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Enhancing the wellbeing of older adults through IoT design with music

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Abstract

The ageing population is increasing rapidly in the world. Between 2015 and 2050, the proportion of the world's population over 60 years old will nearly double from 12% to 22%. Many older adults will experience significant losses, whether of physical or cognitive capacity or of family, friends and the roles they had earlier in life, which may lead to a decrease in well-being, manifesting as poor emotional health and a decline in physical health [1]. Music offers the powerful potential for helping older adults recover from depression and maintain their personal well-being.

New technology, from CDs to digital platforms, has changed our ways of listening to and accessing music. But for older adults, the deficiencies in knowledge about new technology and the difficulties of learning new things can be central obstacles preventing them from accessing music independently, which can decrease their autonomy and then cause frustration, stress or a low self-esteem. Such negative moods may lead to a decrease in older adults' emotional health and physical health.

This thesis aims to explore how to enable older adults' access and enjoyment of music easily and independently through the use of IoT design, in order to reduce their depression and to maintain their well-being. An easy-to-use music IoT design concept was created in order to enhance the older adults' autonomy in selecting and enjoying music. The interfaces of the music application were designed with the aim of making meaningful interaction and communication with the users and the concept of the music device. First, interviews were conducted to gather data. Analyzation of the interviews have defined the target user groups and their needs. Next, based on the user needs, multiple versions' prototypes of a music application were created to investigate and redefine the research questions. Then, some suggestions for designing ease-of-use music application interfaces for elders were given through the methods of user-centered design, prototype design, heuristic evaluation, and usability testing. Finally, some guidelines about music application interface design for older adults were suggested.

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1 Introduction

The ageing population is increasing rapidly in the world. Between 2015 and 2050, the proportion of the world's population over 60 years old will nearly double from 12% to 22% [1]. The Global strategy and action plan [2] on ageing and health has pointed out that many older adults will experience very significant losses, whether of physical or cognitive capacity or of family, friends and the roles they had earlier in life. Such losses come with many challenges to older adults such as age-related memory loss, an inability of self-management and low self-estimation, which are easy to generate social isolation, which lead to poor emotional health, and a decline in physical health. Hence, there is a need for supporting them to get more positive emotional experiences and social engagement, and improving their psychological well-being, such as effective well-being, life satisfaction, and eudaimonic well-being [3]. In this situation, being healthy means reaching a state of complete physical, mental and social well-being rather than accepting medical treatment. The *Ottawa Charter for Health Promotion* stated that health promotion is the process of enabling people to increase control over, and to improve, their health. An individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment, to reach a state of complete physical, mental and social well-being [4].

Recent technological advances have increased the accessibility to music in the modern world. Positive relationships can be found in the literature for all types of music engagement, such as participatory singing [5] and dancing [6], personal music album creating [7], instrument playing [8] and attending live music activities [9]. New technology such as information and communication technology (ICT) and Internet-of-Things (IoT) have been used for independent living and social engagement for older adults. However, the younger population can relate more to the use of ICT when compared with the older generation of whom tends to be more vulnerable to be disease and are afflicted with morbidity and disability, which may limit learning new ways of doing things [10]. Two of the most significant factors are related to memory and language [11]. In addition to these factors, deficiencies in knowledge about technology, sensitivity to stress of using technology and difficulties in understanding the interpretation of advanced technology seem to be the main challenges for older adults. Adoption of technology by older adults is still limited, though it has increased as compared with results of the previous study [12].

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. People can control those devices via the Internet. IoT can aid in facilitating the older adults to live more comfortably and independently [13]. Currently, the IoT

is widely used in the area of elderly healthcare and assisted living. For example, designing wearable remote health monitoring and alert system [14][15], creating Ambient Assisted Living (AAL) system to build better-living conditions [16], coming up with IoT-based smart in-home healthcare solutions for older adults [17]. However, when it comes to the topic of music, health and well-being of seniors, only a few research and design to use IoT as a solution to supporting their health and well-being [18].

This thesis aims to explore how to enable older adults access and enjoy music easily and independently through the use of IoT design, to reduce their depression and to maintain their well-being. An ease-of-use music IoT design concept was created to enhance the older adults' autonomy of selecting and enjoying music. And interfaces of a music application were designed aims to make meaningful interaction and communication with the music device concept in the conceptual model and the related user groups. Observation and interview were used in data gathering. The design was completed through the methods of user-centered design, prototype design and usability testing.

1.1 Research questions

The following research questions are formulated:

- How to use IoT design with music to enable the well-being of older adults?
- What should be paid attention to while designing IoT for older adults to listen to music?

For the first question, my hypothesis is: A musical IoT design which can enhance the older adults' independence of music listening and connection of their social groups could maintain the older adults' abilities such as decision making and relationship building, thereby, enable their well-being. And the design should consider not only the older adults' needs but also the needs of other users such as family members, nurses and volunteer workers. For the second question, I supposed that the efficiency of using music IoT should be considered, such as fulfilling the old adults' music preferences, creating an ease-of-use interface with the least learning cost and simplifying the procedure of music selecting.

1.2 Project goals and contributions

The purpose of the project is to improve the health and quality of life of older adults through the use of Internet of Things (IoT) design. In this project, a conceptual model of the physical music device and prototypes of digital interfaces were developed focusing on different user situations. The contributions in this study are twofold. Firstly, understanding the older adults' daily life, habit and behaviour of music listening and identifying the target user group. Through the use of qualitative and user-involved research methods, one may get one step closer in understanding the music needs of older adults, and identify which demand is likely to be afforded by an IoT-based design solution. Secondly, prototyping an IoT solution to not only enhancing the older adults' well-being

but also benefiting other stakeholders at the same time. The process of iterative design aims to generate more knowledge on how to utilize qualitative research methods and user-centered design in problem-solving.

2 Background

2.1 Music, health and wellbeing

2.1.1 Well-being

Marmot described wellbeing as a multidimensional construct, which includes satisfaction with life, a sense of autonomy, control and self-realisation, and the absence of depression and loneliness [19]. For older adults, losses such as physical or cognitive capacity or of family, friends and the roles they had earlier in life are easy to generate depression and loneliness. Such negative emotion appears to be a risk factor for poor physical health. Stek et al. [20] showed that while loneliness on its own does not affect mortality rates, it significantly increases mortality rates in the older adults when it co-exists with depression. Literature also showed that health promotion services intended to alleviate social isolation and loneliness among older people have long been considered important in providing support to develop, improve and maintain social contacts and mental wellbeing [21].

Social cohesion is defined as a state of affairs concerning both the vertical and the horizontal interactions among members of society and is characterized by a set of attitudes and norms that includes trust, a sense of belonging, the willingness to participate and help, and related behavioural manifestations [22] [23]. Previous studies have found that social cohesion was associated with psychological well-being and physical health. And for enhancing social cohesion, enjoyment and personal development of the older adults, music offers the powerful potential to let older adults recover from depression and maintain personal well-being [24][25]. Previous studies have used a variety of methods like questionnaire studies, observational studies [26], as well as qualitative interviews [7][27] to prove music as one of the most enjoyable and satisfying everyday activities, which offers a variety of benefits of health and well-being [28].

2.1.2 Health promotion

Health promotion is a process of enabling people to increase control over and to improve their health, supporting people to reach a state of physical, mental and social well-being [4]. Batt-Rawden, DeNora and Ruud [7] explored how it is possible to develop strategies for promoting health and wellbeing. Twenty-two participants aged 34 to 65 with long-term illnesses were recruited as a strategic sample involving eight in-depth interviews. A novel 'Participatory CD design' was developed, involving participants' reflections on and contribution to the making of four CD compilations. The result showed that participants considered music listening and musicking to be

important tools in the process of change and self-development, enhancing well-being and offering resources for recovery and quality of life in the face of illness.

2.1.3 Music can enhance well-being

Research demonstrates that music offers a powerful potential for enhancing health and well-being in old age. The power of listening to music for therapeutic purposes has been investigated. Laukka [3]surveyed 500 Swedish people aged 65 to 75 about their everyday music listening habits and motives for listening to music. The results showed that listening to music is a common leisure activity encountered in many everyday situations and that listening to music is a frequent source of positive emotions for older adults. Ruud [29]explored how people in contemporary society may apply music in their everyday life to improve their health and well-being. The result of the study concluded that music could be applied as a provider of emotional stimulation and expression, resource in building social networks; and way of providing meaning and coherence in life.

Recent findings in the literature show that personal music preference is an important factor in the study of the beneficial effects of music listening. Costa, Ockelford and Hargreaves have found that listening to preferred music can bring some relief to depression and anxiety amongst older adults [30]. In this study, each participant listened to a daily 30-minute program of their preferred music for three weeks. Findings from the qualitative data showed that listening to preferred music resulted in relaxation, positive reminiscence, less depression and less boredom. Physical reactions, such as 'chills' or tears, demonstrated emotional arousal. Research also shows that listening to preferred music during exercise can increase physiological arousal and enhance subjective experience, and support physical activity participation among older adults [31]. However, the challenges of using technology to listen to music have a negative impact on exercising.

2.2 Music, technology and old adults

Technology plays an important role in everyday music listening to enhance health and well-being. An increasingly popular way to engage users with music now is through mobile devices, desktop computers, laptops, tablets and phones utilizing music browsing, streaming and media player software. As the user engages with this technology, it gathers information on their music choices, listening behavior and listening context. However, engaging older adults with such technology seems to be difficult.

2.2.1 Older adults' technology adoption

There exist a number of technology applications with the potential to improve the quality of life of older adults across numerous domains including mobility, health, socialization, recreation, lifelong learning, and home support. However, despite the fact that the potential rewards use of technol-

ogy applications can provide, older adults are less likely to adopt new and emerging technologies because they face several unique barriers and challenges when it comes to adopting new technologies. It includes physical challenges to using technology, a lack of knowledge and confidence, and difficulties learning to use new technologies. For example, a study has investigated the older adults' familiarity with, and barriers to, interacting with new technologies and tablets [32]. Eighteen older adults (65–76 years old; 83.3% female) who were novice tablet users participated in discussions about their perceptions of and barriers to interacting with tablets. Result showed that except for the advantage of using tablets (i.e., positive features of tablets, accessing information) and willingness to adopt technology, some factors such as too complex technology, feelings of knowledge inadequacy and lack of social interaction could affect the older adults' adoptions of tablets and technology. Barnard et al. [33] demonstrated that older adults have experiences with learning and ideas about their own self-efficacy, and more or less positive attitudes towards learning new things, as well as ideas about how difficult it would be to learn a given new technology.

2.2.2 Music technology for older adults

Touch-screen based technology has been used for older adults to access music. Waycott et al.[34] stated how touchscreen tablets, such as the iPad, can be useful in our facility and home environments for older people. Touch-screen based technology can increase interpersonal interactions, improve staff and resident relationships and enhance the quality of life. Stoeckle and Freund [35] designed an appealing music-player interface with only songs and covers. Covers showing images of the musicians were selected when possible to serve as a secondary memory cue. The interactive furniture Resonant Interface Rocking Chair aimed to imbue objects and everyday devices with stories, memories and audio recordings [36]. Music that saved in the rocking chair app can be played while the chair is being rocked. The musical furniture created an environment that is alive with subtle, playful and engaging interactions that support and stimulate memories and storytelling of older adults.

Interactive physical objects is another beneficial way for older adults to access music easily and wake up their memories. Müller-Rakow and Flechtner [37] designed a music player prototype with one button to control the music playing and volume, and with two more buttons to control the music selection. Orpwood et al. [38] designed a one-button music player. The button was used to change music. In order to avoid the condition that most of the users would have forgotten the existence of the music player, an attention-drawing feature was added into the interface. Mann and Oatley [39] designed a cussmart apron, a fabric artifact with electronic technology. It can be put in various kinds of functions in it such as playing music, video and games about memory. However, when it comes to the music playing function, the smart apron needed music delivery systems such as MP3 player to support the music playing function. The notion "Musicking Tangibles" suggested an approach for understanding and designing health improving music technology for people with special needs. It means that people with diverse abilities and motivations can experience vitality,

mastering, empowerment, participation and co-creation through their musicking [40]. Musicking Tangibles should be able to respond to several types of events and to evoke interest and positive emotions. The project RHYME [41] aims to develop Internet-based, tangible interactions and multimedia resources that have a potential for promoting health and life quality. Recently, the researchers from RHYME and MA students in Interaction Design have developed health promoting IoT prototypes for elderly [42].

2.2.3 Internet of Things

The Internet of Things (IoT) is the scenario of everyday objects and devices being connected to the Internet, sharing and receiving data. It is an umbrella term encompassing the augmentation of everyday physical objects using information and communication technologies. The word "things" in the Internet of Things refers to embedded systems that are connected to the Internet, which can interact with each other and cooperate with their neighbors to reach common goals [43]. Currently, applications of IoT are mostly found within environmental monitoring, energy monitoring, home automation, healthcare, and transportation [44]. However, the application of IoT technologies has received little attention in music contexts for older people.

There are some examples of IoT design with music. Prizm is a connected device that's capable of choosing the perfect music to play [45]. As if one person is meeting a partner, while interacting with Prizm, it starts learning and remembering his/her habits, what music he/she like, when and in which context. In addition, it is capable to recognize who is in the room and also sense the mood in there, to adapt the music according to any situation. The project "Sing Song Table" [45] allows one to create a melody while playing. The recording is connected to a computer to transform the match into an original and unique song. It also allows players to choose different preset styles to make this experience even more personal.

3 Methods

This study approaches the topic of using IoT design with music to improve the well-being of older adults. It uses methods of user-centered design, combined with qualitative research methods to understand target users' needs, identify the direction of the design, evaluate and redefine the prototypes. Activities such as literature review, interview, evaluation and usability testing have provided specific information about the situation for which the music IoT design is made. Additionally, the iterative prototyping process plays a central role in the knowledge-generating process [46], which makes doing design as a part of doing research. In other words, this study can be classified as research through design. The study tries to find a suitable IoT solution to enhance the older adults' well-being from its current state to a preferred state.

3.1 Define the stakeholders and users

Stakeholders are those people, groups, or individuals who either have the power to affect or be affected by the organization's actions, objectives and policies. They are affected and can influence one's endeavors to varying degrees, and the degrees should be considered when analyzing and mapping out the stakeholder landscape.

3.1.1 Stakeholder mapping

The method of individual brainstorming was used to identify the initial profile of stakeholders. It is a visual note taking technique in which people diagram their thoughts. A set of stakeholders were created by answering the following questions:

- Who will be impacted by the project?
- Who will be responsible or accountable for the project?
- Who will have decision authority on the project?
- Who can support the project?
- Who can obstruct the project?
- Who has been involved in this type of project in the past?

Table 1 shows the list of the stakeholders in this project. There is no doubt that the older adults will be impacted by the project due to they are the target users in this research. As their caregivers, the older adults' family members and the nurses who work in the elderly care area also can be affected by this project. They have the potential to be the end-users of the product and get benefits

from it. In this case, they could be the essential individuals to influence the research directions, so they have been put into the stakeholders' list, so do the social workers and volunteers. For music therapists, musicians and medical doctors, they may have potential needs of using the product to do some music-related research or treatment on older adults, which may also influence some points of the research direction of the project. Research and development engineers need to take the responsibility of offering the technical support in the project. Without them, the product will only stay in the prototype-stage. Project managers in the elderly care homes can also be the stakeholders, because they may offer help with the user research and give useful suggestions to the feasibility of the project. The groups such as National competence services for aging & health and the city community may offer or contact research and financial support for the project, so they can also be put into the stakeholders' list.

Groups	Individuals
National competence services for aging & health City community	Music therapists Musicians Research and development engineers Nurses in elderly care Medical doctors Older adults Project managers in elderly care homes Family members of the older adults Social workers/ Volunteers Interaction designers

Table 1: List of stakeholders

Based on the stakeholders' list, a stakeholder mapping was conducted by using the Mendelow's Matrix [47], which is a simple tool that helps categorize project stakeholders with increasing power and interest in the project. This tool focus on the key stakeholders that can make or break the project. Mendelow's Matrix consists of four boxes representing stakeholders with different levels of power and interest:

- Promoters (high interest + high power). This group is likely to have the significant influence on a project; they may be the driver behind the change or strategy. Moreover, they will likely have the power to stop the change or strategy going ahead if they are unhappy with a design. It is essential to understand their thoughts by managing them closely.
- Defenders (high interest + low power). Stakeholders in this group usually have an interest in what is happening, but unlikely to have the power to influence change. This group should be kept informed. They could attempt to join forces with an influential group to enhance their power.
- Latents (low interest + high power). This group of stakeholders has the potential to move into the 'High Interest and High Power' group, so it is essential that they are kept satisfied. By keeping them satisfied, they are less likely to gain interest and exercise their power to

influence.

- Apathetics (low interest + low power). This group is unlikely to have an interest in the actions of a business; this is often due to their lack of power to influence a situation.

The goal of the stakeholder mapping is to discover the prior stakeholders that can be interviewed regarding this project and identify the user groups which can have a significant influence on the design.

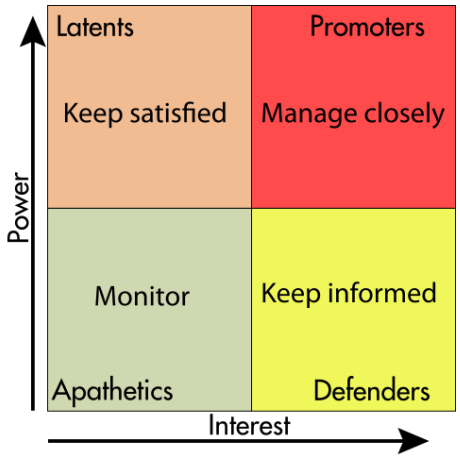

Figure 1: Stakeholders matrix: Mendelow's Power-interest grid

3.1.2 Knowledge area mapping

The People & Connections Map [48] is a quick and simple way to visualize exactly whom the designer is trying to reach and how (see the model in Figure 2). It gives an overview of all the different individuals involved in a project. The review will provide a useful starting point to decide which relationship may need extra attention.

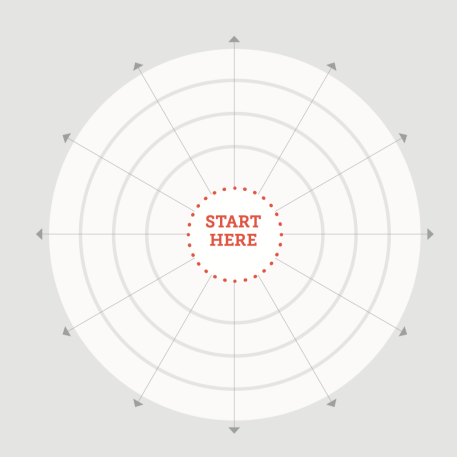

Figure 2: People & connections map

A diagram (Figure 3) was redesigned based on the original model to determine which stakeholder could offer the most useful information. This mapping aims to make clear about who has the most general knowledge and experience in the following areas:

- Elderly care. This category may include the knowledge of services and activities designing for older adults, health care and employee training in the elderly care center or care home. Also, it may contain the experience of taking care of or communicating with older adults. Such contents are important to understand the older adults' daily life in care homes.
- Music & audience. In this category, the target stakeholder should have rich experience about how the older adults react to music while they are listening. They will give clues to the design by grasping the older adult's behavior.
- Music & health. Stakeholders who know the relationship between music and health could give professional suggestions and related research to support the project.
- Technology.

Three grades are used for evaluating the stakeholders' knowledge level: High, Mediate and Low (Figure 3). They were divided into four parts corresponding to the four knowledge categories. Stakeholders will be put into different circles depending on their levels of knowledge in each class.

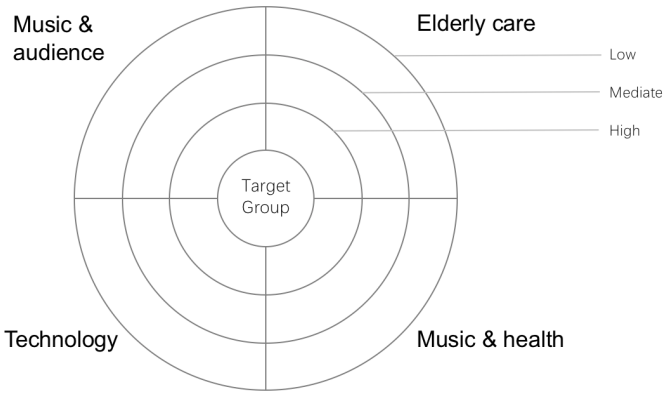

Figure 3: Diagram design

3.2 Understanding the users

3.2.1 Interview

User interviews are where a researcher asks questions of and records responses from users. They can be used to examine the user experience, the usability of a product or to flesh out demographic or ethnographic data (for input into user personas) among many other things.

In this project, the object of conducting an interview is to investigate:

- If using IoT design with music is a beneficial solution for both older adults and their caregivers and relatives
- How the older adults access music in their daily lives
- What factors can be potential obstacles for older adults to access music

Before the interview, the hypothesis was that the following issues could be potential obstacles for older adults accessing music. So that their autonomy will reduce and affect the wellbeing:

- Unsuitable activities
- Difficulties of using and learning technology
- Insufficient communication with workers in elderly care and families

Based on the hypothesis, a semi-structured interview was conducted in order to get knowledge of the users and define the user needs. Two workers from a care home have participated in this interview: one is a nurse with 17 years of working experience with dementia people, and the other one is a project leader that working with different projects in the health area, and most of them

are related to the health of older adults. The primary language used for the interview was English. To make better communication with the interviewees, a Norwegian speaker joined the interview as one of the interviewers, so that interviewees were feeling free of answering questions by either Norwegian or English. A conceptual prototype that created based on the hypothesis to the research questions and previous research was introduced to the interviewees. The interview was audio-recorded and transcribed for this study. Informed consent was offered to the interviewees and signed (see Appendix A.2).

A conceptual prototype related to music selection and communication was brought to this interview and explained to the interviewees in order to test the hypotheses "Difficulties of using and learning technology" and "Insufficient communication with workers and families could be potential obstacles for older adults accessing music".

3.2.2 Data analyze

Several coding methods were used in different rounds of data analyses. Coding is one way of analyzing qualitative data. The portion of data to be coded during *First Cycle coding* processes can range in magnitude from a single word to a full paragraph to an entire page of text to a stream of moving images. In the *Second Cycle* coding process, the potions coded can be the same units, longer passages of text, analytic memos about the data, and even reconfiguration of the codes themselves developed thus far.

Holistic Coding is an attempt “to grasp primary themes or issues from the data by absorbing them as a whole rather than by analyzing them line by line [49][50]. It is applicable when the researcher already has a general idea of what to investigate in the data [51][50]. It applies a single code to each large unit of data in the corpus to capture a sense of the overall contents and the possible categories that may develop [50] and it is usually used as the *First Cycle* or *Second Cycle* coding methods.

Axial Coding describes a category’s properties and dimensions and explores how the categories and subcategories relate to each other[50]. By applying this method, the number of initial codes which were developed in the earlier stage can be reduced by grouping similarly coded data. It can simplify the procedure of sorting and relabeling codes into conceptual categories.

To analyze this interview, a *Holistic Coding* was conducted in the first cycle coding. Initial content was divided into four parts: activities, music listening, technology and feedback. This method was used once again in the four parts of contents, in order to discover more themes and details that related to the hypotheses. Afterwards, the method *Axial Coding* was used in the second cycle coding for sorting and relabeling themes.

3.3 Design methods

The user-centered design method was used to gather as much information as needed to form assumptions. By using this method, some of the useless concept and sketches were removed before the design phase. Involving users in an early stage of the design can reduce the risk of creating unnecessary features. The Lifecycle Model [52] is used in the whole procedure of the interface design, including testing prototypes, designing alternative interactions and visual elements, and redefining the user requirements.

3.3.1 The iterative design process

Iterative design is a design methodology based on a cyclic process of prototyping, testing, analyzing, and refining a product or process. It is a way of confronting the reality of unpredictable user needs and behaviors that can lead to sweeping and fundamental changes in design. Iterative design is commonly used in the development of human-computer interfaces. The benefit of using iterative design method is it allows designers to identify usability issues in the user interface before putting it into wide use. In this study, this method was used to identify usability problems of prototypes and to make iterative prototype to answer the research questions.

3.3.2 Personas and scenarios

A persona is a representation of a type of user. It answers the question of "Who are we designing for" and it helps to align strategy and goals to specific user groups. In this design, the aim of using persona is to define the main user group, give a clear picture of the user's expectations and how they are likely to use the design (see in Appendix B). Using personas offers a quick and inexpensive way to test and prioritize those features throughout the development process, and can help designers develop informed wireframes and interfaces.

Scenarios are used in both of the prototyping and usability testing phases. In the prototyping phase, the task-based scenarios (see Appendix C) help in defining the architecture and content of the design. In the usability test phase, the task-based scenarios (see in Appendix F.1) give users a reason and a goal for going to the design and shows how users will use the application to accomplish the goal.

3.3.3 Prototyping

A prototype is a draft version of a product that allows one to explore ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development [53]. Three versions of the prototype were created to study how to let different user groups feel effortless to use the design in this research. The first digital prototype (Appendix D.1) was designed based on the conceptual model, which aims to present the necessary feature of the design. The second one (Appendix D.2) was an exploitative prototype of the visual design of the

interfaces. It aims to shape and improve the user experience by considering the effects of icons, space, layouts, and color on the usability of the design and its aesthetic appeal. The last digital prototype (Appendix D.3) was an improved version which could be used for the usability test.

3.3.4 Evaluation

Evaluations were conducted after the first and second rounds of prototyping. It includes the heuristic evaluation and the expert review. A heuristic evaluation is a usability inspection method, which helps to identify usability problems of the user interface (UI) design. The main goal of the heuristic evaluation is to identify problems associated with the design of user interfaces. The Jakob Nielsen's Heuristics[54] was used for evaluating the digital prototype. Expert review was conducted in each version of the prototype. Participants from different user groups were involved in the heuristic evaluation and felt free to speak their thoughts on the prototype. Feedback and suggestions gathered from the evaluation were used for improving the design.

3.3.5 Usability testing

Usability testing is a technique used in user-centered interaction design, which aims to evaluate a product by testing it on users. To examine flaws in the design, a usability test was conducted with the third version's prototype. According to Jeff Sauro [55], testing five users would turn up 85% of the problems of an interface. Therefore, five participants were recruited from different user groups to the test. Four of the participants were between 25 to 30 years old, and from the "family members" or "workers in elderly care" user group; and the other one was a 58-year-old adult, who will be the future users of the design. Three of the participants knew nothing about the previous versions' prototype, while the other two had a little impression on the previous design.

In-person and remote testing

In-person testing is when the researcher physically in the same room as the participants. The most significant upside to in-person testing is that one can analyze and experience participants' body language. Remote testing is done via the internet. It is cost-effective and offers great access to the target audience. Moderated and unmoderated testing are two different methods that one can use when conducting a remote usability study. Facilitators can ask questions for clarification or dive into issues through additional questions after tasks are completed. In the moderated testing, it allows for back and forth between the participant and facilitator, because both are online simultaneously, while in the unmoderated testing, tasks are completed alone by the participant, and there is no opportunity for facilitators to ask detailed questions specific to the user's actions. In these five usability tests, the first three tests used the method of in-person testing, while the fourth one (the test with the older adult) used the method of moderated testing because of the geographical issue. The last test was conducted by using the method of unmoderated testing because it was difficult to reach consensus with the participant regarding the test date. The participant completed all the

tasks independently and offered written feedback on the test.

How to recruit the older participant?

The best way to reach older adults over age 50 is to start with personal networks because they are especially wary of scams. It was found that these approaches did not work well for recruiting older participants:

- Community web sites, message boards, or chat sessions. Older adults tend not to take part in these groups, so posting ads in those places is not a fruitful way to find participants.
- Flyers at a senior center, when they did not make clear that we were recruiting for a study. Many older people are much more cautious and skeptical than younger people. They are often fearful of being cheated or "taken."
- Cold calling from a database. This is probably again because older people are afraid that they may be scammed into buying something.

These approaches did work well:

- Calling with a personal connection. If we could say that a mutual acquaintance had suggested the contact, potential participants were much more receptive to hearing about the study and considering taking part.
- Being careful in the initial call to say where we had gotten the contact information and that we weren't selling anything.

As older adults are a vital user group in this project and have some difficulties to recruit, finally, one of my relatives has been chosen to complete this test through the use of Skype.

4 Results

This chapter presents all the results of the user research. Chapter 4.1 describes how the target interviewees are selected, and 4.2 displays the interview results according to three aspects: music activities, music preference and selection and suggestions from the interviewees. Chapter 4.3 gives a conclusion of the target user groups and their needs, and Chapter 4.4 introduces a design concept to the readers. In Chapter 4.5, it shows the different versions of prototypes and their evaluation results, and in Chapter 4.6, it concludes the main problems found in the usability test.

4.1 Stakeholders and users

The goal of stakeholder mapping is to discover the prior stakeholders who can be interviewed regarding this project, and to identify the user groups that have a significant influence on the design. Results of the mapping are shown in Figure 4. From the figure we can see that for this musical IoT research project, stakeholders in the individuals' category, such as nurses and family members, need to be closely contacted. Asides from older adults, family members and nurses in elderly care have the most opportunities for trying the design or helping old people in using the design, as secondary users. Both of the two groups have a good knowledge of older people's daily activities, behaviors, and preferences. Project managers and social workers/ volunteers in the elderly care home usually consider the older adults' benefits a lot, so that they may have an interest in knowing and participating in the research. With regard to the research & development engineers, they assert a great deal of power in the decision-making realm of technical issues, but seem to show a low interest in designing or using the final product, so they were categorized into the Latents' group (high power and low interest). For medical doctors, they usually have much power in clinical diagnoses and treatment plans, however, when it comes to music and technology, they appear to have limited power and interest, so that they were categorized into the Monitors' group (low power and low interest). In this analysis, music therapists and musicians were also categorized into the Monitors' group, because their interests of the research may vary from person to person. However, they have the potential to be keep informed in the future research.

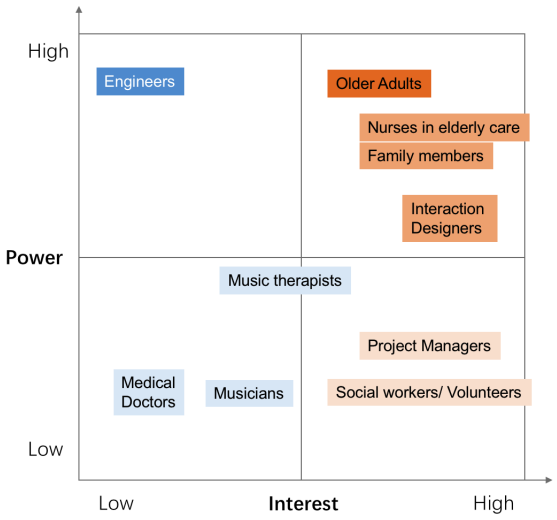

Figure 4: Stakeholders mapping result (Individuals)

4.1.1 Decision of selecting the interviewees

In Figure 5, we can see the knowledge area of the selected stakeholder groups that could be selected for interview. The most potent stakeholders for each category are engineers, music therapists, nurses in elderly care and musicians. Nurses in elderly care were chosen as the target interviewee after the analyzation of the four selected stakeholders.

Nurses in elderly care are knowledgeable about elderly care and healthcare, and at the same time, they integrate new methods and put them into place– as caretakers and trained specialists, they understand the benefit of music therapy and how older people access music. They may know little about IoT technology. However, as secondary users with not in-depth, but general, knowledge and experience in a variety of areas, they will have a high potential in understanding the benefit of integrating music IoT design for older adults and will be the best candidate for the interview. In their daily job, caregivers communicate frequently with older people and work to understand their needs. Nurses working in elderly care have to make decisions about whether they are able to fulfill the older people's requests for help and companionship. By repeating this procedure during their work, they also began to understand the conditions they need to provide adequate care. For the subject of this interview, I chose nurses working in care-giving positions as the target interviewees.

Music therapists' roles depend upon the task at hand, and as part of that task, their position and identity changes according to the setting and the needs of the participants taking part in therapy. They could be therapists and musicians, researchers and teachers. Though they have a high level of expertise in music, health, psychology, and sociology, not every music therapist may have a wealth of

experience with working with older adults. In addition, few are interested in using new technology for their research. A narrow range of research focuses on using music technology in music therapy [56] [57]. Researchers may have demonstrable interest in the design but have few opportunities to apply it in a practical setting. Such limitations add to the difficulty of finding an appropriate person to hold the interview.

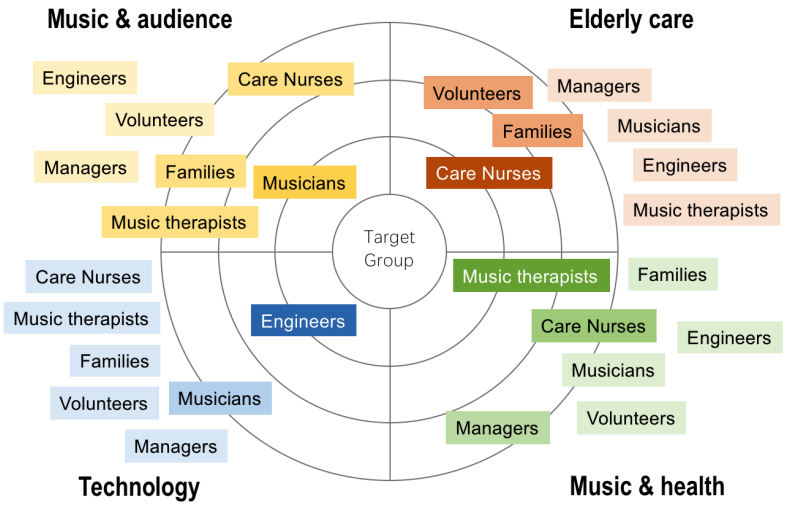

Figure 5: Target group in different knowledge area

Pure musicians may acquire information about music and health by cooperating with specialists such as music therapists, but their work provides them greater knowledge and experience in composing, performing and integrating audience response (in or after their performance). As part of their role, they may play music for older people every day and may have accumulated much experience about how older people are feeling, enjoying, and reacting to music; however, the knowledge gap between elderly care and music health could lead them to make a biased judgment about the effectiveness of the design. Moreover, like music therapists, they will be not the primary user of the design but will in fact have a stakeholder interest in it.

Engineers are distant from other stakeholders in this mapping. They have substantial expertise in the area of technology, but it can only benefit the design on a technical level. They focus on how to use technology to realize necessary functions and offer possible solutions but are limited with regards to their ability to impact people– they have little chance of reaching real users and understanding their needs. In this project, they have limited grasp of all the other categories of knowledge available to them.

Interaction designers should take into consideration the importance of understanding different

fields of knowledge, such as elderly care, music, and technology in this project. Designers can get to know theories from reading research articles but are not always able to promote the target group's experiences as a result of a lack of interchange; the target group seldom converts their experience into articles, and such removed experiences may not offer the best insight. As a result, interviews with a specific user group offers a viable and suitable framework for gathering knowledge about users, allowing designers to translate their lived experiences into sources for further research.

4.2 Interview results

The following passages include the coding result of the interviews and related analyses. The first two categories are related to older adults' music activities, preferences, and selection. Assumptions from the nurses and workers about what is important for older adults has been placed into the last category.

4.2.1 Music activities

From the nurse's response, older adults who live in care homes usually have different kinds of live shows taking place in their canteen. The care home offers a special project for those with dementia: Every 2nd week, one of the two musicians cooperating with the care home will hold a live show for the older adults with dementia in one of their living units. Except joining into music activities, almost each older adult's room has a stereo. So that they can listen to the music either in their own rooms or in the living room with other people by selecting CDs which placed on the living room's shelves. Apart from music the activities and CDs, individuals can also find musical accompaniments on YouTube through the use of a tablet in each living unit. Nurses will arrange the use time for each individual. Moreover, older adults can also listen to music by the radio, but they seldom use it.

The nurse mentioned some positive effects resulting from the older adults' music activities. During the concert, the older people could sing along with the song. When the show was finished, the older adults with dementia would continue singing and humming for the rest of the day. Live music seemingly provided them with positive mental states, such as feelings of happiness and safety. While listening to the music in the living room, they discussed their favorite music type, songs, and artists. When they were in conditions of ill health, listening to music could allow them to relax, calm down, and soothe pains.

Challenges in music activities

Challenges often occur when older adults engage in music activities. The first challenge is, as live concerts are held in a public area, older adults affected by their illness or bad mood will miss the chance of participating in the activity. The second is that most of the older adults cannot use streaming services to listen to music independently on iPads and require nurses to assist them with how to use such devices. The last one is, in each living unit, one iPad may not satisfy multiple persons enjoying their favorite music simultaneously. Identical challenges appear when older adults

listen to the radio.

The part "Music activities" has answered the question "How do older adults access music to enhance their wellbeing". Participating in a live concert, listening to CDs, using music/video apps in iPad are three target ways for older adults to access music. Meanwhile, nurses bear witness to how music enhances the older adults' positive emotions, decreasing their agitation, depression, or ailments and pain.

In particular, as an interviewer, I was interested in the live concert held every two weeks for the older adults. Do they expect another live concert within two weeks? Is a two weeks' waiting time too long? A follow-up email responds: The interviewee believed several of the older adults in the department were so afflicted by illness that their experience of time varied from that of the general population. Their reduced memory leads many of them to deny that they have been to a show like this in the past. As a result, they have lowered expectations for concerts.

4.2.2 Music preference and selection

When asked about how the older adults selected their favorite music, interviewees responded that they could decide what music they hope to listen to before attending a music live show. They could select songs from a music book. Moreover, the staff have used a project aimed at finding the older adults' music preferences. They have asked the elder's families to join the project and delve into what kind of music the elders like and play many CDs to match their preferences at the same time. However, the nurses have replaced the project by using an iPad to search for the older adults' favorite music through apps such as YouTube and Spotify, a convenient method for discovering music preference and selecting new music. Said one respondent, "It may just take a few minutes for us to find their music, but the music will keep them relaxed and calm for a very long time."

By discussing this issue, we can recognize a positive attitude in the staff– they did their best to give the older adults quality music selection, based on their own well of experience and skillset. The nurse conveyed that they had planned to create personal music playlists on YouTube so that each person can listen to their favorite music. When questioned about whether they use Spotify for the elder's daily music listening, the project manager described that they have only attempted one playlist of Christmas songs. The staff expressed a desire to design playlists popular with all the older adults. Table 2 concludes the needs of older adults and workers in the elderly care home.

Limitations of different music tools

During the interview, the nurse expressed a departure from using CDs to detect older adults' music preferences. When asked if there were some MP3 players for elders to use, they said no. In place of traditional methods, the nurses favor music apps on iPads to help the older adults connect to their favorite music. From the nurse's response, we see that, compared to using applications on iPads, using CDs to detect older adults' music preference is relatively time-consuming. From this point, we can see the limitation of the CD. The following part is a comparison of three different music

Music tools	Live concert	CD	Music app	Radio
Music selection ways	Music book	Choose CD	Search in app	Press buttons
Effects of tools	Singing along with songs Positive feeling inside	Leading to a conversation Bring old memories back	Being calm for a long time Find favorite quickly	Do not often use it
Challenges	Not engage every one	Limited number of CDs	Using time is restricted Hard to learn Need help	Buttons are complicated
Older adults' needs	Songs can be sing together	Match their music taste	Simple music selecting ways Individual's favorite music	Simple radio design
Caregivers' needs	Good solutions in activities	Find popular music efficiently	Easy to make song lists System for individual music links	

Table 2: Different music tools and user needs

listening tools.

CD is hardware. For each CD, the content and the order of songs are selected and decided by the creator, so that listeners can only choose their songs by pressing last/next buttons. All the songs will repeat in a fixed order if one does not press any buttons. If a listener has two CDs, A and B, but she likes only Song 1 in CD A and Song 2 in CD B, she has to create a new CD including the two songs. This procedure is time-consuming. It is not a user-centered music-listening solution, and the user may have to recreate a new one with all of her/ his favorite songs. Though listeners can decide which CD they want to play, the real decision maker is the "person in the CD"– the one who designed the music content of the whole CD. So, it is not a "user-centered" music listening method.

When technology developed, iTunes had appeared. It is a media player, media library, Internet radio broadcaster, and mobile device management application developed by Apple Inc. It is used to play, download, and organize digital multimedia files, including music and video, on personal computers. It is an example that brings music listeners to the center. For PC users, they can input their favorite music from CDs and the local document file and download music from Apple Music. They can also create their playlists or albums by adding and organizing music. However, if users are not members of Apple Music or do not pay the song, they cannot access it. Compared with CD, it gives users the right of selecting and organizing music, and also the freedom of skipping any song while using it.

Spotify is a music, podcast, and video streaming service. Apart from its abundant music resources and conventional media playing features, it provides users with the chance to discover music and detects users' music preferences. Unlike music software such as iTunes, which stops playing after the last song in a playlist, Spotify's streaming service can continue playing similar songs to the last song in the playlist. When a user has marked a song as "like", it will be automatically saved into the user's library. If more songs are marked as "like," Spotify will offer more songs that match the user's tastes and preferences. Based on the music types in the user's library, it can create different "Daily Mix" playlists. Users can then pick their favorites and their new discoveries without applying any other effort.

One important thing is that Spotify can automatically generate playlists that match the user's music taste. It relies on its algorithms, machine learning and a number of playlists from users. For example, to generate the playlist "Discover Weekly", it follows the process in Figure 6[1].

[1]Resource of the picture: https://qz.com/571007/the-magic-that-makes-spotifys-discover-weekly-playlists-so-damn-good/

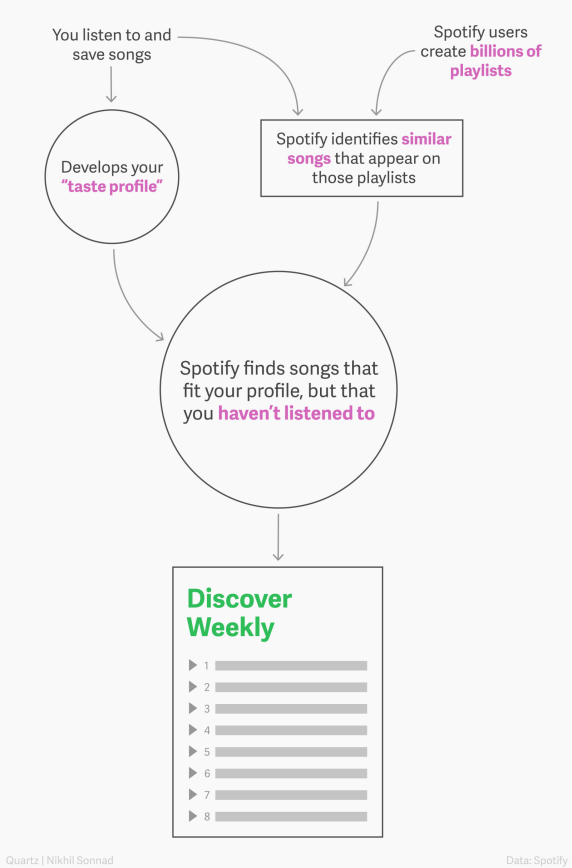

Figure 6: The procedure of creating "Discover Weekly" playlist

User behaviors will lead to the final results of the playlists. By adding songs one likes to a playlist or to the Spotify library, skipping the songs one does not like in the first 30 seconds, and staying positive while trying new features in the app, users may create high-quality playlists.

Compared to iTunes, music content in Spotify is more dynamic, allowing users to enjoy and meet music rather than finding and curating it. However, for older people, Spotify's features pose a challenge due to the interface's high volume of functions. In this situation, IoT can provide a practical solution for their needs. Here we have two design choices for the IoT: The first one is, designing only an ease-of-use physical device for older adults and leaving the system operation for other user groups; and the second is, simplifying the system and allowing access to some older adults. At the same time, other older people can use only the physical device.

Why music IoT design can be a good choice for older adults?

Though the older adults have rights of selecting and requesting for music, they are always hindered by trying new things: some of them are afraid to try new technology, so most of them have to depend on caregivers' help while listening to music. In fact, older adults need to get past the fear of the newness and embrace the technology that can enhance their lives and keep them connected to their loved music while they age in place. Once they do, they realize all of the potential uses and benefits of using smart gadgets [33]. IoT has its advantage in engaging older adults with music: The physical device and software can be operated separately, so the older adults do not need to force themselves to understand a complicated application interface. The IoT can be designed with multiple control methods in order to decrease the elder's operation error. Combining with music recognition technology (such as Soundhound) and algorithmic music recommendations, older adults will be able to search for their favorite music and discover new music without exerting a great deal of effort. The obstacle to using new technology could be decreased by using IoT so that the seniors can access music more frequently. As a result, their mood and health could improve.

4.2.3 Suggestions from the respondents

During the interview, the word "memory" was mentioned for several times. The staff said they use photos, videos, music, and some old objects to wake up the older adults' memories and start a conversation with them. "Anything can bring back memories from the old days is good," the project manager said. At the end of the interview, a conceptual prototype was introduced to the interviewees. Respondents gave positive feedback on it. They thought the operation would be easy for people with dementia because in this way the elders did not need to press too many complicated buttons to play music. At the same time, they think it also benefits workers in the elderly care home for the reason that they will not be forced to create music playlists. They also suggested that we could come up with solutions for older adults who have only physical illnesses living the third floor of the care home, because they tended to be more anxious. Many people on this floor have brought their tablets, smartphones, and laptops from their home, but they could not use them because the care home did not offer them wi-fi on this floor.

From the interview we know now that the staff in care home like to use the iPad as a memorizing tool in order to communicate with the older adults and recover their memories. Using pictures and music are popular ways to start older adults' conversations or interests.

4.2.4 Conclusion of the interview

Again, the research question of this project is: How to use IoT design with music to enable wellbeing of older adults in their living environment, and what should be paid attention to while designing music IoT for them.

We can break the first research question into three concepts: "music, IoT design and wellbeing".

From the workers' talking, the words "music", "picture", "memorize", "help", and "iPad" appeared with a high frequency. From a worker's view, the first question can be answered like "using music and pictures to help older adults memorizing by using iPad is an important way of enhancing their wellbeing".

This interview investigated how older adults access music to get wellbeing and confirmed that music IoT design is a solution that benefits both older adults and workers in the care home. Results showed that difficulties and dependence on help with using complicated technology could be potential obstacles for older adults to access music, which may negatively affect their wellbeing. Part of the hypotheses before the interview have been confirmed: difficulties in using and learning new technology may obstruct older people from accessing music, impacting their autonomy and effecting their wellbeing. The older adults' need for listening to favorite music without effort should also be put into consideration. In the meanwhile, secondary users' needs (workers in elderly care homes and older adults' family members) also should be considered in the design. They try their best to satisfy old people's music needs, but lack of ideas.

4.3 Define the target user group and their needs

Three interviews were analyzed to define the target user group and their needs. In addition to this interview with a nurse and a manager who work in an elderly care home, two previous interviews were also used for defining the user needs. Interviewees of the two interviews were a social worker in an elderly care home and a daughter of an older adult.

4.3.1 Target user group

The result of target user groups are as follows:

- Older adults who are over 60 years old and live in a care home or usually stay at home
- Family members who concern about their old parents or grandparents
- Nurses/social workers who work in the elderly care centers or older adults' homes

Why these user groups?

From the three interviews, we have got sufficient information about the older adults' challenges in approaching music. The main challenges are:

- Difficulties in using applications with a complicated interface. For some older adults, they usually use their own portable devices (such as laptops and tablets) to listen to music. However, some of them only have basic knowledge about how to operate the device and struggle with simple tasks (such as the actions of taping buttons, scrolling a page, swiping pictures, and using the home button), experiencing difficulties navigating loaded interfaces. Moreover, some physical ailments such as inflexible fingers and impaired vision leave older people more

prone to error than young people while using an interface.
- Difficulties in learning new things. As people get older, their memory begins to decline. For older adults, it may cost a shorter time to forget what they have learned rather than the time of learning a skill. As a result, some older adults would rather like to refuse new technologies than spend time relearning how to use them. To overcome this, they have to ask for help from other people they could rely on, such as their family members and workers in the elderly care home. What's more, in the repeated-learning process, they also have to ask for help again and again, generating feelings of frustration, depression, and low self-esteem. In the end, they may refuse to use new technologies.

For the older adults' family members, their challenges are:

- Losing patience with teaching older people about new technology. Though they are willing to teach and help the elders how to use mobile devices and applications, some of them may lose patience if the elders still can't remember how to use a device or an application after helping them on many occasions.
- The issue of time and distance for offering help. Some children do not live together with their old parent(s). When their parent(s) meet obstacles in listening to music through devices and ask for help, children usually cannot solve the problem for reasons of long distance to the older adult's home or a lack of time. In this situation, older adults must rely on their own abilities to resolve the difficulties on time.

Nurses and social workers who work with older adults have to take the responsibility of helping them. In addition, they also have to come up with ideas to make the older adults' day happy and meaningful. Their challenges are:

- Lack of efficient ways to find the older adults' music preferences. From the interview, we already know that using CDs and collaborating with the elders' family members to find the older adults' music preferences is costly. However, when they have new ideas about music listening, it cannot be realized in time because of limited resources (e.g. equipment, system and environment).

4.3.2 User needs

The needs of the target group are concluded based on their challenges. The results are listed as follows:

- For older adults, they have the need of selecting and listening to music with fewer difficulties and errors.
- For family members, they need a solution to offer help remotely to the older adults, who have difficulties in using music devices or applications.

- For workers in elderly care home, they need solutions of building both popular and personal playlists for older adults, which can afford the older adults' needs for activities and positive emotions.

Based on the target user groups with their challenges and needs, three personas were created representing the different user groups respectively (see in Appendix B).

4.4 Design concept

After discovering the user needs which was based on the interviews, a design concept was created by brainstorming and sketching. Two conceptual scenarios are created to develop the conceptual model of the product (see Appendix C). Each one is written to meet a specific user requirement. The first scenario describes how an older adult can listen to music through the product by themselves. The second one expounds how a nurse or a family member helps an older adult to build their favorite playlist and how the older adult enjoys their activity. The conceptual model is in Figure 7.

One older adult can start listening from one song by using a music device and keep listening without time constrains until they want to stop. They can start one song either by voice search or press the play button and get a random song. With the device, one can mark the song as "like" or skip the song one does not want to listen. The songs listened by the older adult will show as a history in the app, so that his/her family members and nurses can check it and make new song lists based on the history. At the same time, the app will learn the older adult's music taste and discover similar songs and new song lists for him/her.

When the older adults in a situation of forgetting how to operate the music device or having made an error which stopped the object from working, they can notice one of their family members or nurses to log on to the app and solve the problem in time, even if they are not residing in one area.

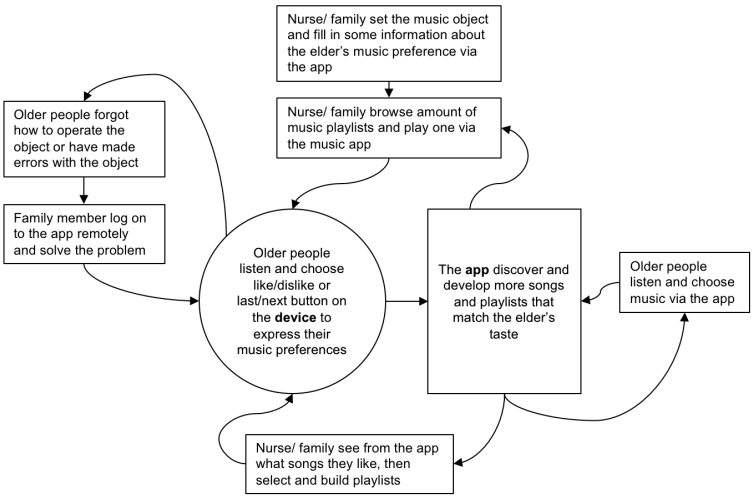

Figure 7: Conceptual model of the design idea

The concept of the music device– "Music Ball"

Figure 8 has described the concept of the tangible music device. It aims to assist those older adults who are not be able to use the application on the mobile phones or tablets– they may have no experience or have fears of using mobile devices, or may have fatigable visions, which lead them difficult to stare at the mobile device screens for a long time. The main goal of the music device is to arouse the older adults' interest of exploring their favorite music, and to get the data of older adults' music preferences.

The music device is a sphere and its size is easy for users to hold by one hand, so it has been given the name "Music Ball". There are two options for users to listen to music (see the Figure 8). One is called "Station". When users choose this option, the device begins to play songs that the users may like, and users can mark these songs as "Like" by pressing the heart-shaped "Like" button or skip their disliked songs by pressing the "Next" button. The other option is called "Favorite". When users choose this option, they can only listen to those songs which have been marked as "Like" by themselves. In addition to this, users can also search a song by speaking or singing though the microphone on the device. When the device finds the song successfully, it can play the song automatically.

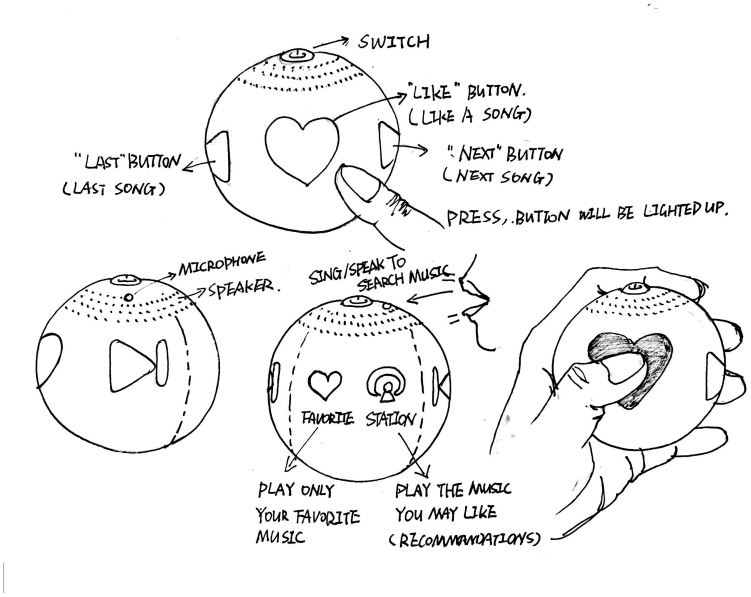

Figure 8: Concept of the music device

Why this concept?

There are three reasons for choosing this concept. The first one is that older adults can have an alternative if they know little about how to use music applications to listen to music on smartphones or tablets. They can use the music device instead of the application and still have the right of picking their favorite music, which may keep them in a good mood for a long time. Older adults skilled at operating applications on portable devices can benefit from an ease-of-use interface, which can reduce their fear in using a new application. The second reason is that family members and nurses who work with elders can easily build music playlists in the app based on the songs preferred by the older adults. The last reason is that when the older adults meet problems about using the music device, other users who have already connected their app with the object can operate it remotely without the limitation of time and space. So, it is a solution for benefiting all the target groups.

A complete IoT system integrates four distinct components: sensors/devices, connectivity, data processing, and a user interface [58]. Sensors or devices collect data from their environment, and a user interface make information useful to the end-users. In this concept, the music device is used for collecting the users' music data, and the music application makes such data visible, and the users also be able to perform actions and affect the music system. As we talked in Chapter 4.3.1, three user groups are the target users of the design and all of them can use the music application to perform actions, so in the following research, it turns to focus on the user interface design of the music application, and especially pay attention to what kinds of interface design that older adults can adapt to quickly. In this situation, the research question turns into:

- How to design a music application that can be easily used and learned by both the older adults and their care givers?

4.5 Prototyping and evaluation

Based on the conceptual model, the first version's prototype of the music application was built and evaluated. Based on the evaluative result, multiple versions of some specific interfaces were created and evaluated. After that, an improved clickable prototype was created for the usability testing.

4.5.1 The first round of prototyping and evaluation

The whole prototype is in Appendix D.1. The main functions of this prototype are:

- Connecting, operating and showing data of the music object
- Defining the user's music taste
- Offering amount of song lists and dynamic music playlists based on the user's music taste
- Searching music
- Collecting and creating song lists

Heuristic evaluation was conducted with three participants. Some important results of the evaluation are as follows:

Visibility of the system status

For the visibility of the system status, the fixed menu can keep users informed what status they are in and what they can do. However, in some pages, there were some errors about the links, which led the participants to exhibit signs of confusion and start to click buttons at random. As a result, they lost their navigation in the application.

Consistency

Consistency is a design principle that emphasizes the importance of uniformity in appearance, placement, and behavior within the user interface to make a system easy to learn and remember [57]. The biggest problem in this prototype is a lack of consistency.

- Buttons are inconsistent. In the first three screens, the buttons were not in the same position, and not in the same style. It was very tiresome for a user to go through the same kind of content up and down and with more than two different colors. There should be a rule of placing different elements consistently.
- Shapes are inconsistent. The inconsistent use of shapes and symbols generated confusion for the participants. For example, one participant thought the pictures of albums should always keep the same shape, but in this prototype, the album picture was a circle in the song progress

bar and changed into a square in a playlist. The use of different shapes should fulfill the design goals and context.

- Flows are inconsistent. A card view of the music player with the metaphor of a record appeared all of a sudden without any reasons in the functional page "Radio". It is not clear to users how they have chosen the song which is playing. It may make users doubt about what they have done in the last step and what they can be done in the next step. Users should not have to wonder whether different words, metaphors, situations, or actions mean the same thing.

Context and text

In this version's prototype, the word "Radio" represents the function of offering infinite-dynamic music playlists. When users clicked it, a record player pooped up and started playing music. Two participants thought that though the symbol of the record player worked well with the context of playing a song from a song list, it could not express what the word "Radio" means when one clicks this word in the menu. What's more, the word "Home" did not describe the identity of the content in this page very well. In the menu bar, there were four functions: searching for music, checking user profiles, browsing and listening to music playlists and listening to random music based on some qualifications. The word "Home" corresponds to the function of browsing and listening to music playlists, but participants could not build a connection between the two terms. The texts of different functions and metaphors should be considered twice, and all information should present itself in a natural and logical order.

4.5.2 The second round of prototyping and evaluation

The second version's prototype was created based on the evaluation of the previous version's prototype. Multiple versions of interfaces have been designed and evaluated regarding some specific tasks (see Appendix D.2). Eight participants age from 23 to 58 were involved in this evaluation. After being introduced with the application's concept, they were asked to choose their favorite design among the multiple versions of interfaces in some specific functional pages.

Display of information

"*Song lists*" *page*

The page "Song lists" offers different categories of music playlists created by other users. Figure 9 shows three different ways of displaying the information of song playlists (from left to right: Interface 1, Interface 2, Interface 3):

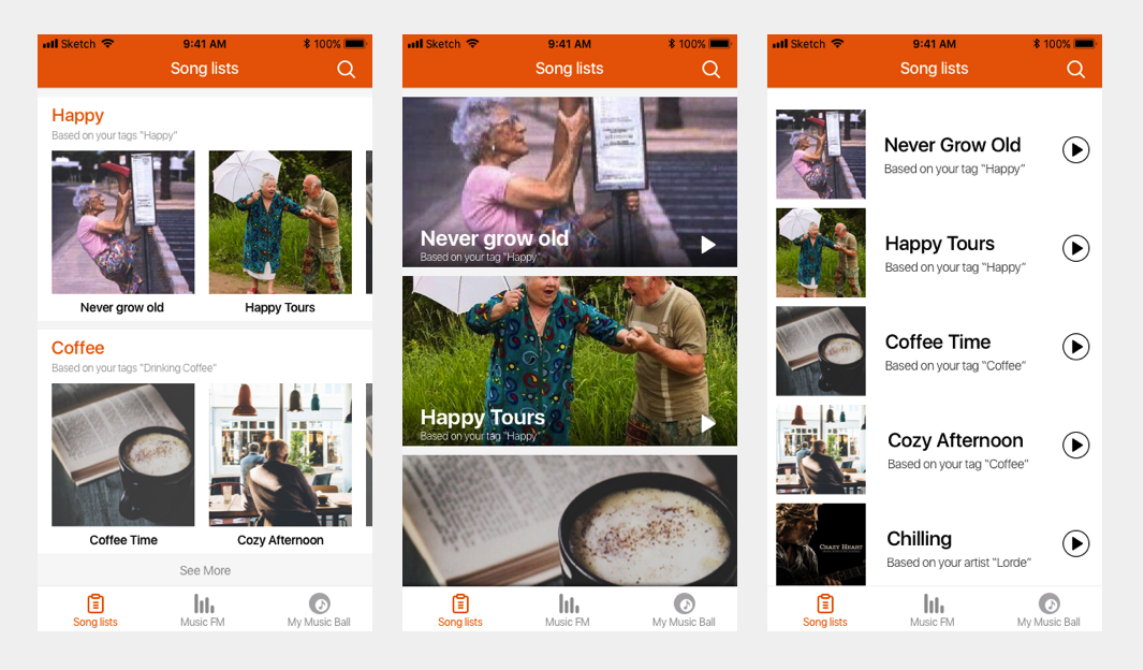

Figure 9: Song lists

The assumption was that most participants may like Interface 2. However, the fact is, five out of the eight participants preferred Interface 3 for its clarity of information display. In their opinion, it had all the necessary information and was easy to navigate and control. One of the five participants thought it would be better to categorize all the song lists like the format in Interface 1.

Some participants thought Interface 2 was appealing, but it offered less information compared with the other two interfaces. Another problem with the second interface was that it could be hard to maintain the harmony of all the pictures in the song lists when additional content showed itself.

Some participants thought the arrangement of the playlists in Interface 1 looked like a grid-layout. Compared with Interface 2 and 3, Interface 1 looked more complicated and difficult to navigate. In Interface 1, users had to scroll vertically and swipe horizontally to go through more contents, but in Interface 2 and 3, users only needed to scroll vertically to see more contents. Another flaw of Interface 1 was that it did not have a play button on each cover of a playlist. Users can not listen to music directly by clicking the playlist.

"*Music FM*" *page*

The page "Music FM" gives users a chance to meet more music they would like to listen to. It includes many music channels created according to the users' preferences and offers music of different

genres. It is not a real FM radio but has the same concept in mind: the content is dynamic, continual and unpredictable. Figure 10 shows three different ways of displaying Music FM channels (from left to right: FM 1, FM 2, FM 3):

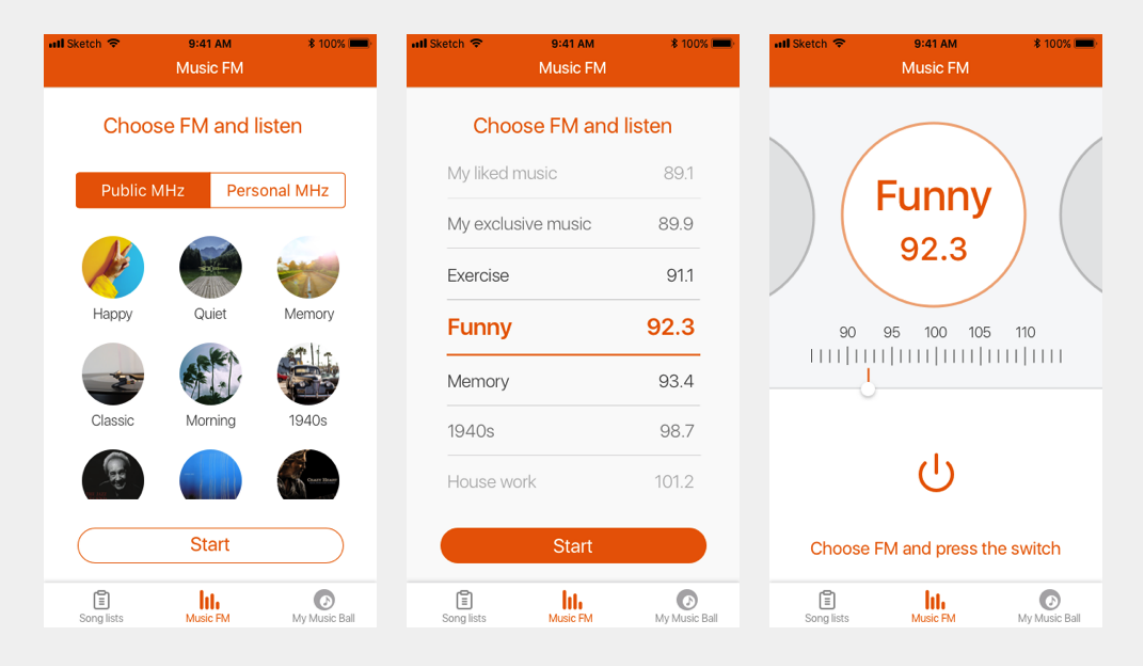

Figure 10: Music FM channels

FM 1 used a grid layout to present all the channels with big pictures and small titles. FM 2 used a vertical-carousel-list layout to display all music channels. Different from FM 2, FM 3 used a horizontal-carousel way to show music channels with big titles. The assumption was that participants would like FM 1 or FM 2.

The results of the evaluation showed that most of the participants preferred the design of FM 2 for its presentation; they were able to receive rich information with a simple gesture of scrolling. Its size and color of a selected channel were also noticeable. However, a few of the participants believed that the numbers on the right side of the channels were not meaningful and did not provide ease of access for leading users to build a connection with the real FM radio channel. Moreover, they thought that FM 3 had the same flaws with FM 2. The interface FM 1 gives users a feeling of engaging with a funny and playable interface, but presents more difficulties to navigate efficiently than the interface of FM 2.

In conclusion, three points need to be noticed while displaying music playlists and channels: Firstly, a vertical layout is a better choice than a grid or horizontal layout. Secondly, the gesture of brows-

ing content should be kept simple and avoid multiple types of gestures. Lastly, the text should be straightforward and positioned according to user need. At the same time, misleading words should be kept to the minimum.

Design of graphical elements

Name and logo of the application

The name of the application is called "Music Ball", which aims to keep consistent with the music device– enjoy music in a playful way. Three different versions of the logo (Figure 11) were created based around this name. As the designer, I personally believe the third logo is better than the other two because it feels clickable and can be used as an icon in the app. Moreover, it can give users the feeling of touching a ball, which can lead them to think of the music device.

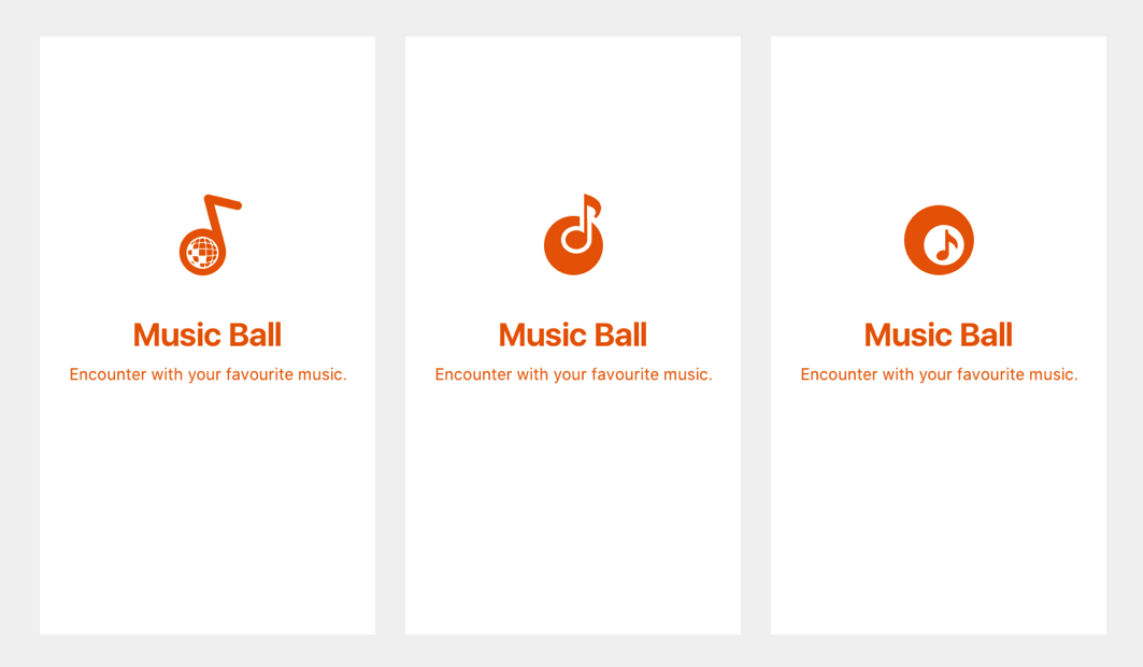

Figure 11: Logo of the app

The evaluation result showed that both the second and third logo could give users the feeling of touching a ball. The third logo tended to be funny and resembled a real object. Compared with the third logo, users thought the second logo was more explicit in expressing the theme "Music Ball" with a concise visual language. From the result, we can see that the use of shapes should fit the identity of the application. Also, the combining form of shape in a logo should be simple and make the logo easy to communicate with users.

Button

Figure 12 is an example of button design for this application. From left to right, we number the interfaces as 1, 2, 3 and 4. For 1 and 2, they use the same style of buttons with texts "Register" and "Sign in". In interface 2, the button "Register" was filled with orange instead of the color of white, which aimed to emphasize the action of registering was more important for new users than signing in. The hypothesis was that more user may like interface 2 better than 1 for it gave users a suggestion of the action priority– they could know what to do instantly without wasting too much time in making decisions. Interface 3 was created to investigate if the use of text would affect the users' preferences of buttons. The text "Register" was changed into "Create an account". Interface 4 placed the two buttons vertically, which aimed to give users more design choices.

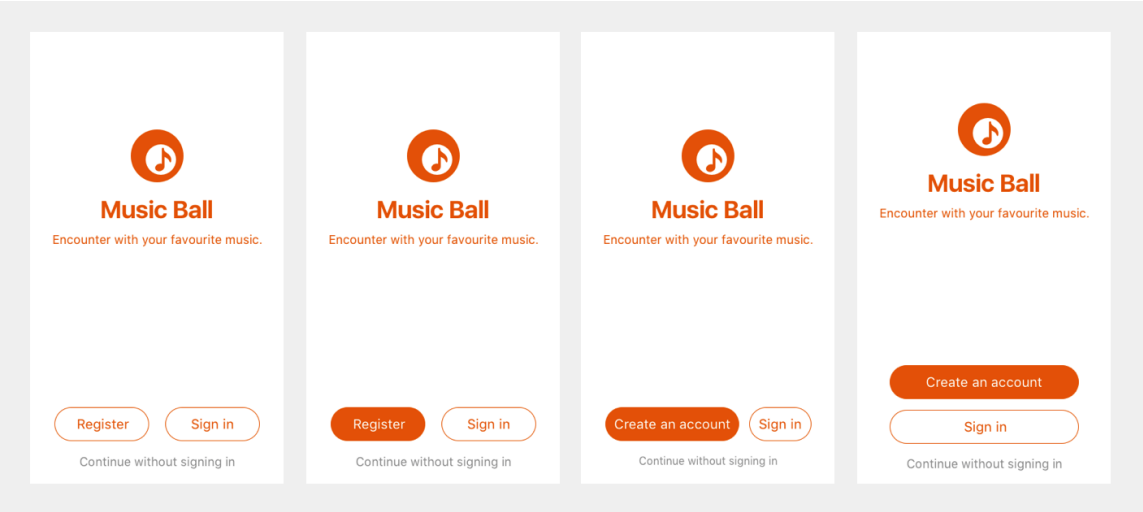

Figure 12: Sign in and register

For the participants who liked the horizontal layout (interface 1, 2 and 3), they preferred 2 better than 1 and 3, because they could tell different actions quickly and make fast decisions. When it came to texts, most people preferred "Create an account" better than "Register" for they could know what would happen precisely– only creating an account without doing any other things. However, in the end, interface 4 was liked by five participants and became the most popular one. The first reason was that the two buttons followed a top-down browsing sequence, which fulfilled the participants' browsing habits. The second reason was that most of the participants had experience in using similar interfaces in other music apps.

Progress bar

Two versions of the music progress bar were created (Figure 13). The black music progress bar showed the music progress with an orange bar, while the white one used an orange line.

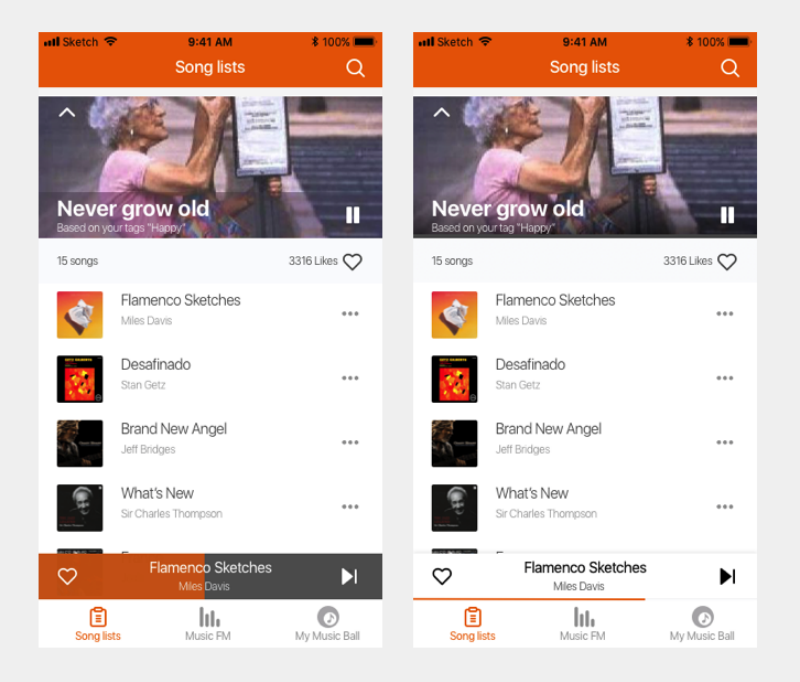

Figure 13: Music progress bar

Six participants chose the white bar, while only two people chose the black one. The six participants thought the white bar looked tidy and clean, and it was bright enough to see the music progress, but the other two thought it was not noticeable. What's more, they thought there could be a relationship between the orange progress line and the orange icon "Song lists". Comparing with the white one, they felt the black one to be more functional.

In summary, when designing graphical elements for this music application, three points should be paid attention to. Firstly, for symbols, the visual language should be consistent with the text to help users understanding the context quickly. Secondly, when there are two or more action buttons with the same style, it can be better to use different colors to prioritize the actions. Lastly, under the premise of maintaining usability, aesthetics could take priority over function.

Use of metaphors

Metaphors provide a structure that is similar in some way to aspects of a familiar entity (or entities) but also has its own behaviors and properties [52]. From the interviews we already know the older adults were familiar with the CD player and radio. Therefore, in this version's prototype, radio was chosen as a metaphor to build a relationship with the music FM function (Figure 14).

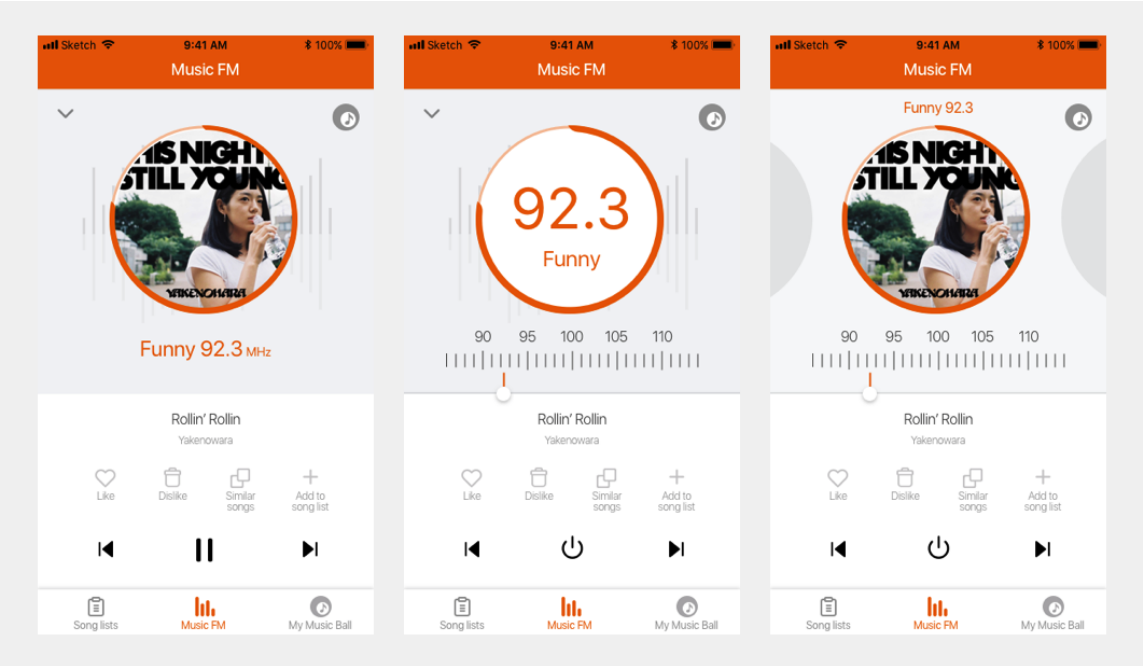

Figure 14: FM card view

The result showed that after choosing a specific music channel and turning to the ongoing-music page, users did not pay too much attention to the channel's name and its format, but with a concentration on the cover picture of a song, though they felt the metaphor of radio was appealing and evocative. Another issue of the metaphor was, it was not consistent with the music-player page (see Appendix D.2, Figure 23). Most of the users considered that while playing a song in the music FM functional page, the card view should follow the similar style with the music-player page.

4.5.3 The final round of prototyping

The final prototype was created based on the second round's interface evaluation. Final decisions of some specific interfaces are displayed in the prototype (the link is in Appendix D.3). Evaluation of the results will be explained in the usability testing part.

4.6 Usability testing

The goal of the usability testing was to discover and fix major usability flaws in the prototype of the music application. The testing aimed to study how users interact with the interfaces through doing four specific tasks. Task 1 was about testing the functions of signing in, connecting the music device to the application and choosing music preferences. Task 2 aimed to investigate how the users play a specific song list and explore the card view of a song. Task 3 focused on exploring how the users navigate to a specific music station. The last task was about letting the users find the listening history and add one song from the history to a specific song list. The usability testing tasks and notes can be seen in Appendix F.

4.6.1 Usability problems

By analyzing the testing notes and observations, it was found that most participants completed Task 1 and Task 3 smoothly but had difficulties in completing Task 2 and Task 4. Most of the participants tended to make more errors when they were doing the following tasks.

Connecting the Music Ball to the app

In Task 1, participants had to sign in and connected their music device to the app. Three participants completed this task without any hints or questions, while the other two met with some difficulties. Participant 3 got stuck in the guide page: he wanted to connect the music device with the app by tapping the "Music Ball" icon in the onboarding screen (see the first interface in Figure 15). He thought if he could not finish any tasks in this interface, then the interface had no excuse to exist. Participant 5 also wanted to connect the music device by tapping the icon, but her action happened in the final step (the last interface in Figure 15). She knew that tapping the button "Connect" is a right choice, but she thought it would be better to make the icon work too.

Other participants also expressed their opinions while doing Task 1. Participant 1 thought the onboarding screens should appear after signing in, and Participant 4 thought there should be a "Skip" button in the guide page because it was not necessary to everyone. He also thought the guide page could be put into a "Help" page instead of placing it in the beginning of the application. So, is it necessary to keep the onboarding screens?

Onboarding is a human resources term that was borrowed by UX designers and is defined as a way of making someone familiar with an app. Onboarding screens demonstrate the benefits or value the user will get from the app, teach the user how to use the app, or show users new information as they progressively navigate through the app.

In this music application, the two onboarding screens aim to tell users what they can do with the music object by connecting it to the app. It looks like instruction of the whole product. Before the test, I thought these screens could help users understand the application better. However, as there were some flaws in the onboarding design, it did not offer enough help to the users in the test. For

young participants, they would rather skip it than read it. For the older participant, his insufficient experience in using app onboarding made it hard for him to understand this function. Also, the test result showed that the participants generally thought the app was easy to learn and understand, so I think the onboarding can be removed from its original position.

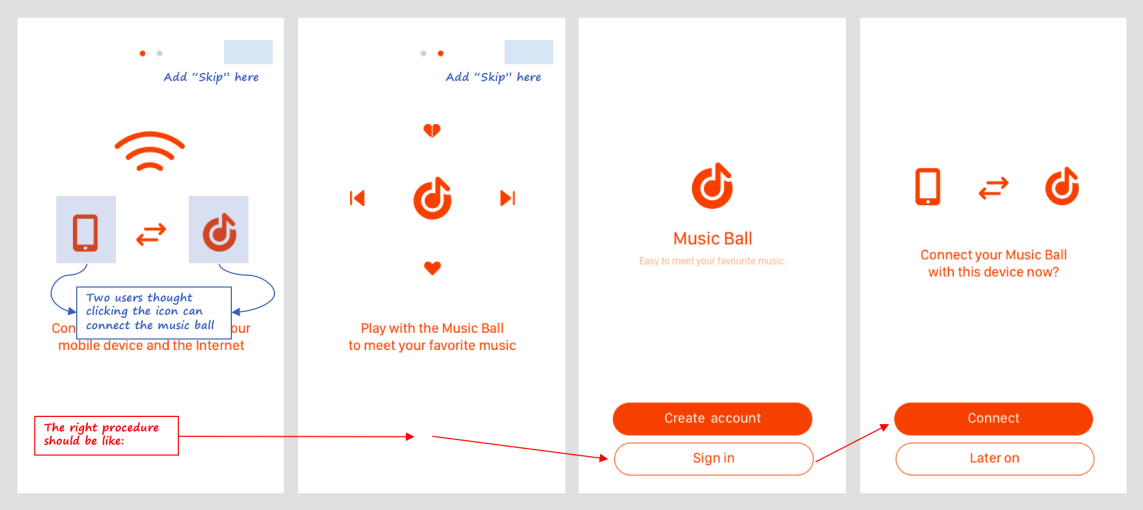

Figure 15: Sign in

Play a specific song list

Task 2 required users to find a specific song list and play it. Figure 16 and 17 shows the two ways of playing a song list. The first way is (Figure 16):

1. Click the play button beside the name of the song list (e.g. position 1 in the first song list);
2. The music player shows up and starts to play the first song in the list.
3. User can browse any other contents while the music is playing (e.g. click position 2: see the preview of the first song list).
4. If a user goes to the detail page of a song list, he/she can see the playing status of the song list.

The reason of putting a play button in each song list (marked as position 1 in Figure 16) is, I supposed, for some users, they may start listening from the first song even if they have seen the preview of all the songs in a song list. Therefore, the play button gives them quick access to playing songs. In the task "Play the first song list", three of the five participants chose to tap the play button instead of tapping the name or the cover picture of the song list at first. However, all of them finally changed to tap the name of the song list. What made them change their behaviors?

When participants tapped the play button, they did not get enough visual feedback. Though the

music player popped up after the play button was tapped, most of the participants did not notice that. Hence, they tried to find another way to complete this task– tapping the name or the cover picture of the song list. Based on the participants' feedback and the designer's own observations, I think there are two reasons why users ignore the music player. The first one is, the color of the music player is blended with the white background color, so it is hard to catch user's attention. The second reason is, the users' browsing gestures may make the music player invisible. Three participants keep the phone on the desk. When they were interacting with the prototype, their hands almost covered the bottom part of the screen. As the music player's position was on the bottom of the interface, it was easy to be ignored. Besides, I think the lack of sound feedback leads users hard to catch what has happened after tapping the play button. As a result, they still focus on the song list and could not remove their attention to any other positions of the interface.

To fix this issue, I think when a song list is playing, the play button should be changed into a pause button (marked as position 3 in Figure 16).

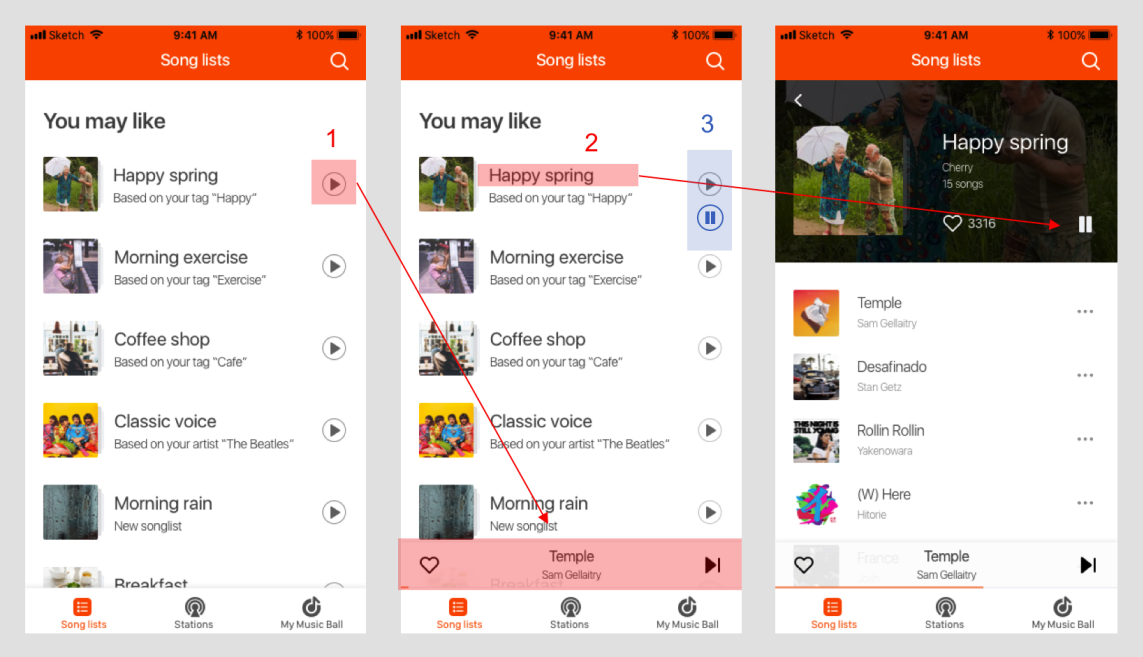

Figure 16: Play a song list 1

Figure 17 shows the second way of playing a song list: press the song list's name– go to the preview page– press the play button or start by pressing any song's name in the list. Two of the participants followed this step from beginning to end to complete the task of "Play the first song list". By this way, participants noticed when the music player came out. One participant thought the music player should also appear when she clicks a song's cover picture.

Comparing the two ways of playing a song list, the first one seems to be convenient, but its interaction design does not give enough feedback to the users; while the second one is a generally accepted way for users to play a song list, and they can control the entire procedure without over thinking, hesitation or asking questions. Is that mean in the "Song lists" page, the play buttons should be removed? I think this is not necessary, because by improving its visual feedback design, it can give users a chance to get quick access to playing music. The play button introduces an element of chance— the pleasant possibility of running into something surprising and good [59].

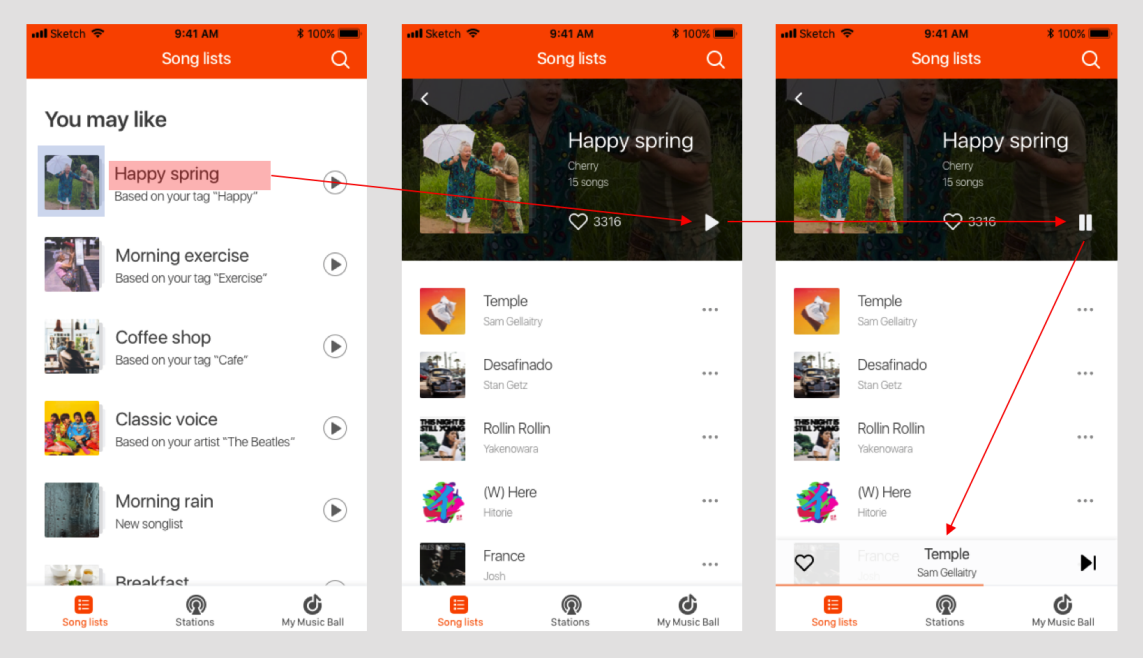

Figure 17: Play a song list 2

Explore the "song station" icon

One subtask in Task 2 was letting users explore the "song station" icon, but all of them were failed in completing this subtask. Four participants collapsed the music player and navigated to the menu and tapped the "Stations" in the menu. The reason was that they thought the word "station" in the task referred to the icon in the menu. One user did not try the "song station" icon because she was not sure about what would happen after tapping it. When they finished this task, I introduced to them how to use all the five icons in this interface (Figure 18). Participants generally reflected that the icons "like", "dislike" and "add to song list" were easy to comprehend, while the other two were difficult to understand.

Figure 18 displays the design of the music player interface. Apart from the control buttons, there

are five interactive icons on this interface: like, dislike, see the similar song list, add song to a song list and start the song station. There is a difference between the concepts of similar song list and song station: in the similar song list, users can only listen to limited numbers of songs which in a similar style, and the content is fixed. In the song station, the next song will change based on users' reaction (like/dislike/skip/add to playlist/no reaction) to the ongoing song. When a user taps the icon (marked with a red frame in Figure 18), a toast notification (the black information boxes in Figure 18) is used to notice a user the ongoing action. The user can stop using the function by tapping the icon again.

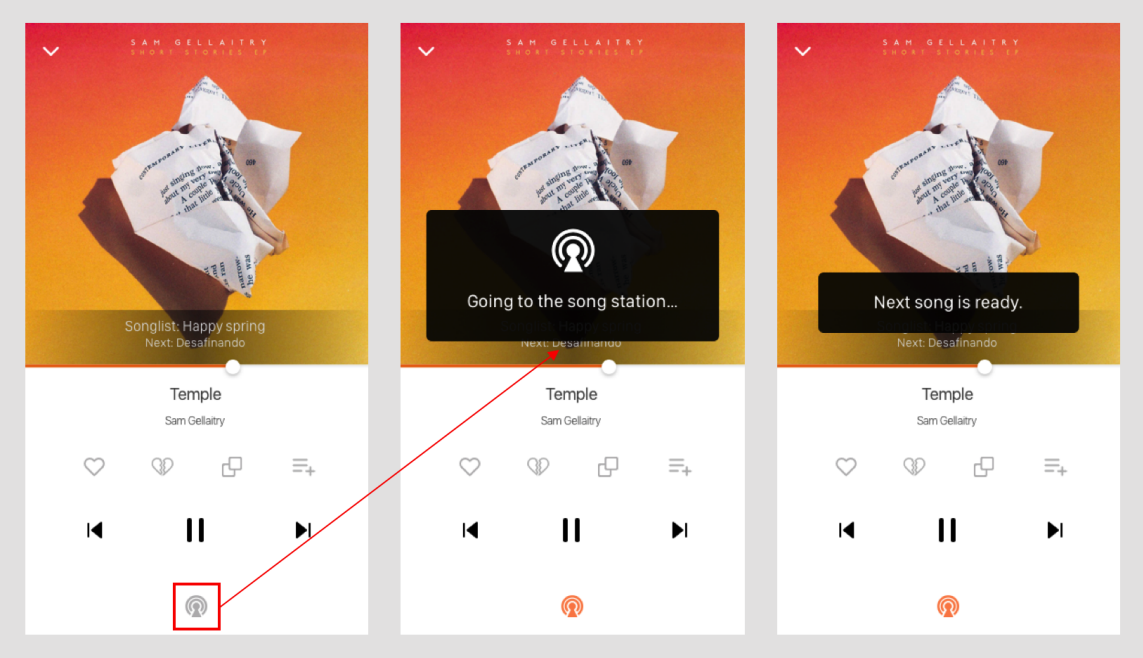

Figure 18: Music player interface

Add a song from listening history to a song list

Task 4 required users to find out where the "Listening history" located and added one song to a specific song list. The whole procedure for completing this task shows in Figure 19.

In the task "Check listening story", three users went to the "Song lists" menu at first, but didn't find the "Listening history". Then all of them went to the menu "My music ball" and found the target successfully. One user thought the word "song list" in the task description leading her to tap the icon "Song lists" (the blue position in Figure 19).

When they did the task "Add song 'Yukizakura' to the Song list 'Breakfast music'", one user did not know how to complete the task at first. But after several attempts, he added the song to the song

list successfully. Based on my observation and the conversation, I think his mental schemes made it difficult for him to finish this task: he wanted to find the song list "Breakfast music" first, and then added the song to the song list. It is opposite to the procedure shown in Figure 19 (follow the red arrows in the figure). Apart from the tasks, one user suggested that the user profile and the "Music Ball" device's profile should be put into a new category called "Settings" or "Profile".

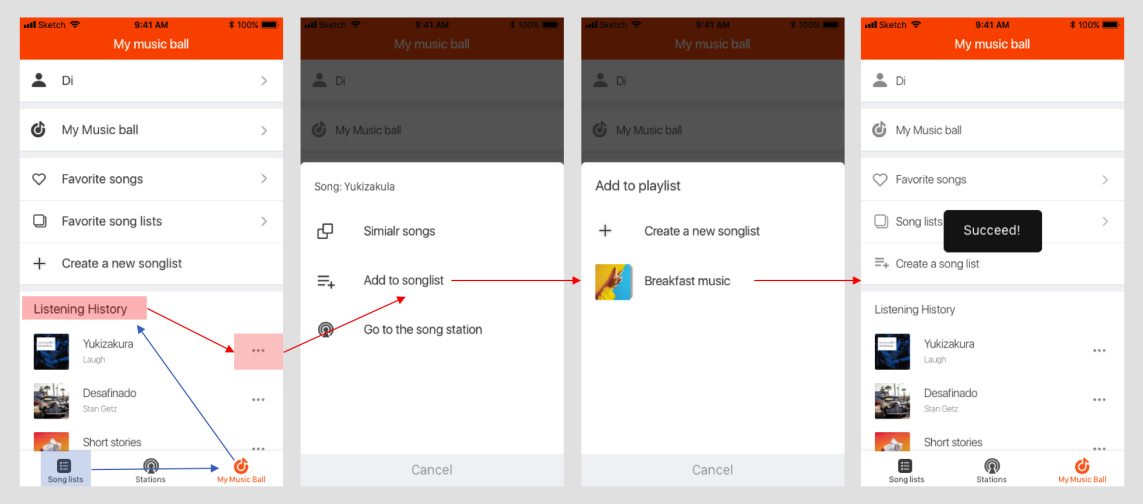

Figure 19: "My music ball" page

4.6.2 Conclusion of the usability testing

This usability test provided much useful feedback, both to confirm the design choices and also to find usability problems. Overall, the users' first impression of the app was clear, natural and minimalist-aesthetic. At the same time, some valuable suggestions were also received from the participants. Moreover, they were curious as to the function and appearance of the music device.

The following lists present what design choices were accepted by users in this test, and what should be improved in this prototype.

Design choices accepted by users:

- Orange color makes a user feel positive and energetic
- Information display by using a vertical list layout is preferred by users
- Fisheye list is easy to navigate
- Pre-selected items help user understanding the interface quickly
- A picture with multilayered-bordered shadows gives a user the sense of a song list.

What should be improved in the prototype:

- Onboarding page should be redesigned and moved into a new category called "Help"
- Play button beside each song list needs to change its status when the song list is playing
- Music player bar should be obvious
- When a user stop using the "song station", there should be a feedback
- In the "Station" page, there should be a button to control the music playing
- User profile and the music device’s profile should be put into a new category

5 Discussion

This chapter reflects on the findings presented and methods used in the previous chapters and relate this to the initially established research questions. In Chapter 5.1, It discusses how this design can enhance the older adults' well-being and what should be paid attention to while designing music app UI for multiple user groups, and in Chapter 5.2, it evaluates the methods and results of the study.

5.1 Discussion of the research questions

5.1.1 The first research question

How to use IoT design with music to enable the wellbeing of older adults?

This question is generated based on the existing knowledge about the relationship among music, wellbeing and older adults, and the older adults' challenges of using new technology. The interviews offer more knowledge about how the older adults access music in their daily life, and what obstacles they might meet while listening to the music. It gives insight into not only the older adults' needs but also their caregivers' needs, which helps in defining the direction of the IoT design. On the one hand, older adults need the mastering of selecting their preferred music, but are struggling with the use of music tools, and feel embarrassed to ask for help from their caregivers. On the other hand, their caregivers are willing to offer help when older adults encounter difficulties and searching good music for them. However, limitations such as time and distance can reduce the efficiency of their helps. In this situation, we can say that IoT is a solution to benefit both sides: for older adults, an ease-of-use music application with a simple music-selecting device can help them access their favorite music independently. For their caregivers, they can offer help imperceptibly, without the limitations of time and distance through the use of music applications. By using the musical IoT, older users can overcome the challenge of using new technology, get the sense of mastering, and keep their mood positive, which can improve their emotional health and maintain their wellbeing.

Older adults' conditions vary in different generations. Now for the "young old (60-74)" group, they use the Internet and portable devices more often than other groups (75+) [60]. Although most of them only have basic knowledge about using applications, they can still learn more if supported by thoughtful design. It indicates that in the musical IoT design, the music application design tends to be more critical for it can benefit both of the caregivers and a part of the older adults. In this phase, the research question can be formulated into *How to design a music application that can be easily used and learned by both of the old people and their caregivers?* This research question has been studied

with an iterative design approach. By repeating the prototyping-evaluating-redesigning procedure, new knowledge related to the music application design has been generated. Simultaneously, such knowledge can be analyzed to answer the second research question.

5.1.2 The second research question

What should be paid attention to while designing IoT for older people to listen to music?

Two older adults were recruited to evaluate different versions of prototypes in this project. Although the two participants are a little younger than the target group of older users, we can still see the performance differences between old and young participants: older ones tend to take longer to complete tasks, use different mental models, be more distractible and have more misunderstanding about graphic elements. It is because, for older adults, their visions and cognitive capabilities are declining, and also, their digital technology knowledge is not enough [61]. Based on the findings from the whole study, some guidelines about music app UI (User Interface) design for the older adults are suggested in the following part.

Design for supporting vision

As adults age, health problems and challenges inevitably arise, often making it difficult for them to interact with certain features on smartphone apps, especially the changes in vision. People over the age of 40 are more likely to experience presbyopia, or long-sightedness [61], which makes reading small text challenging. Likewise, color vision, or the ability to distinguish certain colors, also fades with age. Therefore, when designing music app UI for older adults, it needs to consider their visual needs. Some suggestions are listed below:

- Use bright and warm colors as the theme color with a clean, high-contrast background.
- Display information vertically rather than horizontally.
- Use vertical-scrolling browsing gestures only.
- Make headings stand out by increasing the font size or weight or by using a different color.
- Larger font size can be preferred.
- Make the prior option look quite different from minor ones by using different colors.
- Give clear visual feedback when an action has happened.
- Group related information with spacing or the same color.
- Use metaphors to remind users the interface can be scrolled.

Design for improving cognition and knowledge leaning

In short, cognition refers to thinking. It includes processes such as attention, the formation of knowledge, memory and working memory, judgement and evaluation, reasoning and "computation", problem-solving and decision making, comprehension and production of language [62]. As adults age, their working memory starts to decline, which impacts the ability to think, reason, and

make sense of the world [61]. However, older adults can learn and gain mastery of any number of skills, including technology/app use, if they are supported by thoughtful design. Some design suggestions are as follows:

- Keep layout, navigation, and interactive elements consistent across pages and screens as much as possible.
- Label the icons and symbols with texts.
- Make language straight-forward and keep sentences simple.
- Set a pre-selected item to imply users what to do.
- Use toast notification to notify users the ongoing action.
- Provide easy access to help.
- Match users' mental model of navigation space.

The guidelines need to be further tested and verified.

5.2 Evaluation of methods and results

This chapter aims to examine what are the deficiencies of some study methods in this project, how they influence the study result and discuss what can be improved while researching with these methods. Even if one has chosen a method and prepared to execute it, it is not always true that the results are complete as they should be. It may be for various reasons, for example, that the method did not fit, or questions should have been worded differently.

5.2.1 Interviews

The initial research questions formulated in the first chapter were, how to use IoT design with music to enable the wellbeing of older adults, and what should be paid attention to while designing IoT for older adults to listen to music. In order to answer the first research question, knowledge about musical IoT design and the methods of enhancing older adults' wellbeing were gathered from a literature review, but there was a lack of newer literature about IoT design for older adults for music listening. However, it is demonstrated based on results from the interviews, letting older adults select and listen to music independently through IoT design is a rational solution to enhance their wellbeing. By conducting and analyzing the interviews, a rough idea of the musical IoT design was generated based on results of the analysis. Therefore, I think the method of interview is effective. However, for the interview in this research, there are still some deficiencies.

One deficiency is how the interview questions were asked and how interviewees responded to questions may affect the result of an interview. During the interview, several questions were responded by one answer sometimes. How to make control of asking suitable questions is essential to the following process. Unfortunately, some leading questions were asked, which led to less useful answers. The question like "Is there any special environment for the older adults? For example, a room full

of old things to help the older adults get their memory back?" may lead the respondents to think of memory environment firstly but forget to tell other types of environment the care home has. So, asking leading questions may have a potential bias on the respondents' answers.

The other one is, for the interviewees, they work for the care home. They cannot entirely stand on the older adults' side. Some of the answers in the interview may be a little different from the fact. Besides, the followed-up questions were asked by email, and the interviewee replied the email later than 3 days, which added the risk of giving a processed answer.

5.2.2 Heuristic evaluation and usability testing

The heuristic evaluation was used for inspecting usability problems in the first and the second prototype, and the usability testing was used for evaluating the third prototype. In general, both of the methods are good for getting feedback from different groups of people, including usability experts, nonexperts and end-users. It is worth mentioning that the most of the participants preferred to "think aloud"–they naturally verbalized what they were going through as they worked through a usability test session. It offers many insights into why a problem exists and how someone tries to work around it. However, to some extent, participants may consciously or unconsciously filter their thoughts and leave things out as they talk, so that the observer always has a potential to miss some usability problems that might be important for improving the application.

In the evaluating procedure, it would be better to ask more questions about what participants thought would happen or appear when they tapped or swiped on different elements on the app, why they completed a task like that but not in another way, and how did they feel when interacting with the prototypes. In the usability test, the result would be different if let participants have a quick look-through of the whole prototype before doing Task 1.

Another thing that needs to be discussed is the communication with the participants. As the design was made for multiple user groups (older adults and their family members, and workers in elderly care group), participants were recruited from different age groups. Compared with younger participants, getting older participants involved were more difficult. In the usability test, the older participant (nearly in his 60s) needed more time and hints for understanding and completing a task. In addition, this participant did the test remotely via Skype with an iPad in a non-ideal internet environment, which lead the prototype hard to load and made the communication much more difficult. If the test can be re-conducted, it may include a practice task to help older participants understand how the session will work and try to teach older participants more about the how to operate the prototype if they are failed in a task.

5.2.3 Evaluation of the design results

Iterative designs

In this study, the iterative design process improved the usability of the design step by step. The first round's iterative design presents some serious usability problems such as the invisibility of the system status, inconsistent elements and flows, and the use of misleading texts and inappropriate metaphors. Inconsistencies among requirements, designs, and implementations have been detected in an early stage. The second round's iterative design helps the designer to find out the best design choices from multiple alternative interfaces. It forces the designer to focus on those design choices that are most critical to the project and shields those choices which may distract the designer. It is worth mentioning that logical hypotheses can improve the efficiency of the alternative interface design. The designer needs to be clear about what elements need to be redesigned and tested (variable) and what should be kept (controlled variable). In Chapter 4.5.2, Figure 14 has offered three alternatives of the FM card view. Comparing whichever two interfaces, there are more than three differences. We can say that the alternative design of the three interfaces are not successful, because one cannot tell which element should be compared firstly. The last round's iterative design gave the designer an opportunity to get both feedback and suggestions of the design from the users. The users' participation provided valuable experience on the prototype design and usability testing design. However, though the usability testing has collected a lot of meaningful data related to the design, it is not enough to support creating guidelines of the music application's UI design, and the result of the guidelines are not convincing. To make it more convincing, the designer needs to do more iterative design in the future.

Design choices

In Chapter 4.4, there were two design choices based on the design conception. One was to explore the hardware– the music device, and the other one was to research the user interface– the music application. When it came to the prototyping phase, the designer chose to study the user interface. Why did the designer choose to study the digital user interface but not the music device?

One reason was that the music application design could visualize the necessary information for the users. For older adults, using the IoT design to listen to music may be the most appealing thing, but for their caregivers, knowing the older adults' music preferences seemed to be more intriguing, as it could offer a chance for them to make better communications with the older adults. In this situation, a music application design could give the caregivers an overview of the older adults' music preferences, as the music device did not have a screen to show these details. Also, the music application took the responsibilities of connecting and controlling the music device. For example, there was always a risk that the older adults would make some errors while using the music device, which may lead the device stop to work. If this happens, the older adults may not be able to solve the problem by themselves. In this situation, their care givers could solve the problem by resetting the device through the application.

Another reason was that for the designer, designing the music device was more challenging than creating the digital user interface. As the music device was only designed for older adults, getting them involved in the prototype testing in an early stage was important, as the design should fulfill the older adults' interactive behaviors. However, it was hard for the designer to reach the appropriate older adults for the lack of interpersonal relationships and the language barrier. Moreover, as the designer was not familiar with coding and making physical models, creating one mid-fidelity or high-fidelity physical prototype may be more difficult and time-consuming than making several high-fidelity digital prototypes. Due to whole research process started a little bit late and the time was limited, the designer finally chose to study the music application first and planned to put the music device's design into the future study.

5.3 Ethics

Privacy issues in the Internet of Things have been discussed widely in recent years. Some have suggested that individuals should have a basic right to opt out, delete, or mask their information from systems in the IoT. However, it may be infeasible or impossible for an individual to control all the data generated about them by IoT systems. What should a designer do when the product faces ethical challenges?

On one hand, give the users multiple options. Users' privacy interests are different, and some of their interests may conflicting. Placing the liberal principles of providing maximum personalized options and complete freedom can alleviate the conflict. Designers present the full scale of the system in the easiest and clearest way, and the users are free to do as they please. Multiple options give users the benefit of freedom, and maximum assistance for every action they might want to perform [63]. However, the user is expected to waste much time, as at any moment it is possible to backtrack and change settings.

On the other hand, limit the users with pre-made options. Designers strive to get the system as foolproof as they can by asking users as few questions as possible. For example, when the onboarding/tutorial showcases the options, it is common to allow the user to confirm only the most crucial choices. By this way, the interface would be linear, reduced and efficient, while guiding the user into performing specific actions without having to mess around with the system [63].

As this study is mainly concerned about using IoT to dig the users' music preferences and to make music recommendations for them, it is necessary for users to control the privacy of personal music data. For example, now in the "My music ball" page of the third prototype (Figure 18), the content of "Favorite songs" and "Favorite song lists" are visible to the public. However, some users may like to make their music collections private, so the design needs to offer users a chance to set their music privacy.

5.4 Future work

In general, some findings of this thesis should be verified and investigated in depth to get a better understanding of the knowledge. In this study, evaluating and testing prototypes is a critical method that allows users to participate in the design and express their ideas, but the user group of older adults are not well engaged, and the sample size of this group is too small, so that the suggested guidelines of music app UI design may have some bias. The future research can be verifying the guidelines through iterative design and testing the design with a larger sample of older adults. Simultaneously, to accomplish a complete IoT solution, future studies need begin to consider the design of the music device, which focuses on the older adults who are unfamiliar with or uncomfortable in using the digital interface. The feature of the music device can be developed based upon the functions of the music application. The iterative design processes will be used to exploring the music device's design.

6 Conclusion

The purpose of this master's thesis was to explore how to use IoT design with music to enable wellbeing of the older adults in their living environment, and what should be paid attention to while designing musical IoT for older adults. Overall, this study gives insight into what kind of IoT design with music is suitable for older adults: (1) letting older adults select and listen to music with fewer difficulties and errors, (2) detecting older adults' music preferences and giving related music recommendations, (3) easy for their caregivers making music contributions and offering help to the older adults. The whole study procedure are as follows:

Based on the hypothesis to the research questions, the initial objective was to acquire the knowledge about what kind of well-being is essential to older adults, how music can enhance their well-being, and what kind of technology has already available for seniors to enjoy music.

The literature review gives an overview of the knowledge mentioned above. It demonstrated that well-being is the satisfaction with life, a sense of autonomy, control and self-realization. Listening to preferred music can offer a powerful potential for providing satisfaction and coherence in life, promoting health, but what might be lacking is the newer study about IoT technology in music contexts of older adults.

Interviews were conducted to get knowledge about how the older adults access music in their daily lives; investigate if using IoT design with music is a beneficial solution to both older adults and their caregivers. It finds out what factors can be potential obstacles to older adults to access music. The result of the interview showed that the difficulties of using and learning technology could be potential obstacles for older adults to access music so that their autonomy could be reduced. The older adults' need of listening to favorite music independently should be putting into consideration. Likewise, their caregivers' needs are also concluded from this interview (see in Chapter 4.3.2). A conceptual model of music listening & selecting IoT was created to afford the needs of all the user groups. As the music application was a part that can be used by all the user groups, it has been selected to study first. In this situation, a new research question was generated: what kind of interface design can reduce older adults' difficulty of using a music application, and also easy to be used by other user groups?

Then, an iterative prototyping procedure was used to explore this research question. Useful feedback was received from the evaluation and usability testing of three versions of prototypes and used for improving the application and answering the research question. The final prototyping result indicated that the use of (1) warm color, (2) pre-selected items, (3) vertical list visual format, (4) appropriate metaphors and icons, (5) feedback and contextual texts could reduce a user's difficulty

of using a new music application. Finally, the thesis evaluated the research questions and discussed the limitations of the study, including bias in the interview, flaws in the evaluation and usability testing, and deficiency of the design.

The future work will focus on verifying the music app UI design guidelines through iterative designs and testing them with a larger sample of older adults, and developing the physical music device, which focuses on the older adults who are unfamiliar with or have difficulties in using the digital interface.

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A Interview

A.1 Interview consent form

We are students from NTNU in Gjøvik majoring in interaction design and going to do a research project for the master thesis. The topic of this project is designing Internet of Things with music for the elderly people. The purpose of the interview is to get more knowledge about elderly people. The interview will take 30 to 60 minutes. We don't anticipate that there are any risks associated with your participation, but you have the right to stop the interview or withdraw from the research at any time.

Thank you for agreeing to be interviewed as part of the above research project. Ethical procedures for this academic research require that interviewees explicitly agree to being interviewed and how the information contained in their interview will be used. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Would you therefore read the accompanying information sheet and then sign this form to certify that you approve the following:

- the interview will be recorded and a transcript will be produced you will be sent the transcript and given the opportunity to correct any factual errors
- the transcript of the interview will be analysed by (name of the researcher) as research investigator
- access to the interview transcript will be limited to (name of the researcher) and academic colleagues and researchers with whom he might collaborate as part of the research process
- any summary interview content, or direct quotations from the interview, that are made available through academic publication or other academic outlets will be anonymized so that you cannot be identified, and care will be taken to ensure that other information in the interview that could identify yourself is not revealed
- the actual recording will be (kept or destroyed state what will happen)
- any variation of the conditions above will only occur with your further explicit approval

By signing this form I agree that:

1. I am voluntarily taking part in this project. I understand that I don't have to take part, and I can stop the interview at any time;
2. The transcribed interview or extracts from it may be used as described above;
3. I have read the Information sheet;

4. I don't expect to receive any benefit or payment for my participation;
5. I can request a copy of the transcript of my interview and may make edits I feel necessary to ensure the effectiveness of any agreement made about confidentiality;
6. I have been able to ask any questions I might have, and I understand that I am free to contact the researcher with any questions I may have in the future.

(Signed by project participants, place and date)

A.2 Interview content

1. Can you introduce your position and your everyday work?

Interviewee A works as a nurse for 16 years with people with dementia. Interviewee B works in the utvikling senter. She is a project leader in fagkonsulent (subject adviser), fagutvikling. She works with different projects in health area, mostly related with old people. She also teaches the employees fagutvikling in a community. Her job has no contact with patients, only work in the office.

2. Is there any environment for improving old people's memories, for example, a room full of old things?

We used to have such a room with old things but now we don't use it anymore. But we try to decorate the room and make it feel as home. We have a few old things that can make people memorize. They can look at and talk about them, and the employees can start the memorizing with the old people, help them to talk about different things. Workers help them to remember the life stories, let them talk about their different lives and have a good time. Different units have used iPads for 4 years, for the elder's life stories, pictures, interests. There are 4 units for dementia people, and each unit has one iPad.

3. Could you describe a typical day of the inhabitants in one unit? What kind of social activities do they have?

The condition of each unit is different. It varies how ill the people are. Some patients can talk a lot and some are in bad condition. What workers do depends on what the patients want to do. There are many different kinds of activities such as physical exercises, music, talking, and outdoor walk. It varies from week to week. We have different live concerts in the canteen, and every 14 days there is a live concert on the second floor. We have 2 musicians and each time one of them will come and holds the concert in one of the elder's living space. That's a project for dementia people. They can choose what kind of music they want the musician to play, and the staff accompany with the patients. Family members can join if they want to. The activity is called "ønskeallsang", old people can choose their favorite music through a music book of many songs, and the activity will last for 45 minutes. They can choose the music and sing along with the musician's playing. We also have a cinema on the 0 floor, the old people can watch movies monthly. And we also have

different activities in each unit, in the summer time we have bicycle tours with the staffs. We have daily quizzes and discussions with papers, and there is a morning TV program called "god morgen norge", some people will watch it in the morning.

4. Any music listening and activities? Interviewee A: There are stereos in almost every room, so old people can listen to music in their room whatever they want. In the living room you can find the music that most people like. They also can sit there together. We also play their favorite music in their last days for people who are dying. Old people like to talk with each other about their favorite music type, songs and artists. They also listen to radio, but usually in their own room. For the sickest PWD, they cannot attend any kind of activities, but for the people with light or middle dementia, they can do more things and participate in activities.

Interviewee B: We can see after the activity "ønskeallsang", the staff members told her that these old people started singing after the activity. They were still humming and smiling in the living room the rest of the day. It's very positive, maybe they forgot the song after a while, but they have the feeling inside – something joyful. This is important for dementia people, they have their own safe areas. Old people are not forced to attend activities, usually the activities keeps only 40-45 minutes, if they don't want to go on they just leave.

Interviewee A: For the dying people, playing the music they like in the last days is a best way to pacify them. One patient is very ill because of the breathing problem, coughs and an attack. We use music to calm down and relax the patient to relive the ill condition. We use the iPad to play music and he can start breathe normally again. We have done this several times successfully.

5. Do the old people like using iPad to listen to music?

At the beginning we are not sure about how they use it either. We are worried about they don't know how to use it or press it, but they do, and we also help them. Now the nurses use iPad to help the elders choose songs from YouTube, we know the artists they like, and it works very well. And also, the old people know how to use headphones.

6. Do you think it will be very busy for the staff to help them choosing songs?

Now it is not a big problem for us because each unit only have 1 iPad. We arrange each patient use it at different time, and I don't think it takes too much time. It maybe just takes a few minutes to find the things and keep the patient calm for a long time. Though the old people often have problems in selecting songs in YouTube, nurses can help with them.

7. Do the elders hold activities by themselves? Most of the time the workers have to start the things, some of the old people ask for help to start an event, such as take a walk, listen to music, watch the TV.

8. Do they have difficulties in using equipment such as CD and DVD players?

I would say so. Some of the people with middle dementia don't know how to play the radio, because

they don't know how to use the buttons, so we need to help in some way.

9. How do you find their music preference?

We have a project about music preferences but now we don't use it too much. A few years ago, we talked to their family members to find out what kind of music they like. And we also used to play a lot of CDs of music to find their favorites.

10. Do you often use the Spotify play lists?

Not very often. We use the pads, CD players and the radios. We haven't use Spotify that much. We have talked with staff members trying to make Spotify music playlists that almost everyone likes, but we still not have done it yet.
We have discussed building personalized playlist link for each patient in one iPad, but we haven't done it yet. Many of the dementia patients spend 2 weeks here and 2 weeks at home, and they have a lot of resources.

11. Do they like to try new things?

I think you can have more solutions for the people with physic problems, they are more anxious. But on the third floor it has a bad Wi-Fi connection. Many people brought their pads, iPhones and laptops from their home, but we can't offer them internet. The old people now are different from previous. Many patients use the devices. Anything that can bring memories from old days is good.

A.3 Followed-up questions and answers

1. You have mentioned many music activities. Which activity do old people like the most?

Jeg tror pasientene setter mest pris på de sangaktivitetene der de er aktivt delaktige selv, som for eksempel «Ønske allsang».

2. Do the old people expect another live concert less than two weeks after one had finished? Do they think 2 week's waiting time is too long?

Jeg tror flere av de pasientene vi har i avdelingen er såpass syke av sin demenssykdom, at de ikke har samme opplevelsen av tid som vi har. Nedsatt hukommelse gjør at mange har glemt at de har vært på konsert. På den måten er det mange som derfor ikke har konkrete forventninger.

3. You said that there was a project about music preference before, but you don't often use it. Why?

Det skyldes kanskje at for få har denne opplæringen og at den bruken vi lærte kan være noe tidkrevende.

4. You said the staff want to create personal playlist links in iPad for each individual. And Elin said the staff also want to create Spotify music playlist that everyone likes. Why the staff haven't done it yet?

Det skyldes at nettbrettene vi bruker ikke er tilpasset individuell bruk enda (vi har ikke noe system for dette enda). I tillegg kan en annen årsak være at vi har såpass mange CD plater i avdelingen at mye musikk blir spilt uansett.

5. What do you think is the most difficult part when you work the old people? Have you ever come up with any ideas that can solve your difficulties in your work?

Mye forskjellig kan være utfordrende når man jobber med personer som har demenssykdom. Eksempelvis kan det å tilpasse individuell aktivitet være utfordrende, men vi forsøker å være bevisst på dette, slik at alle som bor i avdelingen er med på noe de liker. Jeg tror de ansatte kan være ganske kreative på gode løsninger, både i pleie, behandling og aktivitet.

6. How do the old people communicate with their families? (Apart from visiting and taking part into activities with old people, do you know what other ways they can keep in touch?)

I vår avdelingen bruker vi ikke digital kommunikasjon med pårørende enda, men andre avdelinger i kommunen prøver dette. Noen pasienten har egne mobiltelefoner og noen har egen PC. For øvrig låner pasienter telefon fra avdelingen når de vil ringe sine pårørende.

7. You said that the old people have difficulties in using radios because the buttons are complicated, may I ask that is it a dab radio or a traditional radio?

Siden FM nettet er slått av, har de pasientene som har egen radio DAB. De som har problemer med å forstå bruken av radioen sin får imidlertid hjelp fra personalet.

B Personas

B.1 Character of the old adult

Name: Anni

Age: 67

Facts:

- Retired
- Widowed
- Mother of three children and two grandchildren
- Live in a care home

Pain points:

"*New technology seems a little hard to learn, but I'm trying to manage it.*"

Previously she used a laptop to send emails, did social network communication and paid the bills, but she gives up and uses a smart phone instead. As she's getting older, her vision also has become weak, it is often hard to read words or pictures with a small size. She was a big fan of listening to music before and have a lot of CDs.

Task and behaviour:

When Anni lives in care home, she rarely listen to CDs because she doesn't like the CD collection here. Sometimes, nurses in this living unit use an iPad to help Anni find her favorite music, but when they are busy, Anni only go through the pictures in the iPad. Because she feels she can't manage with the music application by herself.

Anni often uses Messenger or making phone calls to ask for help from her children if she forget how to operate the smart phone. But most of the time she can't receive help in time because all her children have to work and live far away from her. At times, she feels bad having to ask for help from her children. She feels like she's a burden. This often makes her feel sad.

Goals:

- Listen to music in an easier way
- Decrease the frequency of asking help from her children

B.2 Character of the nurse in elderly care

Name: Isabella

Age: 43

Facts:

- A nurse in an elderly care home
- Mother of three children and two grandchildren
- Live in a care home for 2 weeks per month

Pain points:

"*Engaging everyone in an activity is hard, but we are developing solutions now.*"

Isabella usually feels hard to let each old person take part in activities because of their bad physical conditions, improper times or multifarious factors. This makes it hard for her to activate these patients. She loves her work and doesn't want to leave any patient alone. She has many ideas about using music to keep these elders happy, but she thinks the care center doesn't have a technical support.

Task and bevaviour:

- Look after the elders
- Communicate with elders in their daily works
- Find different kind of music to keep the elders calm and happy

Goals:

- Finding appropriate music listening solutions for satisfying elderly people

B.3 Character of the family member

Name: Mia

Age: 35

Facts:

- Tourist guide
- Anni's daughter
- Mother of two children

Pain points:

"*I really want to stay with my mom. But I'm too busy.*" Mia's work schedule is always full and she often miss her mother's call. When she calls back to ask her mother if she needs help, her mother always answer no. But she understands her mom should have met some difficulties and miss her. She wanted to look her mom last Saturday, but her little sun was sick.So she had to change her schedule. Maybe next Saturday? She feels guilty when she thinks of her mother.

Task and bevaviour:

- Help her mom solve problems as many as possible
- Communicate with her mom via phone call
- Be used to deal with work by smart phone

Goals:

- Offering help to her mom remotely

C Scenarios

Anni uses music object to listen to music

Anni got a Music Ball from her daughter Mia and she learned how to use it yesterday. Today, she wants to listen to some fresh music with it during the breakfast. Firstly, she opens the app on her mobile phone and clicks "music radio", then music starts playing on the music ball. She thinks the first song makes her feel sad, so she presses the "dislike" button on the ball. But when it comes to the next song, Anni feels energetic and want to sing along with it. It is a song that has been liked by her for more than 40 years. She clicks the "like" button and the song is automatically saved in her account in the app.

Mia and Isabella use the music app

Mia knows her mother's music taste very well. After connecting the music ball to the app, she filled in the music taste information instead of her mother in the app. This morning, the app reminds her "Three songs has been added to your collections successfully." Mia founds many new songs are liked by her mother, so she adds all of them into a new playlist called "Breakfast music".

Some elders are eating breakfast. Three of them want to listen to some music. The nurse Isabella opens the music app and wants to find a suitable song list. The list "Breakfast music" seems to be the right one she is looking for, so she presses the play button and play them via the music ball. The elders seem to be pleased with the songs in this playlist, so Isabella adds the playlist into her collection.

D Prototype

D.1 The 1st version

The link of the whole prototype is: https://invis.io/NUIBEBVA7DV

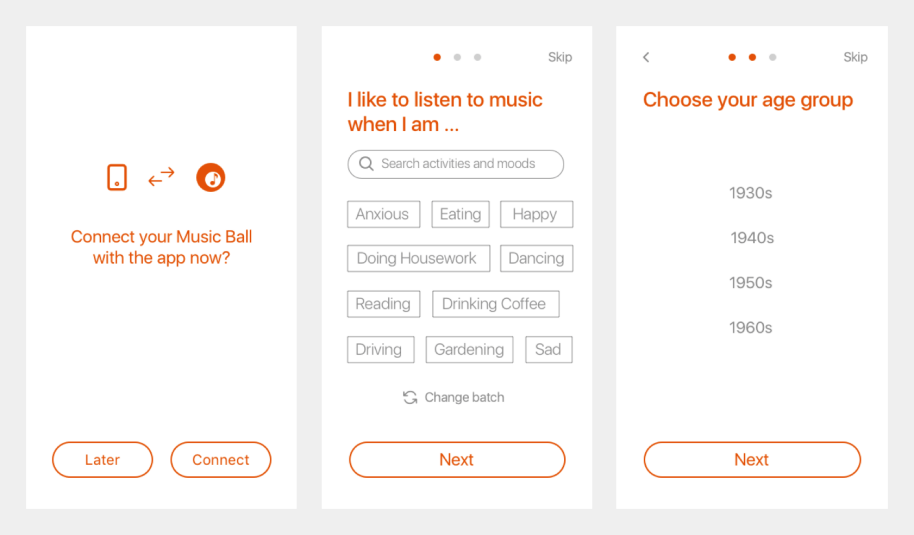

Figure 20: Connect to the music object and detect music preference

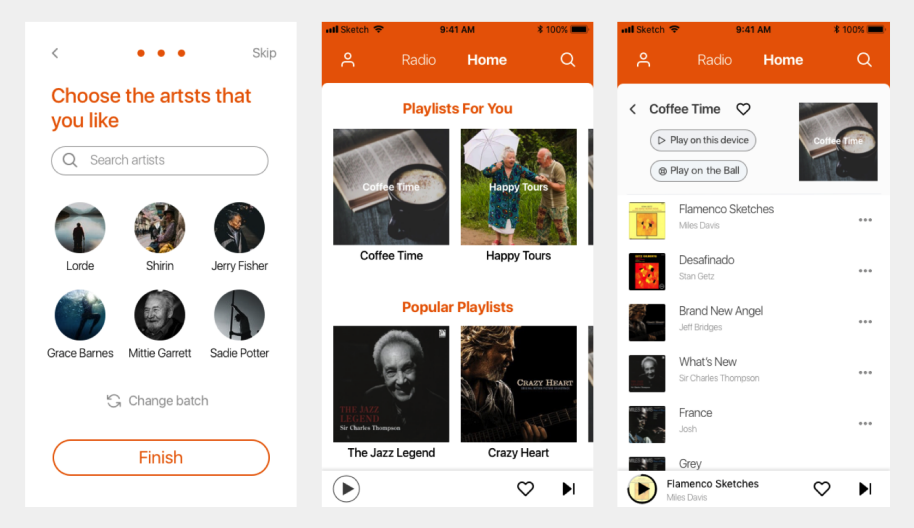

Figure 21: Playlist

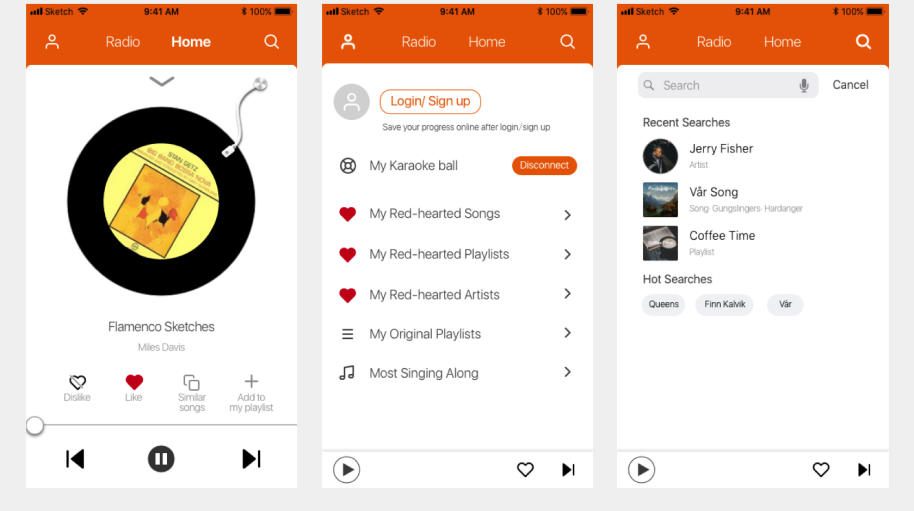

Figure 22: Card view of the playing interface, Profile and Search

D.2 The 2nd version

The link of all the interfaces is: https://sketch.cloud/s/ob4L3

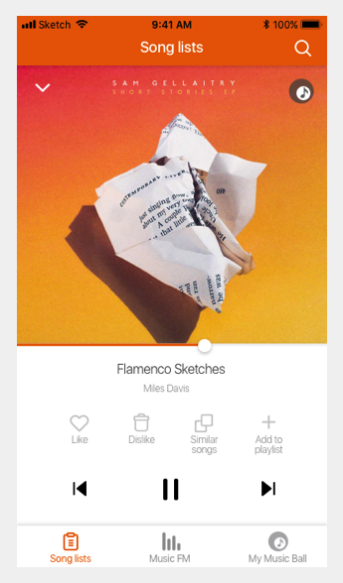

Figure 23: Music-playing card view page

D.3 The 3rd version

Link of the prototype: https://sketch.cloud/s/z8A8b/all/page-1/start-page/play

The link of all the interfaces is: https://sketch.cloud/s/z8A8b

D.4 Conceptual prototype of the music device

Figure 24: Conceptual prototype of the music device

E Form of the first evaluation

Participant:
Date:

Task	Succeed/Failed	Issues/errors	Notes and comments
Choose tags			
Choose decades			
Choose artists			
Understand the navigation bar			
Understand the navigation bar			
Listen the playlist “coffee time” on phone			
Like the song “flamenco sketches”			
Like the song “flamenco sketches”			
Add the song in a new playlist			
Go to the card view of the song			
Go to the card view of the song			
Explore the similar songs			
Collapse the radio			
Search “vår” in the frame			
Search “vår” in the “Hot searches”			
Go to the user profile			
Disconnect the ball			

Table 3: Evaluation form of the first prototype

Participant comments and opinions:

1. What’s your suggestions of the music ball?
2. What’s your suggestions for improving the app?

Discover Attitudes and First Impressions:

1. Does the product look easy to use?
2. Does the product look easy to use?
3. Is the product similar or very different from other products, or even from previous releases of the same product?

F Usability testing tasks and notes

F.1 Tasks

Anni is a 68-year-old woman, born in 1950, and lives in an elderly care home now.

Her daughter is called Mia. She knows her mother's music taste very well.

The nurse Isabella takes care of Anni in the care home. She always helps Anni to find her favorite music.

Task 1
Mia (the daughter of Anni) is setting the music ball and the music preference instead of her mother.

You have already had an account of this app.

- Sign in
- Connect the music ball
- Connect the music ball

Task 2
Isabella (a nurse in a care home) finds a good song list for Anni.

- Find the song list "Happy spring"
- Play the list
- See the card view (playing page) of the song "Temple"
- In the card view of the song 'Temple', explore the icon in the bottom of the page
- Collapse the card view
- Like the list

Task 3
Anni starts to listen to the Station.

- Go to the Stations
- Go to the channel "Instrumental" in the category of Genres
- Go to the card view of the song
- Like the song "Yukizakura"

Task 4

Mia adds a song into a song list from the Listening history.

- Check Listening history
- Add song "Yukizakura" to the Song list "Breakfast music"

F.2 Notes

(S) = Task Succeed
(F) = Task Failed
(E) = Error

Participant 1

Task 1

- Sign in (S)
  When she went to the app guide page, she felt she had already signed in and confused. She thought it is a market message. She used the gesture of click, not swipe.
- Connect the music ball (S)
- Choose music preference (S)

Task 2

- Find the song list "Happy spring" (S)
- Play the list (E-S)
  She firstly clicked the play button on the right side of the music list “Happy spring”. At that time, the first song in the list had already begun to play. But as the prototype does not have a sound, she did not notice the music-playing bar. Then she clicked the name of the playlist.
  What made her ignore the music-playing bar? Her browse gestures. When she doing tasks, her hand covered almost half of the screen. So she couldn’t see the bottom part of the interfaces.
- See the card view (playing page) of the song “Temple” (F)
  After showing her the position of the music-playing bar, she went to the card view of the song right away.
- In the card view of the song ‘Temple’, explore the icon in the bottom of the page. (F)
  At first, my task description was misleading. I said “ explore the ‘station icon’ in the card view”. She clicked the “Stations” in the menu directly. After changing my description, she understood the task and finished it in a right way. What made her go to the wrong place?
- Collapse the card view (S)
- Like the list (S)

Task 3

- Go to the Stations (S)
- Go to the channel "Instrumental" in the category of Genres (E-S)
  She scrolled the interface firstly and want to find the channel. But then she found it was not the right category and clicked “Genres”. Then she went to the channel “Instrumental”.
  Hi-fi prototype sometimes is necessary. Music app without sound and dynamic effect = loose some feedback. Feedback is important for a music app.
- Go to the card view of the song (S)
- Like the song "Yukizakura" (S)

Task 4

- Check Listening history (S)
  She went through the menu first, and then chose “My music ball” and located the Listening history.
- Add song "Yukizakura" to the Song list "Breakfast music" (S)
  She thought for a while and clicked the “···”. Then she added the song to the list in a right way.

When she plays a song, she hopes to see it is playing on top of the page, but not the bottom. For playing a song, she hopes she can click both the pic and the song name+ artist.

Participant 2

Task 1

- Sign in (S)
- Connect the music ball (S)
- Choose music preference (S)

Task 2

- Find the song list "Happy spring" (S)
  He clicked the name of the playlist to check it.
- Play the list (S)
  When he came to the guide page, he used the gesture swipe. That was what I hope to see.
- See the card view (playing page) of the song “Temple” (S)
  He used the gesture of swiping up. I reminded him that now the prototype did no have this effect. So finally he clicked the music-playing bar.
- In the card view of the song ‘Temple’, explore the icon in the bottom of the page. (F)
  He clicked the station icon in the menu. Both of the description and the icon made him confused.
- Collapse the card view (S)

Right click. But he also tries to swipe down the card view.
- Like the list (S)

Task 3

- Go to the Stations (S)
- Go to the channel "Instrumental" in the category of Genres (S)
  He didn't find the target channel in the first page, then he realized this category was not genres. Then he found "Instrumental".
- Go to the card view of the song (E-S)
  In the card view of the song, he asked about what was the meaning of all the buttons. I let him to click them by himself. He discovered and understood.
- Like the song "Yukizakura" (S)
  He also asked about the broken heart icon: was it equal to an icon of a trash can?

Task 4

- Check Listening history (S)
- Add song "Yukizakura" to the Song list "Breakfast music" (S)

In the Stations, he wants to see more channels because the list shows too little choices.

Participant 3

Task 1

- Sign in (S)
  Confused with the guide page: He read the text and then want to click the icons in this page, in order to connect the app and the device. He thought he had already connected.
- Connect the music ball (E-S)
  When he went to this step, he realized he was wrong.
- Choose music preference (S)

Task 2

- Find the song list "Happy spring" (S)
- Play the list (E-S)
  He ignored the music-playing bar. He thought if he press the play button on the "song lists" page, the bar should show the name of the song list, but not the name of a song. That was not clear for him to know where the song was from.
- See the card view (playing page) of the song "Temple" (S)
- In the card view of the song 'Temple', explore the icon in the bottom of the page. (F)

As it was a remote test, I couldn't control the process very well. When I asked him "what do you think the meaning of the heart", he responded "Share to your friends". And also he did not understand the meaning of the broken heart. But he said: "If I use the app for several times, I will totally understand it. At first I also don't know how to use a smart phone, but now I can manage it."

- Collapse the card view (S)
- Like the list (S)

Task 3

- Go to the Stations (S)
- Go to the channel "Instrumental" in the category of Genres (E-S)
  He was a little confused about the word "Genre".
- Go to the card view of the song (S)
- Like the song "Yukizakura" (S)

Task 4

- Check Listening history (S)
  He spent a long time to think over where the function was.
- Add song "Yukizakura" to the Song list "Breakfast music" (E-S)
  He didn't know how to add the song at first. He thought it for a while. And then click the icon "..." behind the song "Yukizakura" and finished the task.

He thought the guide page was useless. It can be removed.

Participant 4

Task 1

- Sign in (S)
  He swiped the first guide page, but tapped the second one. He said there are only two dots on top of the page, so he would like to tap the second page. But he said he wants to skip it, but there was no this option. He also suggested that it could be a part of the help page.
- Connect the music ball (S)
- Choose music preference (S)

Task 2

- Find the song list "Happy spring" (S)
- Play the list (E-S)
  He ignored the music-playing bar.

- See the card view (playing page) of the song “Temple” (S)
- In the card view of the song ‘Temple’, explore the icon in the bottom of the page. (S)
- Collapse the card view (S)
  He used the gesture of swiping down. When he found it didn’t work, he clicked the button.
- Like the list (S)

Task 3

- Go to the Stations (S)
- Go to the channel "Instrumental" in the category of Genres (S)
  He used the gesture of scroll.
- Go to the card view of the song (S)
- Like the song "Yukizakura" (S)

Task 4

- Check Listening history (E-S)
  He went to the song list at first, and then went to the right place.
- Add song "Yukizakura" to the Song list "Breakfast music" (S)

He was familiar with the gesture “long press”. He thought it would be nice to include this feature for checking the detail operations of a song. For each song list, the play button gives him a feeling of “this playlist is a song.” Though he understands the metaphor of the cover implies it is a song list. What’s more, he thought the station should have a play button to control the music. It would be embarrassed to use this function in a public space without earphones, if you haven’t decided which channel you want to listen. It will be annoying.

Participant 5

Notes from the participant:

Task 1

- Sign in (S)
  "Just a note: Who’s email address should I sign in with here? My own or the Isabelle who meets her everyday? I had this issue with a person I look after. I had to make him an email address in order to make playlists on youtube and the account was connected to my gmail account in case the staff lost the password, which they did. They called me at any times during the day asking me to verify the new password."
- Connect the music ball (F) "Here I clicked directly on the illustration. I think it would be great if it was active too. I saw the connect button later, because it was the illustration that caught my attention. Perhaps the “connect”and “later on” buttons could be placed further up?"

- Choose music preference (S)
  "It says 'I like to listen to music when I am . . . ' It might confuse some users who are not so tech savvy thinking the app needs to know the relatives preferences to work as well." Perhaps there could be an option to where I can choose to define who I am doing this on behalf and it could say "Anni likes to listen to music when she is.." instead.

Task 2

- Find the song list "Happy spring" (S)
- Play the list (E-S)
  "I pressed the cover illustration on the left side of 'Temple'. Perhaps both the playing bar and the cover illustration can lead to the same place."
- See the card view (playing page) of the song "Temple" (F)
  "The button is quite far down on the screen. I don't usually use this button and don't know what it means because I don't use it on Spotify and other apps. Perhaps there could be a name there under the button?" "I like the graphics. Clean, minimalistic design. And easy to use the controls with lots of distance between each other. In case one are stressed, which one often can become in a job working with elders this looks calming and easy to understand. I think the chance for making an error is lower when there is lots of space between controls too, including personal and relative with reduced physical abilities. (with arititise and diabetes for instance.)"
- In the card view of the song 'Temple', explore the icon in the bottom of the page.
- Collapse the card view
- Like the list

Task 3

- Go to the Stations (S)
- Go to the channel "Instrumental" in the category of Genres (S)
- Go to the card view of the song (S)
- Like the song "Yukizakura" (S)
  This task was easy for her.

Task 4

- Check Listening history (E-S)
  "A little hard to find it bacause coming straight from the last task. I thought maybe it would be inside of "song lists" because I think it is the a list of songs. But when I go into "song lists" I think the content should be named "suggestions". I'm thinking where can it be. "What is my music ball? " Is it a place to read about the ball..? But I press it and find it."
- Add song "Yukizakura" to the Song list "Breakfast music" (S)

> "I have not heard the word “song list” be used before. Just “list of songs”, or “list of suggestions” but much more frequently “playlist”. Based on the content I would call it “Suggestions”, but that’s me."

I really like the colors and the illustrations, they are positive and I like the hearts which are broken and whole indicating I can like and dislike music in a fun way.

One comment that is not about the tasks. Is the card “My music ball” supposed to be under the category “my music ball”? When I see it I think it would take me back to where I am now. If it doesn’t take me to the same page I would name it something else. “About” or “Your music ball”, “The music ball” maybe.

The card “Di” and could be moved under a settings icon that could be a card or a icon in the right in the header perhaps... like in Spotify. But I don’t know enough about the functions to say much really. I generally like the app. Would be great to see a storyboard/ illustration with the ball itself in action.