I can chat with people... and I need more than that,”* expressed P2.

Since *Your IM*’s simplicity was also very much appreciated by other elderly, it is important to keep it as simple as the way it is now. Therefore, to include more elderly with diverse needs and abilities to use *Your IM*, it is highly recommended to have the flexibility to customize it, which means including what the elderly users want and they can choose to exclude what they do not want. P5 commented after hearing this suggestion, *“Yea this sounds really great. After I learn more, maybe I can use more things and they can be useful to me in future when I know how to use them. Now it is important that it is easy to use, and people like us see that it is something easy to start with! So next is just something more fancy maybe!”*.

7. Discussions

After the final user testing, it was crucial to analyze the test results to see if the objectives set from user requirement study were achieved. In order to do that, a comparative study was done where the quantitative and qualitative test results were compared.

7.1. Comparative study

The quantitative results from user requirement study and final user testing are made into Table 7 to make direct comparison. Only same tasks that have been conducted in both user testing are compared. Tasks such as installing are not compared as they only appear in final user testing as a new feature.

There are color indications in the column of final user testing results in Table 7. Green color means the performance has improved with less time required to complete the task, while red means more time was required as compared with before. Yellow indicates no difference in time between two user testing.

Most of the tasks showed improvement in time, except five tasks took the same amount of time and three required more time. P2 required five seconds more using *Your IM* to share an image from phone gallery, than using Facebook Messenger in user requirement study. P4 who also used Facebook Messenger in previous testing, spent additional 5 seconds performing this task. The possible reason for these extra time was that they were not familiar with *Your IM* at the beginning, as compared to Facebook Messenger since they used Facebook Messenger on daily basis. It explains why they did not spend extra time in the next task, which was to take a picture using camera and send as picture message, as they had learnt how it worked in *Your IM* in previous task and they already familiarized themselves with *Your IM*.

P4 also required extra 1 second finding a contact from the contact lists. Through the observation, it was noticed that she was not used to the contact list. When asked her opinion about it, she told that she was used to looking at both profile picture and name of the contact in Facebook Messenger (Figure 45). So she took a bit more time because she was not familiar with *Your IM* that had no contact's profile picture (Figure 35). P4 said, "*Profile picture kinda help me to identify who is who. I got two friends that have same names. So their profile pictures really help me to find them on the list easy and fast*".

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# Time in minute (m) and second (s)	P1		P2		P3		P4		P5		P6	
1. Find a contact	2s	1s	1s	1s	2s	2s	1s	2s	1s	1s	3s	2s
2. Send a text message that says "Hi"	1m 6s	5s	6s	6s	10s	8s	9s	8s	13s	5s	1m 23s	8s
3. Share an image from gallery	2m 34s	19s	15s	20s	20s	16s	16s	21s	19s	19s	2m 15s	22s
4. Send an image by taking picture	20s	18s	18s	14s	21s	15s	18s	14s	20s	14s	3m 21s	19s
5. Send a voice message that says "Hi"	2m 8s	18s	1m 15s	19s	1m 14s	14s	1m 5s	17s	2m 1s	13s	2m 7s	19s

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6. Create a new group chat and invite one friend to join	2m 8s	1m	1m 5s	1m 17s	2m	50s	1m 9s	1m 10s	2m 16s	46s	3m 2s	52s
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Table 7: Comparison of time required to complete MIM user testing tasks using *Your IM* and existing MIM applications

Task 6 was not labeled with any color because it cannot be compared apple to apple. It was the similar task in both user testing but the mechanism to perform it was different. In user requirement study, the elderly participants were asked to create a group chat with three contacts and this creating group chat task did not require permission from others to be added in the group. Unlike WhatsApp, Facebook Messenger and Viber which were tested in user requirement study, instead of adding directly the contacts into the group chat, *Your IM* had the user created the group chat first and then invited other contact to join.

For task 6, P1, P3, P5 and P6 improved because the interface seemed easier to them. During user requirement study, all of them had to spend time and effort to look for the button to create new group chat as they were confused between creating new group chat button with adding new contact button (Figure 10 for WhatsApp & Figure 13 for Facebook Messenger). With *Your IM* this issue was resolved as it grouped both similar features under one button (Figure 17). Dialog box then popped out for user to choose between two types of contact after tapping on that button (Figure 12).

In addition, issue such as privacy concern mentioned by a few of elderly in user requirement study has also been addressed accordingly. Creating new group chat function in *Your IM* only allowed user to create the group, then invite friends to join. The decision making power to join or not still relied on the users themselves as their permissions were sought first. Most of the elderly were satisfied with this mechanism after testing *Your IM*. P1 commented, “*This way is better now, because I don’t have to worry if someone adds me into a group that I don’t want to be in. I have to give permission to join by adding the group ID myself.*”

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The elderly participants spent less time in most tasks as they learn the application in very short time. From observation, all of them seemed to understand *Your IM* with very little effort. For P2 and P4 who were totally new to it, they did not seem panic or having any difficulty as the way of using *Your IM* appeared easy and logic to them.

The grouping of similar functions made the application flow and interfaces more intuitive to the elderly. Simple instructions were given instead of confusing icons, such as pop up dialog box for choosing type of picture message (Figure 18). *"Here I don't see that many icons, and when I click on them, more instructions are given so I can understand them easily."*, P5 referred to user interface elements on chat screen. Icons were also easy to be understood and the choice of bright color of icons gave good contrast to the dark background. As the result, they managed to find what they required without much effort and time.

Qualitative data was analyzed in three dimensions, which were (1) observation based on the individual user testing tasks, (2) analyzing them cross user testing tasks, and (3) text extracted from their answers during semi-structured focus group interview after the final user testing (Lazar et al., 2010). In terms of individual user testing tasks, there were three tasks that the elderly participants improved the most, and they were (1) sending picture message, (2) sending voice message, and (3) creating group chat.

To send picture message, they were no longer confused between camera and gallery because text in dialog box (Figure 18) had made the instructions clearer to them. The same applied for voice message because the icon, for instance in WhatsApp (Figure 26) was more confusing than text instruction in *Your IM* (Figure 22). Furthermore, there was no long tapping required when they recorded their voice message. Thus, they seemed to perform the task in a way which was more relaxed and less effort required. As illustrated in Figure 32, they could just tap easily to get the recording start and tap again to end it. Instructions seemed clear to them on the screen as well.

In terms of creating group chat, it was seen easier because the elderly participants had to only tap on adding new contact & creating group chat button, then "Create a group" in pop up dialog box (Figure 12) and the group would be created. When Facebook, they required to navigate to other tab first (Figure 13) in order to perform this task. Navigating to new tab is not difficult, but making the elderly users to understand the tab design is not easy. P5 commented the tab in both Facebook and Viber (Figure 46), *"I don't know the content can change when I tap on these tabs. As you can see, if it wasn't because you explained to me, I would still stuck at this..."*

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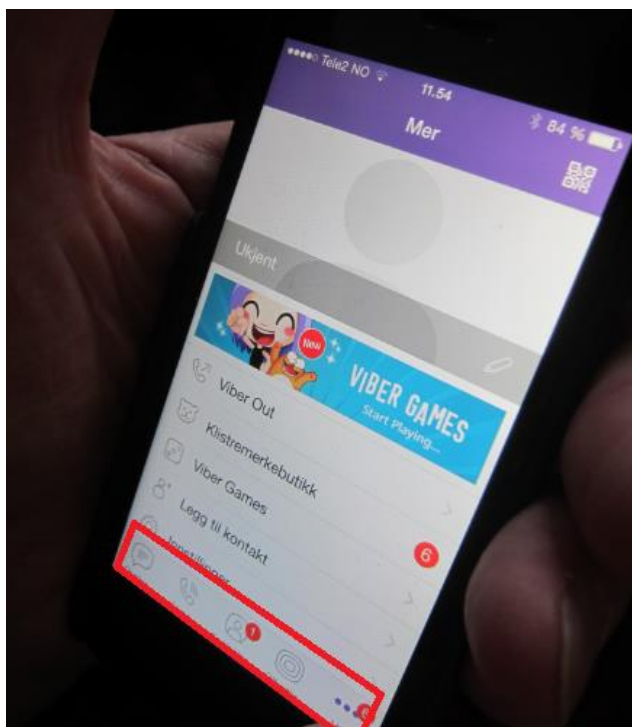


Figure 46: Accessibility option for Google Galaxy Nexus with Android 4.3 OS

Through observation, it was apparent the elderly had to tap and navigate more screens to perform certain MIM tasks. However, comparing to their performances in user requirement study both quantitatively and qualitatively, it seemed that more tapping and navigation did not necessary mean that they were slower. Despite of more tapping required, they ended up spending less time because they made less mistakes. For instance, P6 did not spend time searching for the recording audio button and she did not have to do the recording a few times like when she used WhatsApp in user requirement study. When she used WhatsApp, the recording audio button (Figure 26) was too small for her and she had problem pressing long on it. More time was then required when she slipped her finger and had to redo the recording.

It was also observed that most elderly participants were able to complete the user testing tasks without much guidance and help. They showed more and more confidence in using *Your IM* as they progressed from the first task to the final task. This could be interpreted as they were motivated to use *Your IM* since they managed to achieve what they were asked to do. Thus, it strongly shows the importance of not demotivating the elderly by making the mobile application easy, simple and inviting to them.

Text-based data helps to understand the elderly participants and their interactions between them and *Your IM*, by providing information that can hardly delivered through quantitative data (Lazar et al., 2010). By analyzing their text-based data from interviews, *Your IM* can be concluded as receiving positive feedback as an improved design MIM

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application in terms of accessibility and usability to the elderly participants. P2 and P4 used more of neutral words to describe their user experiences after using it. Both of them remarked that they saw the potential in *Your IM* and they would use it if it could improve in the future with more features and be extended to their friends and family.

Other four elderly participants addressed their high interest in using *Your IM* in their interviews. Most of the answers were often related to two positive phrases, and they were “simple” and “easy to be used”. They mentioned that they could learn and understand *Your IM* without much effort and time because it seemed intuitive to them. P3 commented, “*It is easy to understand this apps. When you have application like this that you just give it to us and we can learn by ourselves, no need to ask you or our grandson how to use it, that just means it is something natural like you know how to eat and sleep!*”. Overall, most of them really liked the design of *Your IM* and would recommend to other to try it out.

The only achieved user profiling feature was preferred font size setting. However it was valued very differently among the elderly participants. P4 commented that it was useless as there is already font setting in the phone itself. In order to validate her comment, another user testing was then carried out to see if font setting in the mobile device was sufficient to address elderly users’ accessibility problem. Google Galaxy Nexus with mobile OS Android version 4.3 was used in the user testing. It was detected having the option under “Accessibility” to select only “Large text” and no other font size (Figure 47). In order to have font size option, the user has to choose under “Display” (Figure 48).

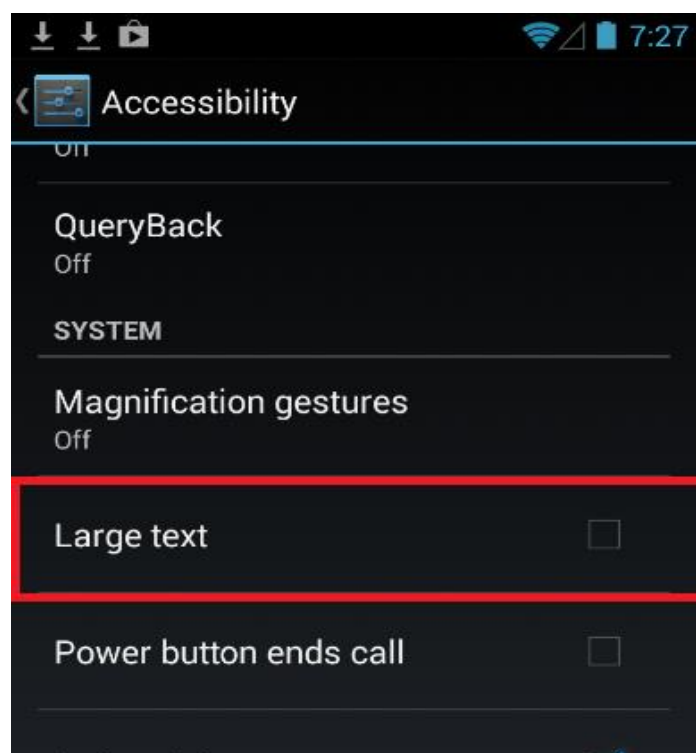


Figure 47: Accessibility option for Google Galaxy Nexus with Android 4.3 OS

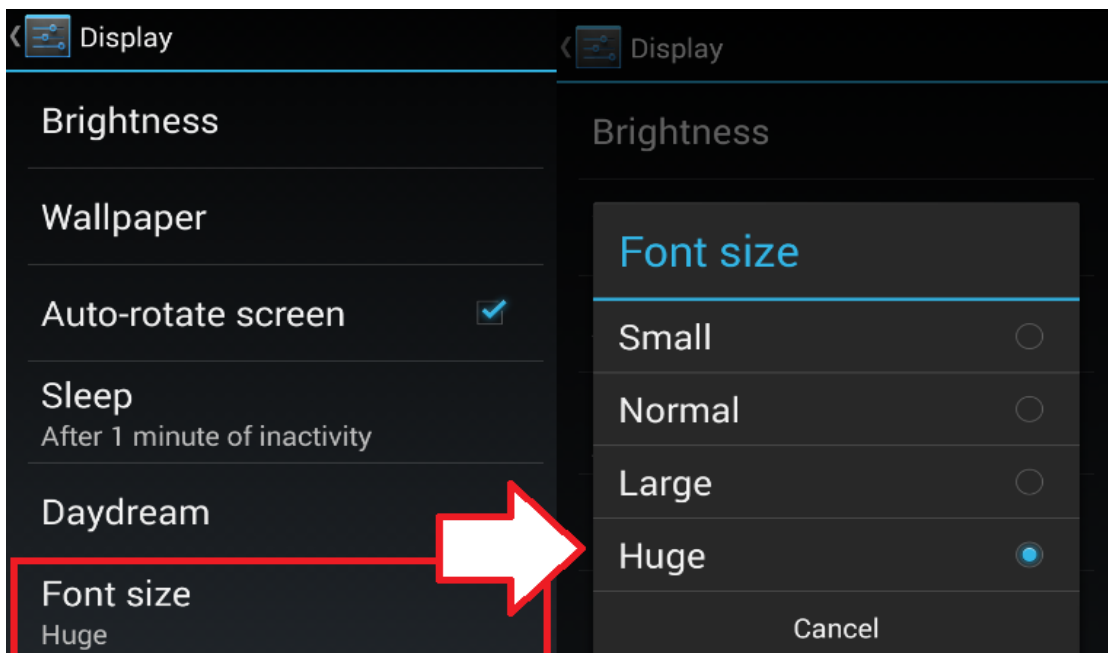


Figure 48: Display font size option for Google Galaxy Nexus with Android 4.3 OS

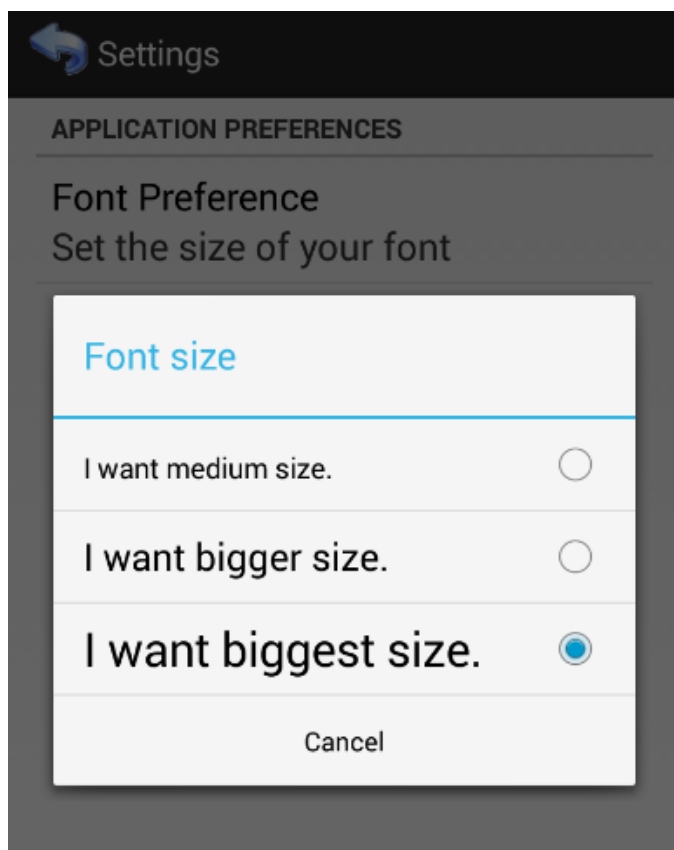


Figure 49: Your IM's font size settings

Your IM itself provides three font sizes, which are (1) medium, (2) bigger and (3) biggest (Figure 49). It was found out that Your IM's preferred font sizes varies based on the

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font size setting under display (Figure 45) in mobile device. For example, when device font size is chosen “Huge” and *Your IM*’s font size is chosen “The biggest size”, then the font size was larger than “Huge”. This is then seen as helpful still, because it provides more alternatives to the elderly users, if they only want larger text on messenger and not on the whole mobile device. A summary of display font size in *Your IM* resulted from the combination of device font size and *Your IM*’s font size settings is presented in Table 8.

Mobile device font size	<i>Your IM</i> ’s font size	Display font size in <i>Your IM</i> (using mobile device font size as standard)
Small	Medium	Smaller than small
Small	Bigger	Same size as small
Small	Biggest	Slightly bigger than small
Normal	Medium	Smaller than normal
Normal	Bigger	Same as normal
Normal	Biggest	Slightly bigger than normal
Large	Medium	Smaller than large
Large	Bigger	Same as large
Large	Biggest	Slightly bigger than large
Huge	Medium	Smaller than huge
Huge	Bigger	Same as huge
Huge	Biggest	Slightly bigger than huge

Table 8: Display font size in *Your IM* resulted from the combination of mobile device font size and *Your IM*’s font size

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When asked about issues that they faced while using *Your IM*, P1 and P6 mentioned that their problem did not seem to be font size anymore. *Your IM's* font preference upon installation and font size setting in device seemed able to help them to resolve the small font size problem. Now their problems are about the size of mobile devices instead. P1 commented, *"May be that's the reason I have iPad but not smart phones. I think it is difficult to use such a small screen."*

When asked about their privacy concern regarding to using *Your IM*, all of them did not raise much concern as previously in user requirement study. They felt like *Your IM* seemed safe and had not disclosed much information about them when they chatted. More specifically, they liked that they could not be seen when was their last time online and if they had read the messages like WhatsApp (Figure 3), Viber (Figure 2) and Facebook Messenger (Figure 50 & Figure 51). P3 stated that if it was just for chatting, he did not want to feel the pressure as if he was being watched by someone. Indicators such as "seen" or "read" that were commented by Church and Oliveira (2013) as intrusive have been removed as well.

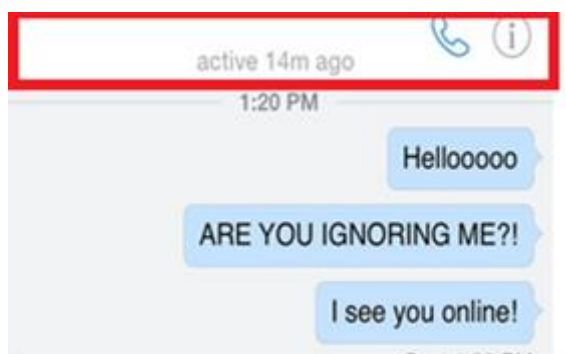


Figure 50: Last time online indicator in Facebook Messenger

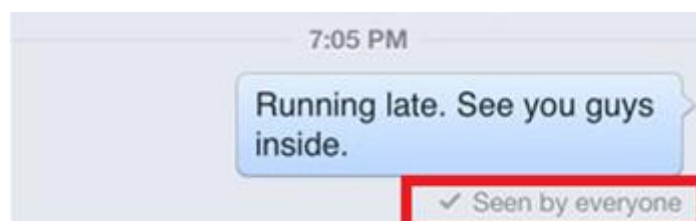


Figure 51: Message read indicator in Facebook Messenger

In addition, P3 made a remark about other unknown people managed to contact him through Facebook Messenger and he did not like it. *"I think it is scary when I have some friends, or someone I don't even know sending me message on Facebook. So I like when this application only can chat if someone knows my ID. If someone can just send me message by searching my name up, I think it has no privacy at all"*, expressed P3.

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When discussed about this issue with other participants, P2 and P4 did not mind if others send them messages by searching them up, while the rest did not have much opinion as they did not have Facebook or did not use it very often. P2 and P4 know that Facebook has already filtered the incoming messages by putting messages from unknown or non-friend contacts in “Other” folder (Figure 52) and they only checked the “Other” folder once in a while.

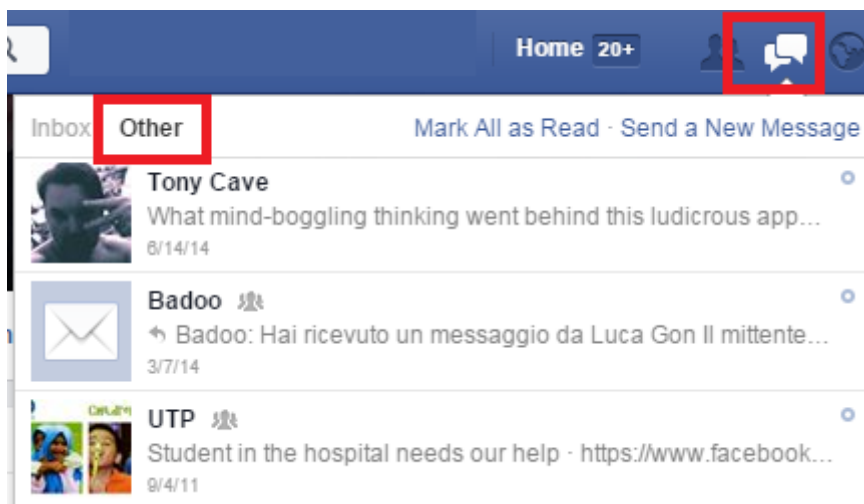


Figure 52: Other folder in Facebook Messenger

Another positive feedback about *Your IM* was its integration with TalkBack speech recognition in the Android mobile phone. The preliminary study for this research has shown that most of the current MIM applications were not compatible with speech recognition feature in the mobile OS, which were VoiceOver in iOS and TalkBack in Android. Elderly users can benefit from using multimodal inputs and outputs for MIM, as recommended by Teixeira et al. (2012).

They have studied IM on desktops and found that touch modality for interaction was most preferred by elder people followed by speech modality. They are exactly what *Your IM* is offering, both touch and speech modalities. Due to aging, vision impairments such as glaucoma, or motor impairments such as arthritis can occur to the elderly. Therefore, a good MIM application should be integrated with multimodal inputs and outputs in order to increase its usability and accessibility to the elderly user group.

All in all, these improvements indicate that all design principles that were adopted resulting in addressing accessibility and usability issues for elderly while using MIM. *Your IM* appeared to be simpler yet usable than Facebook Messenger, WhatsApp and Viber to some of the elderly participants in this study. It has less functionality that elderly participants do not require. In addition, its application flow and interfaces are more organized and intuitive as well. Grouping theory helps to organize the functions while clearer instructions are given

through easily understandable metaphorical icons or short texts. Elderly participants spent little time learning it and did not seem as confused as before when they used other MIM application during user requirement study. Lastly, it was also compatible with Android's TalkBack which means there is alternate modality to support more diverse groups of elderly.

7.2. Limitation of the project

One limitation of this research is the small number participants. In the initial focus group interview and user testing, there were only six participants. In each iteration it was only one user being invited to test the prototype due to the availability of the users. More elderly users with diverse abilities involving in the testing of prototypes could give more diverse feedback in terms of usability and accessibility. In addition, because of the individual differences in preferences, abilities and experiences, it was necessary to generalize the results and feedback while designing and implementing the prototypes. Nevertheless, the amount of six participants in final user testing can still be considered sufficient, as Virzi (1992) suggested that five users will already manage to find approximately 80% of usability problems. Thus, the findings with this small number of participants are still worth being attended.

Another limitation of this study is the mobile OS. It was only focused on Android OS in this research. It is acknowledged that the test results are difficult to remain timeless since the existing MIM applications on the market are updated with newer version and improved design constantly. However, some of the usability and accessibility issues that were identified remain unaddressed, such as small font size, confusing icons and interfaces for back button, creating new group and sending multimedia messages.

Using interviews to get participants' feedback has the downfall of participants providing answers that favor the interviewer (Lazar et al., 2010). Thus, informal interviews were also conducted while the user testing MIM tasks were carried out, under the circumstances that the elderly participants were not distracted and resulted in affecting the accuracy of quantitative data. As suggested by Crabtree and Miller (1999), "*look at behavior, listen to perception*", combination of interview and observation was used to gather more reliable data.

Besides, elderly participants might have also provided inconsistent responses. Therefore, in order to minimize this shortcoming, questions that were slightly redundant were included (Lazar et al., 2010), especially the semi-structured interview questions that aimed to gather feedbacks from the elderly participants about the prototype (Appendix F).

While analyzing quantitative data, data cleaning up was the first thing to do after data collections, in order to screen possible errors (Lazar et al., 2010). Though the results seemed quantitatively positive, there is a big limitation for the quantitative data of this

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comparative study, which is its accuracy. It was affected by a few factors. Firstly, in user requirement study some elderly were not very familiar using smartphones or mobile application. Thus, this resulted in more time required to complete the user testing tasks. When they became more familiar through user testing in iterations of development and design, they certainly used less time to complete the user testing tasks in the final user testing. It was not entirely because *Your IM* was easier to be used, but because they had also familiarized themselves with mobile application and smart phones.

On the other hand, for P2 and P4 who were both experienced user in mobile application and smart phones, they were using iPhone and Facebook Messenger for user testing during user requirement study. iPhone and Facebook Messenger were used by them on daily basis, which means they were very familiar with them. In final user testing, they had to use Android phone instead of iPhone as *Your IM* was only supported in Android mobile OS. As the result, the quantitative data was not as accurate as it could be due to the differences in experience and knowledge in using different mobile OS.

In addition, the elderly also gained more experience performing the task if they were asked to redo the task due to error which was not application related. For example, typing error while sending text message. P1 and P6 were both having problem using soft keyboard at the beginning, as P1 did not even own a phone and P6 was using old phone with rubber phone keyboard. To make direct comparison for time required to complete text message sending task, typo error was not counted so they were asked to redo the task. As the result, user experience once again affected the accuracy of the quantitative data for the comparative study.

Lastly, the speed of elderly users typing, speaking, taking picture and selecting image were also external factors that affected the results' accuracy. They were told to send random picture and they might ended up spending extra time choosing image from gallery, or choosing what to be captured while using camera. Thus, in order to eliminate these external factors and get more accurate data for the comparative study, they were told to select first picture in the phone gallery, take picture of a particular item, and accomplish the tasks as fast as they could without error.

7.3. Summary of design principles

From user requirement study and user testing in every iterations a set of design guidelines were collected and referred throughout the development process. These guidelines were also inspired by related literature and other design principles such as the principles of universal design from Connell et al. (1997), HCI design principles from Hinze-Hoare (2007) and Nielsen (1994)'s usability principles. They are presented in Table 9 and discussed below.

- [1] Eliminating unnecessary functions (Connell et al., 1997; Nielsen, 1994).
 - [2] Interface should be simple, organized and informative (Connell et al., 1997; Nielsen, 1994; Rosenholtz et al., 2009).
 - [3] The application flow and icons should be intuitive (Connell et al., 1997; Nielsen, 1994; Prior et al., 2008).
 - [4] Allow elderly users to choose their preferred settings (Connell et al., 1997; Nielsen, 1994).
 - [5] Minimal physical effort for elderly (Connell et al., 1997; Farage, Miller, Ajayi, & Hutchins, 2012; Rossit & Harvey, 2008; Taveira & Choi, 2009).
 - [6] Guide elderly by providing simple instruction (Connell et al., 1997; Farage et al., 2012; Nielsen, 1994).
 - [7] Pay attention on choice of color and color contrast (Farage et al., 2012).
 - [8] Provide other alternate modality to support elderly with different needs (Android, n.d-a; Jacko et al., 2004; Teixeira et al., 2012)
 - [9] Error prevention for elderly (Hinze-Hoare, 2007)
 - [10] Keep elderly motivated (Jones & Bayen, 1998; Kurniawan et al., 2006; Nielsen, 2013; Prior et al., 2008).
-

Table 9: Set of design guidelines

1. During the user requirement study, most elderly users mentioned that unnecessary features create confusion while using mobile applications. They could be discouraged from using the applications because of the unnecessary features. The same happens to their friends of similar age. Therefore, the design was made eliminating a few of the features in current MIM application, such as sharing location and contact's phone number. *Your IM* keeps three main features of IM application, which are (1) sending text message, (2) sending audio message and (3) sending picture message. There is no other types of message, such as emoticon and video message as they were not identified as important in literature study and user requirement study.
2. Elderly users have limited knowledge and understanding in mobile phones with touch screens and most of them are not familiar with mobile application (Farage et al., 2012). When the interface seems complex, they have difficulties in interacting and performing tasks in these applications. It is also easier for them to make mistakes with complex interfaces. Better organized interfaces and avoiding irrelevant features and icons can make the interface appear simpler. Current MIM applications have too many icons in one screen which makes them difficult to learn and use. Therefore the design for *Your IM* applied grouping design principles (Rosenholtz et al., 2009) to make the interface more organized.
3. To make elderly users understand the application with minimal efforts, the application flow and icons should be intuitive. Intuitive application flow and icons can make mobile applications easier to use for elderly users since they may have reduced cognitive

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abilities in terms of learning, remembering and staying focused (Farage et al., 2012; Nielsen, 2013). When the back button was redesigned, a larger back icon (Figure 16) was used to replace the application icon so that it is more intuitive and easier to recognize it for the elderly.

4. To make the MIM application flexible in use, the concept of user profiling was incorporated into the design (Connell et al., 1997). This allows users to choose their preferred settings so that the application can be adapted to their needs. Besides font size, there are other features in preferences that would be developed in up-coming iterations. For instance, color of the application and notification sound for incoming messages. P5 from user requirement study suggested the feature to edit contact's profile picture so that he can choose profile pictures for his contacts himself. Profile pictures are considered to be helpful for some elderly users in identifying their contacts. However, many do not choose profile pictures that represent them, or pictures that they choose are not clear enough to illustrate themselves. In the future version of *Your IM*, it is planned to allow users to choose pictures for their contacts so that they can easily recognize their contacts.
5. Elderly users normally do not have good motor control over their fingers (Farage et al., 2012; Rossit & Harvey, 2008; Taveira & Choi, 2009). Therefore when designing touch screen applications for elderly users, it is recommended to avoid gestures that require extra effort in motor control such as long tapping and swiping. When *Your IM* was designed, it was focused more on single tapping. In addition, the design guidelines from Android was referred while designing icons for buttons, where suggested size is at least 48 dp (approximately 9mm) in length and width (Android, n.d-b).
6. Simple instruction should be provided to elderly while they interact with the mobile application (Farage et al., 2012). These can ensure that elderly users have good experience using the application. In *Your IM*, texts were used instead of icons in some features to provide clearer guidance of the features. For example, choosing picture from gallery and taking picture using camera can be confusing when they are represented using icons instead of texts. Simple instruction in text can be more helpful to elderly when it is difficult to use icon to represent a feature, especially when icons can be interpreted differently due to trend and culture (Farage et al., 2012).
7. Color perception declines with age (Johnson, Adams, Twelker, & Quigg, 1988). Thus, elderly users need better color contrast. In addition, Wijk, Berg, Sivik, and Steen (1999) found out that elderly have better color discrimination towards warm colors than cold colors (Wijk et al., 1999). Therefore, in *Your IM*, cold colors such as green and purple were avoided during design. Low color contrast such as darker color for icons was avoided as well, since touch screen background is already in black.
8. Modality was proven important in a few studies such as in Jacko et al. (2004) and Teixeira et al. (2012). Jacko et al. (2004) concluded their studies that computer-related task of elderly with varying levels of computer experience was improved with the use of some form of multimodal feedback. Teixeira et al. (2012) highlighted the importance of

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having multimodal especially speech modality and universal design in fighting e-exclusion for the elderly. In *Your IM*, this was seen as one of the important features though there were no visually impaired elderly among the participants. Integration with Android's TalkBack was implemented to ensure it can be used by elderly with diverse needs and disabilities.

9. Elderly might get frustration easily when they encounter error or do mistake, especially those that cannot be recovered. Thus, it is vital to include error prevention mechanism while designing application for them, as suggested by Hinze-Hoare (2007). In *Your IM*, this was achieved by having confirmation before sending picture message (Figure 31). Besides, the sufficient sizes of button and font are also expected to help preventing elderly from making mistakes.
10. All of the above guidelines aim to achieve good user experience and enjoyable learning process for elderly in order to keep them motivated to use the application. Motivation is essential for elderly people to use new technologies. When some elderly become motivated to use a communication application such as MIM, they would encourage their friends to use it as well. In doing so they establish a group who can communicate and socialize through using the application. They can also help each other when difficulties or problems occur.

8. Conclusion and future work

In this thesis, the research in design and developing a usable and accessible MIM application for the elderly has been presented. In terms of the methodology used, the combination of user-centered design with participatory action research methodology was found appropriate for the process. The requirements were gathered through focus group interview and user testing. The involvement of users in each iteration during user testing has provided genuine feedback to improve the prototype, thus led to a more usable and accessible MIM application for elderly users. The participants have also shown positive attitudes towards using *Your IM* in the future as they found it more accessible.

Reflecting from the whole process using user-centered design and participatory action research principles, it was found out that users' knowledge in using mobile application, regardless where they started off, has grown and they gradually showed positive attitudes towards learning and using mobile applications. They gave positive feedbacks and provided requirements for *Your IM*, in a way that they felt like this prototype was specifically designed for them. Thus they showed more willingness in learning and using it. It was essential to recognize that this was a good learning process for them and more importantly, *Your IM* did not seem to demotivate them from using MIM though they had bad experience with other current existing MIM applications.

In terms of achieving the aims of the research, *Your IM* has addressed identified usability and accessibility issue faced by elderly during user requirement study using other MIM applications. As agreed by all six participants, it was simple and easy to be learnt. Some of them commented that if they could learn and use it, their friends would do the same as well. After the final user testing, when asked if they would use *Your IM* in the future, P5 said, "*Of course I will use it, as long as it is free! It is not so much different from regular SMS and SMS costs me money. This I can do as long as I have internet!*". All in all, *Your IM* has achieved its main goal which is a more usable and accessible MIM for elderly users.

Most of the elderly participants showed incredible improvement since *Your IM* has eliminated unnecessary functions and come with simpler and more intuitive design. Participant P7 who role-played as a visual impaired elderly user also commented that *Your IM* was easy to use with Android's TalkBack, thus showing that *Your IM* has included elderly users who might need the integration of speech modality. However, there are some essential features suggested by the elderly participants that should be included and implemented in *Your IM* for its further development. They are (1) having user profile picture in contact list, (2) deleting message and (3) having the option to customize *Your IM* by enabling the integration of other applications. User profile pictures help elderly to identify their contacts in the contact list. However since other users might choose bad pictures to represent themselves, for instance pictures which are not current or group pictures where

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the user was in the crowd, it is sensible to have the feature where users can edit the pictures of their contacts themselves (Figure 53c) when they have the need to do so.

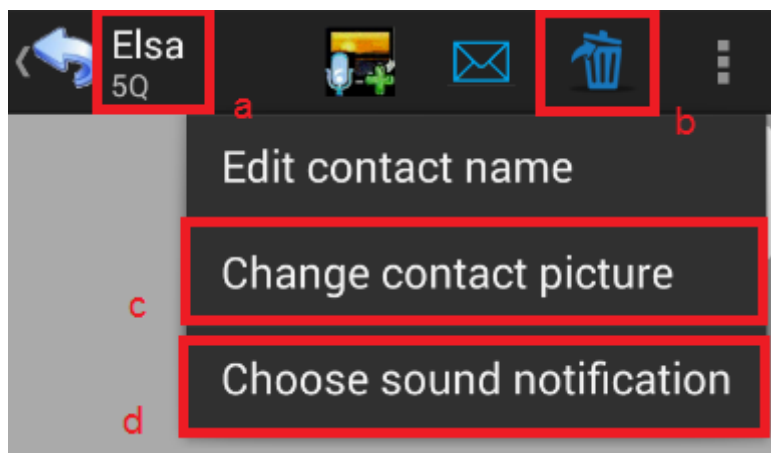


Figure 53: (a) User name, (b) delete message button and (c) change contact's user profile picture button in *Your IM*

Deleting message feature should also be designed and developed in a way that it can work intuitively with the elderly users. As discussed in Section 6.3, it should not be a feature that only pops out after long tapping on a particular message (Figure 42 for WhatsApp & Figure 43 for Viber) or the screen (Figure 44 for Viber). Therefore, the future version should have a delete button appear all the time on the menu bar, as illustrated in Figure 53b.

Integrating other build-in applications can make *Your IM* more useful and helpful to elderly users. The elderly users nowadays might not have much knowledge in using mobile applications, but in the future this elderly group will be joined by more "baby boom" population (born 1946 – 1964) that might be more experienced and knowledgeable in using mobile applications. Thus, to cater for the needs of more diverse group of elderly, it would be helpful to have the option for users to customize their own *Your IM* where they can choose to enable the integration of other build-in applications such as calendar and email.

Besides the suggestion from elderly participants, there are also other features that can be implemented in the future development of *Your IM*. First, there should be a small user profile picture that appears beside the user's name (Figure 53a). This helps the elderly users to recognize their contacts as they can recognize from users' profile pictures. Furthermore, contact identification can be improved by personalizing contact sound notification as well. For example, sound notification that elderly users choose to customize for their contacts (Figure 53d), or even sound notification that says "there is incoming message from (the name of the contact)".

Even though this project is only limited to MIM, which means it is only applicable on mobile devices, it is also recommendable to make it workable on computer and laptop,

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since elderly also like to have computer based IM (Prior et al., 2008). So it would be good if elderly can use *Your IM* on both mobile devices and computers. Participants P2 and P4 commented that the reason why they would prefer Facebook Messenger to *Your IM* was its flexibility to use on both mobile devices and computers.

Last but not least, other features in user profiling can be included as well, for instance selecting preferred colors and sound notification. Providing more user profiling features in *Your IM* can be seen as giving the elderly users more personalized and satisfying user experiences. User profiling can also include privacy settings if the users would like to have more privacy in terms of receiving messages from unknown contacts. As seen from participants P1, P2 and P4 in the final user testing, some of them do not like to be contacted by unknown people while some do not mind. Privacy settings can be implemented in *Your IM* for elderly users to choose if they wish to receive message from anyone, or only their added contacts.

Without a doubt, there are enormous rooms for improvement for *Your IM*. As told by the elderly participants, it has very good potential to be their daily social messaging tool. With a more features, complete and functional version of *Your IM*, more thorough comparative study with existing MIM applications can be conducted in the near future which could provide more evidence that *Your IM* is more usable and accessible for elderly users and can contribute to their well-being.

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10. Appendix

A. Participant consent form

Introduction and purpose:

This study aims to get insights and feedback of users regarding to using mobile instant messaging applications.

Procedure:

If you agree to take part in this study, you will be asked a few questions related to yourself and some feedbacks of using mobile instant messaging applications. Then you will be asked to perform a number of tasks with regards to mobile instant messaging applications. The total time required is approximately 30 minutes.

Voluntary Nature of the testing/Confidentiality:

Your participation in this study is entirely voluntary and you may request to stop if you feel any discomfort during the session. Your name will be kept confidential and your information or study result will be represented using pseudonyms to protect confidentiality.

Participant certification:

I have read the above information and I consent to participate this study.

Name of participant: _____







Signature: _____

Date: _____

B. Semi-structured focus group interview for user requirement study

1. How old are you?
2. How often do you use computer? How about mobile phone?
3. What kind of mobile phone do you use?
4. What do you use your mobile phone for?
5. In a scale of 1-10, how would you rate yourself in terms of skill in using mobile application?
6. Tell me about your willingness to learn and use new application.
7. Do you chat or talk to your friends and families often?
8. What do you use to communicate and keep in touch with them?
9. Do you use MIM? What have you been using?
10. What do you think of (current MIM applications)?
11. What features of MIM are important to you? Do you think what is unnecessary?
12. Anything in MIM application seems confusing to you?
13. How about icons in the application? Do you understand them?
14. What do you understand from these icons (showing some metaphorical icons)?
15. Do you have any other concern while using MIM? For example, privacy?
16. How about sending messages to wrong person? Have you had that kind of experience? Anything can be improved in MIM to prevent that kind of mistake?
17. Any kind of bad experience with using MIM?
18. Do you mind if others know about your online or offline status?
19. Do you mind to share other personal information such as message being read, or your current location?
20. Do you think sharing those information is required?
21. How about the text size? Shall they be changed? How they can be improved?
22. What do you think of the current layout?

C. List of metaphorical icons used as touchable buttons

D. User testing tasks for user requirement study

1. Find a contact
2. Send a text message that says "Hi"
3. Read an incoming text message
4. Share an image from gallery
5. Send an image by taking picture
6. Read an incoming picture message
7. Send a voice message that says "Hi"
8. Read an incoming voice message
9. Find other contacts and create a group chat with minimum of 3 members

E. User testing tasks for final user testing

1. Install *Your IM* and set the preferred font size
2. Change font size
3. Add a new contact
4. Find a contact
5. Send a text message that says “Hi”
6. Read an incoming text message
7. Share an image from gallery
8. Send an image by taking picture
9. Send a voice message that says “Hi”
10. Create a new group chat and invite one friend to join

F. Semi-structured focus group interview after final user testing

1. What do you think of this MIM?
2. What do you like and what do you dislike about it?
3. What do you think of the selecting preferred font size feature?
4. How do you feel about the adding contact feature? Was it difficult for you?
5. Do you like the group chat feature? Do you think it is better that you or your friends are invited and join the group by yourself or themselves? Or someone can just add you without invitation?
6. Can you send text message easily? What do you think of this feature?
7. Can you send picture message easily? What do you think of this feature?
8. Can you send voice message easily? What do you think of this feature?
9. What do you think can be improved?
10. What do you think is unnecessary? (If there is any)
11. Do you think it is easy to be used?
12. Do you have any problem with the size of icons? Do you understand them?
13. Do you like the font settings after you chose the font size during installation?
14. Do you think this font settings help you in any way?
15. Do you have any privacy related concern?
16. Do you think the statuses tell too much?
17. Will you use this application in the future?
18. Do you think this application can help you to keep in touch with your friends and families?
19. In a scale of 1-10, kindly rate this application based on your satisfaction level of using it.