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Mobile Instant Messaging for the Elderly

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Abstract

While the use of Mobile Instant Messaging (MIM) has been expanding vastly along with mobile technology, existing MIM applications have not sufficiently addressed the needs of elderly users. MIM applications have great potential to support social interactions, and thus contribute to the well-being of the elderly. User interface design features such as small font size, confusing icons and application flow in current MIM applications, however, make them difficult for the elderly to learn and use. Our research aims to provide a usable and accessible MIM application for this user group. In this research, we combined user-centered and participatory action research principles. We conducted a focus group interview and user testing to identify the usability and accessibility issues in current MIM solutions, and collected requirements from elderly users. Based on the requirements and the principles for accessible design, we designed and developed a MIM prototype named *Your IM* to address the usability and accessibility issues faced by elderly when using MIM.

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1. Introduction

Populations around the world are rapidly ageing¹. In 2010, Vincent and Velkoff² predicted that by 2050, the older population in the United States will be more than 88 million. As of today, elderly people constitute a large part of world population, and it is undeniable that the elderly population is likely to increase over the next three decades³. Social interactions are very important for the well-being of the elderly. Studies such as that by Cornwell and Waite⁴ discussed social disconnectedness (e.g., small social network and infrequent participation in social activities) and perceived isolation (e.g., loneliness and perceived lack of social support) in relation to the physical and mental health of the elderly. Their findings showed that the association between disconnectedness and mental health may operate through the strong relationship between perceived isolation and mental health. Lower levels of self-rated physical health do not have much influence on either disconnectedness or perceived isolation. Zhu et al.⁵ examined the relationships among demographic characteristics such as age, gender, education and chronic disease with social support and cognitive function. Their findings suggested that elderly people who had more family support had better cognitive function. Better family support here refers to being married, living with a spouse or with children. This shows the importance for elderly people to be socially connected to their families, which can lead to better cognitive function. A number of projects and applications have been developed to help reduce loneliness and enable elderly people to stay socially included^{6,7}.

Mobile Instant Messaging (MIM), a messaging service on mobile devices, is becoming increasingly popular. MIM applications have the potential to support social interactions, and thus contribute to the well-being of the elderly. A well-designed MIM application for elderly users can help them overcome social exclusion by increasing their use of information and communication technology (ICT) and improving their quality of life through social participation⁸. Church and Oliveira⁹ studied users' motives and perceptions of a popular MIM application called WhatsApp to gain insights on what this application offers beyond traditional short message service (SMS). Benefits offered by MIM, such as cost saving, the capability of group chat and unlimited text messaging, are the factors that cause people to eventually switch from traditional SMS to MIM. Other popular MIM applications include Viber, Facebook Messenger and WeChat.

While the use of MIM has been expanding vastly along with mobile technology, current MIM applications have not sufficiently addressed the needs of elderly users. There has been very limited research on usability and accessibility of MIM applications. Our research shows that existing MIM applications are not accessible for elderly users. Examples of problematic issues for elderly users include small font size, confusing icons and unintuitive application flow for navigating from one screen to another in the applications. To our knowledge, there have not been any attempts to develop a MIM application for elderly users.

The goal of this research is to address the usability and accessibility issues in current MIM applications faced by elderly users, and to provide a usable and accessible MIM application for them. To achieve this goal, we combined user-centered and participatory action research principles. We conducted a focus group interview and user testing to identify the usability and accessibility issues in current MIM solutions, and collected requirements from elderly users. Based on the requirements, we iteratively carried out design, development and evaluation. The feedback from each evaluation was used to adjust and revise the design and development of the prototype.

This paper is organised as follows. After the Introduction, a brief review of related research is presented in Section 2. Section 3 describes the focus group interview and user testing we conducted to evaluate existing MIM solutions, and presents the requirements gathered. The iterations of design, development and evaluation of *Your IM* are presented in Section 4. In Section 5, we reflect on the process and present our conclusions and future plans.

2. Related work

2.1. Mobile technologies for the elderly

Mobile technologies and applications have the potential to support social interactions. Many of them, however, are difficult for elderly users to use. Kurniawan et al.¹⁰ had a focus group interview with seven older women with a median age of 67.5 years old, aiming to study their usage patterns, problems, perceived benefits and desired and unwanted features of mobile phones. In terms of usage patterns, the participants used mobile phones only during

emergencies. Problems that they faced with their phones, which did not incorporate smart-phone or touch-screen technologies, included buttons that were too small and rubbery; menus with too many unnecessary functions; functions that were difficult to understand, complicated and thus impossible to recall and devices and screens that were too small to hold and read comfortably.

The newer touch-screen mobile phones have resolved some of the problems identified (e.g. rubbery buttons and small screen size). The difficulties with complexity and complicated functions (e.g. menus) are more profound in the new touch-screen mobile phones. When asked about desired features, the elderly participants from the study by Kurniawan et al.¹⁰ emphasised the importance of having a large screen and text, but they did not want a large screen if the screen did not display large text. Caller identification, such as through the use of photos, was also essential for the elderly users since it can remind them of who the caller is.

Studies have also been conducted to investigate whether aging affects the ability of elderly users in corrected and inhibited pointing movements¹¹. The results showed that older subjects achieved the same accuracy as younger subjects in performing the same tasks. Older subjects required more time, however, which resulted from slowing and increased variability of movement planning, initiation and execution on both perturbed and stationary targets. Rossit and Harvey¹¹ concluded that aging is not accompanied by a decrease in inhibition of motor control. By contrast, Taveira and Choi¹² conducted a review of computer input devices and their adequacy for elderly users, and found that touch-screen devices are related to poor typing accuracy. The buttons were found to be too small for elderly users, especially those who have poor control over their finger movements.

2.2. Current research on the usability of MIM applications

There has been very limited research on the usability and accessibility of MIM applications. In term of user interfaces, Teixeira⁸ concluded that current MIM applications do have problematic interfaces, such as small buttons and confusing application flow, which are important in touch-screen interactions. Not all elderly people have good control over their fingers, and their vision might not be clear. Therefore, it could be an unpleasant experience for them to have small buttons on a touch screen while using MIM applications. In addition, some elderly users had problems understanding the icons and application flow in current MIM applications¹⁶.

Church and Oliveira⁹ stated that the ✓✓ symbol in WhatsApp (Fig. 1) is often misunderstood as ‘read/seen’. Its actual interpretation as explained by WhatsApp, however, is “message successfully delivered to the phone of your chat partner”¹³. Other MIM applications such as Viber use words ‘seen’ and ‘delivered’ (Fig. 2), and users seem to understand this better. These kinds of indicators also brought up privacy issues, in which users found their access of WhatsApp to overly disclosed. Thus, this feature could probably be modified to a less-intrusive MIM application design, not just for elderly users, but for all.

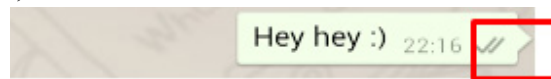


Fig. 1. Double ticks indicator in WhatsApp



Fig. 2. ‘Seen’ and ‘delivered’ indicators in Viber

Elderly users also criticised current communication and social media services such as Facebook as having too many functions⁸. They tend to use only simple functions for their communications, such as sending messages, sharing pictures and having free calls. They prefer systems or applications that are easy to use.⁶ In addition, some elderly have limited abilities. Current MIM applications appear to have too many unnecessary features that confuse novice elderly users and demotivate them from using MIM.

While designing MIM for elderly users, one must also consider the ability of the elderly to learn how to use the applications. Craik and Jennings¹⁴ identified cognitive abilities that differ between older and younger adults. They are discourse comprehension, reasoning, inference formation, the acquisition of new information and the subsequent retrieval of such information from memory. MIM should be intuitive to use so as to minimise the time required to read and learn how to use it. As elderly people have lower cognitive ability to learn, intuitive approaches such as metaphorical icons can facilitate understanding^{14, 15, 16}. Such approaches can help them economise their time and effort in processing resources, thus encouraging their engagement in new technology such as MIM.

3. Understanding the issues and collecting requirements

We combined user-centered and participatory action research in this project. The research started with a preliminary study on existing MIM applications. We conducted user testing with two users (age 51 and 56) and found that both of them did face some usability and accessibility issues while using existing MIM applications. They had problems identifying the correct buttons for performing certain MIM tasks, and one of them even mentioned that using a PC would be much easier, as the buttons on the touch-screen mobile phone were too small. The tested MIM applications were WhatsApp, Viber, WeChat, LINE and KIK.

After the initial study, we conducted a focus group interview and user testing to gather requirements before beginning the iterative process of design, development and evaluation. The feedback from each evaluation in the previous iteration was used to revise and improve the prototype of *Your IM*.

3.1. Focus group interview and user testing

The objectives of the user testing were to gather user requirements, since the needs of the primary target users, elderly people, shaped the design of the MIM application. The user requirements study consisted of two main phases: (1) background interviews and (2) MIM task-based testing. Background interviews collected data related to the needs and expectations of elderly users. The task-based testing was designed to have them perform MIM tasks while being observed, which would provide deeper insights on what could be improved when designing a MIM application^{17, 18}.

The user requirements study encompassed three main aspects. They were: (1) functionalities that elderly users would like to have in MIM, (2) a MIM interface design with which they could interact easily and (3) MIM application flow that they could understand easily. These three aspects were important to ensure that elderly users would find the MIM application easy to learn and use, and therefore motivate them to use it. The requirements gathered would be the starting point for the design phase.

Six elderly people (P1–P6) whose ages ranged from 60 to 80 years were recruited to participate in the study; the participants were two females and four males. They were all retired except for one, who was still working as a manager. Before the sessions started, they were briefed about their roles and rights as participants, and then asked to sign a consent form. They were interviewed, using a semi-structured interview guide. The questions were inspired by the Software Usability Scale¹⁹ and adapted to a semi-structured format to prompt more feedback from the participants¹⁷.

During this interview, their opinions and attitudes towards MIM were also gathered to see if they were interested in using MIM now and in the future. After the interview, they were asked to perform a set of predefined MIM-related tasks in various applications. In order to limit the time spent on the testing, we asked each participant to test only one application, which was chosen randomly. As a result, three participants tested Facebook Messenger, two tested WhatsApp and one tested Viber. The whole process was observed to see if they had any difficulties in using the applications, whether there were any features that they liked or disliked and so on²⁰. Time taken to accomplish the tasks was also recorded.

In terms of their use of mobile phones, one used a keypad phone, four of them used touch-screen smart-phones, while the remaining one did not have any kind of mobile phone. Their usage of MIM applications ranged widely from no experience to regular daily use.

In general, they were all positive about using MIM applications and willing to learn a new application as long as it was useful to them. While performing MIM-related tasks, inexperienced participants had problems finding the

right icons for most of the features. As a result, P1 and P6 took more than 2 minutes to send an image message. All 6 participants also took more than 1 minute to send an audio message. When it came to the task of creating a chat group, all of them had difficulties because they were not able to recognise the icon. Another button that some of them did not recognise was the small 'back' button to the left of application icon (Fig. 3). In addition, they commented that the buttons and text were too small. These issues were found in all MIM applications tested.

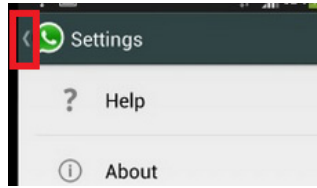


Fig. 3. Back button for WhatsApp at settings page

3.2. Initial requirements

The following issues were identified during the focus group interview and user testing.

- Font size: Some of the elderly participants mentioned that they have poor vision and would prefer bigger fonts. There should be some user profiling mechanism to allow them to choose their preferred font size.
- Back button: It was too small and the participants recognised only the application icon (See Fig. 3). They considered this to be a confusing icon.
- Create a chat group: It was too confusing in both WhatsApp and Facebook Messenger, as the participants confused creating a chat group with adding a new contact. In addition, they had problems navigating from adding a new contact to creating a chat group. This application flow was problematic for them.
- Sending image and audio messages: The participants found these icons to be confusing and hard to identify.

Based on the focus group interview, user testing and evaluation of existing MIM applications, we gathered the following initial requirements. Users should be able to send text messages, audio messages and images, start group chat and configure their preferred font size. In addition to the basic functions, other issues identified, such as confusing icons and application flow, were taken into consideration during.

4. Design, development and evaluation iterations

Four iterations of design, development and evaluation of *Your IM* were carried out. Results from the evaluation of previous iterations were used to improve the design in later iterations.

4.1. First iteration

In the first iteration, the design was based on the initial requirements and design principles. For instance, by adopting Gestalt's grouping by similarity theory, the adding a new contact function and creating a new chat group function were considered as similar functions, and they were grouped together during design by placing them at the application interface (Fig. 4a). Humans tend to perceptually group similar functions by position; understanding that can guide good design for quick and easy use²¹.

The first iteration also included a user profiling feature in which the elderly users would choose their preferred font and button size prior to installing the MIM application, as illustrated in Fig. 4b. The button size was actually dependent on font size. The bigger the font size, the bigger the button size in order to have the words fit within the button. This font preference could also be changed after installing the MIM application. Users could go to the settings page to change it again if the font size chosen during installation was not suitable for them (Fig. 4c).

In this iteration, the back button was also redesigned to make it clearer and more understandable for elderly users. Instead of having a regular application icon and a tiny back arrow icon at the left, as in WhatsApp (Fig. 3) and other MIM applications, the prototype used a big and clear back icon (Fig. 4c).

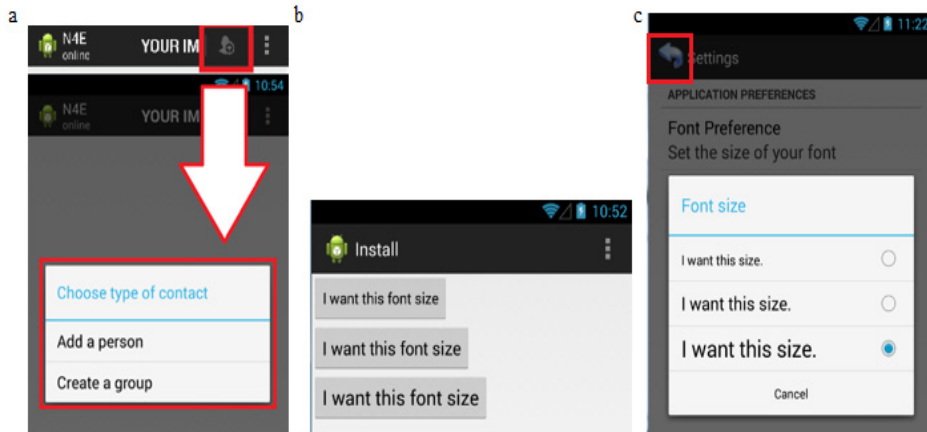


Fig. 4. *Your IM* prototype in iteration 1: (a) add new contact & create new chat group buttons, (b) install page to set preferred font and button size, (c) settings page for choosing preferred font size & redesigned back button

Participant P5 was asked to test the prototype that came out of iteration 1. He liked the user profiling design that asked for a preferred font size, as he thought the messages in some existing MIM applications could appear too small. He commented, “I like the font setting part and I think it is nice to set the size we want. Then maybe I wouldn’t need my glasses anymore just to read messages.”

He had no problem with setting the font size during installation and resetting it at the settings page. When asked about his experience with the back button featuring the 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.” This new design seemed to work better visually for elderly users.

He did not have difficulties when testing the features of adding a new contact or creating a chat group. He found it much easier to create a chat group, as its button was placed together with that for adding a new contact. He commented, however, that the button looked ‘inactive’ due to the colour (Fig. 4a). “At first I was not sure if I can press it, because it looked like it is disabled or inactive. Maybe you can change the colour to make it look like active or can be used”, commented the participant.

4.2. Second iteration

In iteration 2, the colour for the icon of adding a new contact and creating a chat group was changed to light blue, based on the recommendation from iteration 1. The new feature added in this iteration was sending media messages (Fig. 5), which allows users to perform two tasks. One was to choose an image by taking a new picture or choosing an existing picture from the phone gallery. The other was to choose voice message. This design was also based on grouping theory from Gestalt²². Image and audio were both considered as media and their functions were grouped under one button.

Participant P1 was asked to test the prototype of iteration 2. He found it rather easy to choose a font preference during installation, change the font preference at the settings page, add a new contact, create a chat group and send a media message. As shown in Fig. 5, after P1 tapped the add button on the menu bar, a prompt box popped out to ask him to choose between a picture message and voice message. After choosing a picture message, another prompt box popped out to request the source of the image, either by taking new picture using the camera or by choosing an existing picture from the phone’s gallery.

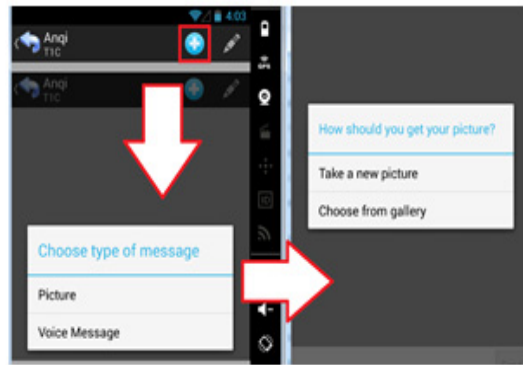


Fig. 5. *Your IM* prototype in iteration 2 (add media message button)

Participant P1 commented that this interface and application flow seemed easier to him, as the text and icons were clear and meaningful to him. He could understand it right away without wondering about what to do, as was the case with Facebook Messenger that he tested in the user requirements study. In Facebook Messenger, he was confused between camera and gallery functions, and took some time to recognise the audio message icon (Fig. 6). The complicated interface with too many buttons and icons caused him to take more time trying to understand them. In comparison, iteration 2 of the *Your IM* prototype allowed him to recognise the add media button within a few seconds.



Fig. 6. Add image and audio message buttons in Facebook Messenger

4.3. Third iteration

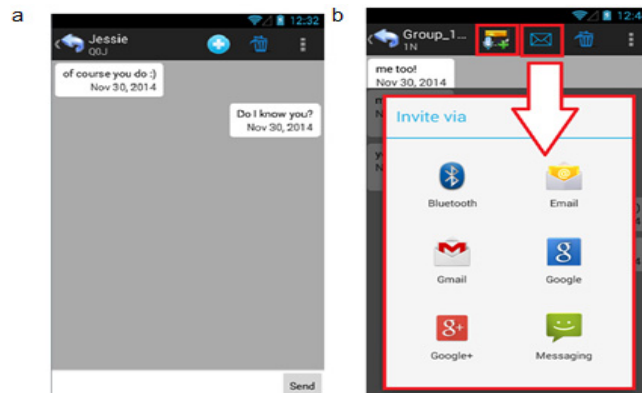


Fig. 7. (a) Chat activity of *Your IM* prototype in iteration 3, (b) Group chat in *Your IM* prototype, iteration 4

The newly added feature in prototype iteration 3 was sending text messages (Fig. 7a). Participant P3 was asked to test all existing features in prototype iteration 3. As with P1, P3 found setting a font preference during installation and changing it at the settings page to be easy and useful. Adding a new contact and creating a chat group were not issues for him either. When it came to sending media messages, however, he had difficulties in identifying the right button. He claimed that the cross button was not meaningful to him (Fig. 5). “I don’t know that it is the add button. I

only see it like a cross, so I really don't know I should press it to add an image or audio," commented P3.

Participant P3 did not have other difficulties with prototype iteration 3. He liked the interface of *Your IM* because he was also a user of WhatsApp. He thought that the sending text message function was similar to WhatsApp and regular SMS messaging. He emphasised only that the add media message button was very confusing and perhaps it should convey meaning as a media button instead of as an add button.

4.4. Fourth iteration

Comments and recommendations from P3 were taken into consideration, and the icon for the media message button was changed in iteration 4. As shown in Fig. 7b, the media message button was changed from only a cross add button to a metaphorical icon consisting of (1) a picture representing an image message, (2) a speaker representing an audio message and (3) an add symbol.

In addition, the share group ID feature was completed. When a user tapped the envelope button on the menu bar (Fig. 7b), a window would prompt him/her to choose how s/he wanted to share the group ID. This mechanism was adopted due to the privacy issue mentioned by some participants in user requirements study. They preferred to be asked for permission before being added to a chat group. Thus, the users of *Your IM's* group chat could decide if they wanted to join a chat group by adding the chat group ID that was sent to them.

Participant P5 was invited to perform user testing for prototype iteration 4. Positive comments were received from him, as he found it easy to use. He had no difficulties using all the existing features. "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 P5.

4.5. Summary

From the user requirements study and user testing in each iteration, we collected a set of design guidelines to which we referred throughout the development process. These guidelines are also inspired by related literature and other design principles, such as the Principles of Universal Design²² and Nielsen's usability principles²³. They are presented in Table 1 and discussed below.

Table 1. Design guidelines

1.	Eliminate unnecessary functions. ^{22, 23}
2.	Interface should be simple, organised and informative. ^{21, 22, 23}
3.	The application flow and icons should be intuitive. ^{15, 22, 23}
4.	Allow elderly users to choose their preferred settings. ^{22, 23}
5.	Design for minimal physical effort by the elderly. ^{11, 12, 22, 25}
6.	Guide the elderly by providing simple instruction. ^{22, 23, 25}
7.	Pay attention to the choice of colour and colour contrast. ²⁵
8.	Keep the elderly motivated. ^{10, 15, 16, 24}

1. During our user requirements 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. We therefore eliminated a few of the features in current MIM applications, such as sharing location, contact's phone number and emoticons.
2. Elderly users have limited knowledge and understanding of mobile phones with touch screens, and most of them are not familiar with mobile applications²⁵. When an interface seems complex, they have difficulties in interacting and performing tasks using that interface. Complex interfaces also facilitate user errors. Better organised interfaces and the avoidance irrelevant features and icons can make the interface appear simpler. Current MIM applications have too many icons in one screen, which make them difficult to learn and use. We therefore applied grouping design principles²¹ to organise the interface better.

3. To help elderly users understand the application with minimal effort, 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 abilities in terms of learning, remembering and staying focused^{24, 25}. When we redesigned the back button, we used a larger back icon (Fig. 3c) to replace the application icon and make it more intuitive and recognisable for the elderly.
4. To make the MIM application flexible in use²², we incorporated the concept of user profiling. This allows users to choose their preferred settings so that the application can adapt to their needs. Besides font size, there are other preferences for features that would be developed in up-coming iterations. During the user requirements study, P5 suggested a feature to edit a contact's profile picture so that he can choose profile pictures for his contacts by himself. Profile pictures are considered to be helpful for some elderly users in identifying their contacts. Many do not choose the profile pictures that represent them, however, or the pictures that they do choose are not clear enough. In *Your IM*, we plan to allow users to choose pictures for their contacts so that they can easily recognise their contacts.
5. Elderly users normally do not have good motor control over their fingers^{11, 12, 25}. When designing touch-screen applications for elderly users, therefore, it is recommended to avoid gestures that require extra effort in motor control such as long tapping and swiping. When we designed *Your IM*, we focused on single tapping. In addition, we referred to the Android design guidelines²⁶ while designing icons for our buttons. The guidelines' suggested size is at least 48 dimensional pixels (approximately 9mm) in length and width.
6. Simple instructions should be provided to the elderly for their interactions with the mobile application²⁵. These can ensure that elderly users will have a good experience with the application. In *Your IM*, we used text instead of icons for some features to provide clearer guidance of those features. Simple instruction in text can be more helpful to the elderly when a feature is difficult to represent with an icon, especially when icons can be interpreted differently by different demographics and cultures²⁵.
7. Colour perception declines with age²⁷. Thus, elderly users need better colour contrast. In addition, Wijk et al.²⁸ reported that the elderly have better colour discrimination towards warm colours than cold colours²⁸. Therefore, in *Your IM* we avoided using cold colours such as green and bluish purple and low colour contrast, such as a darker colour for icons, since the touch-screen background is already black.
8. All of the above guidelines aim for an enjoyable learning process and a good user experience for the elderly to keep them motivated to use the application. Motivation is essential for elderly people who are using new technologies. When some elderly become motivated to use a communication application such as MIM, they encourage their friends to use it as well. In doing so, they establish a group that can communicate and socialise through the application. They can also help each other when difficulties or problems occur.

5. Conclusion and future work

In this paper, we presented the research related to designing and developing a usable and accessible MIM application for the elderly. The combination of user-centered and participatory action research was found to be appropriate for the process. The requirements were gathered through a focus group interview and user testing. The involvement of users in each iteration also provided feedback to improve the prototype, thus leading to a more usable and accessible MIM application for elderly users. The participants showed positive attitudes towards using *Your IM* in the future, as they found it more accessible.

One limitation of this research was the small number participants. In the initial focus group interview and user testing, we had only six participants. In each iteration we had one user test the prototype due to the availability of the users. More elderly users with diverse abilities involved 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 generalise the results and feedback while designing and implementing the prototypes. Another limitation was the mobile operating system. We focused only on Android in our research. Four out of the six participants were Android users. The other two, who did not own smart-phones, used our Android phone for user testing. We acknowledge that the test results will not maintain their currency for long, since existing MIM applications on the market are constantly updated with newer versions and improved design. Some of

the usability and accessibility issues we identified, however, remain unaddressed, such as small font size and confusing icons and interfaces for creating new groups and sending multimedia messages.

In addition to further development, we are currently planning a comparative study with existing MIM applications. By conducting that study, we hope to confirm that *Your IM* could provide more usable and accessible features for elderly users.

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References

1. European Union. *Europe in Figures: Eurostat Yearbook 2010*. Renouf Publishing Company Limited; 2010.
2. Vincent G, Velkoff V. *The Next Four Decades: The Older Population in the United States 2010 to 2050*. US Census Bureau; 2010.
3. Lutz W, Sanderson W, Scherbov S. The coming acceleration of global population ageing. *Nature*. 2008; **451**(7179):716-9.
4. Cornwell EY, Waite LJ. Social disconnectedness, perceived isolation, and health among older adults. *Journal of Health and Social Behavior*. 2009; **50**(1):31-48.
5. Zhu S, Hu J, Efrid JT. Role of social support in cognitive function among elders. *Journal of Clinical Nursing*. 2012; **21**(15/16):2118-25.
6. Pensas H, Kivimäki T, Vainio A-M, Konakas S, Costicoglou S, Köldorfer P, et al. Building a Client-Server Social Network Application for Elders and Safety Net. 2013.
7. AMCOSOP. AMCOSOP 2011 [cited 2014 17th March]. Available from: <http://www.amcosop.eu/>.
8. Teixeira V, Pires C, Pinto F, Freitas J, Dias MS, Rodrigues EM. Towards elderly social integration using a multimodal human-computer interface. *ProcAAL, Vilamoura*. 2012.
9. Church K, Oliveira Rd. What's up with whatsapp? Comparing mobile instant messaging behaviors with traditional SMS. *Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services 2013*. p. 352-61.
10. Kurniawan S, Mahmud M, Nugroho Y, editors. A study of the use of mobile phones by older persons. *CHI'06 extended abstracts on Human factors in computing systems*; 2006: ACM.
11. Rossit S, Harvey M. Age-related differences in corrected and inhibited pointing movements. *Experimental Brain Research*. 2008; **185**(1):1-10.
12. Taveira AD, Choi SD. Review study of computer input devices and older users. *Intl Journal of Human-Computer Interaction*. 2009; **25**(5):455-74.
13. WhatsApp. WhatsApp FAQ - What are those check marks next to my messages? 2014 [cited 2014 6th March]. Available from: <http://www.whatsapp.com/faq/general/20951546>.
14. Craik F, Jennings J. *Human memory, CraikFIM, Salthouse TA, The handbook of aging and cognition*, 51-110. Erlbaum, Hillsdale; 1992.
15. Prior S, Arnott J, Dickinson A. Interface metaphor design and instant messaging for older adults. *CHI '08 Extended Abstracts on Human Factors in Computing Systems*; Florence, Italy. 1358924: ACM; 2008. p. 3747-52.
16. Jones BD, BayenUJ. Teaching older adults to use computers: Recommendations based on cognitive aging research. *Educational Gerontology: An International Quarterly*. 1998; **24**(7):675-89.
17. Lazar J, Feng, J.H., Hochheiser H. *Research Methods in Human-computer Interaction*. Chichester: John Wiley; 2010.
18. Abras C, Maloney-Krichmar D, Preece J. User-centered design. *Bainbridge, W Encyclopedia of Human-Computer Interaction Thousand Oaks: Sage Publications*. 2004; **37**(4):445-56.
19. Brooke J. SUS-A quick and dirty usability scale. *Usability evaluation in industry*. 1996; 189-194.
20. UPA. UXPA: Usability Resources: What is User-Centered Design? : User Experience Professionals Association; n.d. [cited 2014 15th May]. Available from: http://www.usabilityprofessionals.org/usability_resources/about_usability/what_is_ucd.html.
21. Rosenholtz R, Twarog NR, Schinkel-Bielefeld N, Wattenberg M, editors. An intuitive model of perceptual grouping for HCI design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*; 2009: ACM.
22. Connell BR, Jones M, Mace R, Mueller J, Mullick A, Ostroff E, et al. *The principles of universal design*. Retrieved January. 1997; 11:2005.
23. Nielsen J. *Usability engineering*: Elsevier; 1994.
24. Nielsen J. Seniors as Web Users 2013 [cited 2015 13th Jan]. Available from: <http://www.nngroup.com/articles/usability-for-senior-citizens/>.
25. Farage MA, Miller KW, Ajayi F, Hutchins D. Design principles to accommodate older adults. *Global journal of health science*. 2012; **4**(2):p2.
26. Accessibility Testing Checklist: Android Developers [cited 2014 21st May]. Available from: http://developer.android.com/tools/testing/testing_accessibility.html.
27. Johnson CA, Adams AJ, Twelker JD, Quigg JM. Age-related changes in the central visual field for short-wavelength-sensitive pathways. *JOSA A*. 1988; **5**(12):2131-9.
28. Wijk H, Berg S, Sivik L, Steen B. Colour discrimination, colour naming and colour preferences among individuals with Alzheimer's disease. *International journal of geriatric psychiatry*. 1999; **14**(12):1000-5.