Designing Responsive Music Making Devices:

Creating Positive Exercise Experiences for Seniors

Alyssa Wongkee

Carleton University

A Thesis submitted to the Faculty of Graduate and Postdoctoral Affairs

in partial fulfillment of the requirements for the degree of

Master of Design

in

Industrial Design

Abstract

As the population grows older, it is increasingly important to address the challenges associated with aging, such as health decline and loss of independence. Exercise can help seniors remain physically fit, but seniors often are unable to exercise regularly because of barriers and lack of motivation. Current research suggests that music making may provide health benefits and motivate individuals to exercise. This interdisciplinary study combines the fields of music making and design in relation to aging in order to address the question of how design can be used to create devices for seniors to make music, creating a more positive exercise experience. The topic was explored using qualitative design research methods. Music making devices were used as technology probes in a seniors' fitness class, an expert interview was conducted with a fitness instructor, and a co-design workshop was held with seniors. The findings suggest that music making can influence the participants' behaviour in a fitness class and could be used to motivate seniors to exercise. Based on the research, several design recommendations were made concerning the sensory aspects of the object, such as the audio and visual feedback and the tactile experience, and the usability and features of the product.

Keywords: Interdisciplinary Design Research, Electronic Music Making, Older Adults, Health in Older Adulthood

Acknowledgments

Firstly, I would like to thank my supervisors, Lois Frankel and Jesse Stewart for their guidance and expertise. I appreciate their dedication to my project and providing me with support and encouragement throughout.

I am thankful for everyone at the Churchill Seniors' Centre; all of the participants and especially Tara Sullivan, Chris Rogers and Regis Alcorn who helped make my research possible.

I must also thank Sarah Bruch and Nathanael Fung for developing the prototypes used for much of my research and providing me with expertise and support.

Thank you to the staff and faculty at the School of Industrial Design for their ongoing support, and my MDes classmates for sharing in my journey.

Finally, I am grateful to everyone who has helped and encouraged me, this thesis is a product of the tremendous amount support I have received from my family, friends, classmates and colleagues.

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

Almost everyone wishes to live a long life and be able to grow older. As someone ages, he or she does not want to face the loss of independence, failing health and a diminished role in society, but instead hopes to remain active, independent and healthy. Regular exercise can aid in achieving those goals, and research shows that music and active music making can be a motivator for exercise and provide health benefits. This thesis is an interdisciplinary exploration drawing from the fields of music technology and design in relation to aging. This study uses several research methods, such as technology probes, an expert interview and co-design with seniors, to address and make design recommendations for seniors making music through exercise. By using design research methods, it is possible to inform future designers how to develop and design music making exercise devices for seniors.

1.1 Background

In Canada, and in much of the world, the largest growing demographic are adults over the age of sixty-five (Statistics Canada, 2015). The aging population is more than a mere statistic, this translates to millions of older adults who need to remain healthy despite age related health problems and decline. Many individuals face disability in older adulthood due to health problems such as stroke and falls, which can lead to mobility issues, along with age-related sensory decline.

Despite these problems, one way that older adults can contribute to staying healthier is through exercise. Exercising regularly is recommended for older adults, both with and without health problems, in order to maintain well-being, leading to increased independence (Manini & Pahor, 2009; Vaughan et al., 2016). Older adults, specifically those with mobility problems or disability can find it hard to be able to exercise. There are many barriers to exercise for these individuals, such as the disability itself, as well as lack of motivation.

Using technology to engage people in exercise is an emerging area of research, and there are numerous products on the market already, ranging from “exergames” such as the Wii-Fit, and personal fitness devices that track users and set fitness goals.

In recent years, new technology has enabled the development of new adaptive music instruments, which use sensors and electronically-produced sounds to create music. These instruments have allowed people, who may not have the ability or skills to use traditional musical instruments, to participate in the act of music making. These inclusive music instruments have been used by a variety of people for different applications. One application of these instruments involves using music making in order to engage people in exercise. Many of these inclusive musical instruments use movements to create music, creating a natural link between exercise and music making.

1.2 Rationale

This thesis aims to address a gap in the current research; there exists an opportunity to explore the potential of designing products to make music while exercising, specifically in the context of seniors’ exercising. The senior demographic was chosen because of the need to engage them in exercise, as well as the unique design needs associated with aging such as sensory decline, loss of dexterity and reduced mobility.

Inclusive music making has been used with children and adults with disabilities resulting in a variety of benefits, both physical and psychological. In respect to older adults and exercise, there is research literature concerning engagement and motivation, but very few studies looking at music making as a potential source of engagement. By connecting these two areas of research, valuable insights could emerge concerning the benefits of using electronic inclusive music instruments with seniors.

1.3 Scope of Research

The focus of this research is to gain design insights concerning music making devices for use by seniors in a fitness class. This study did not aim to generate a design, but rather gain insights and develop recommendations, which could lead to future products. It explores how using design research methods, such as technology probes and co-design can provide design insights. Exploring the technical capabilities of the sensors with respect to how they are able to translate the exercise movements into music were also out of the scope of this research; only existing systems were used when observing music making with seniors. Improving upon the existing systems was not part of the research; rather, the aim was to gain insights from them for future improvements.

1.4 Contributions

The main contribution of this research is in the form of design recommendations and the insights leading to the recommendations. The main insights being the motivational qualities of the music making, the importance of sensory feedback during exercise, allowing the user to understand where their body is moving. While the recommendations are for this specific application of music making through exercise movements, many of the recommendations could be useful in a wider product category, such as music making instruments in general, or other exercise devices.

1.5 Thesis Structure

This thesis is divided into six chapters that are further divided into sections. This introductory chapter provides the background and focus of the research, and a rationale for the study and research questions. It discusses the scope of the thesis along with the outcomes and contributions to the field of design and design research.

The second chapter is a literature review which explores three relevant fields: 1) music, focusing in particular on the effects of music and music making on well-being and current research concerning electronic music technologies; 2) aging, with respect to exercise and well-being in older adulthood; 3) design, exploring design for older adults, as well as design research methods. Chapter two provides the context and foundation for the study, identifying gaps in the literature leading to the research questions addressed by the study.

Chapter three outlines the methodology of the study. This follows the process of the study step-by-step through the three methods of technology probes, an expert interview and a co-design workshop. The rationale for those methods and the use of a constructivist framework are also discussed in the chapter. Finally, the analysis and synthesis of the data are explained.

Chapter four presents the findings from the three research methods. They are presented by research method, and further sub-divided into themes. These sub-themes are: context of the exercise class, the older adult’s interactions with the objects, the changes in the exercise experience, and the reactions to the music. The findings from all three methods are summarized, leading to the insights discussed in the following chapter.

Chapter five discusses the findings in relation to the research questions and the context of the current literature. The chapter addresses each of the research questions and ends with a set of design recommendations for music making objects for seniors' exercise classes.

The final chapter is the conclusion, which summarizes the key findings from the research. It also outlines the contributions of this research, providing insight into the experiences of seniors in exercise classes, reflecting on design insights that were gleaned through the co-design process, and making design recommendations for future music instruments intended for use by seniors during exercise.

Chapter 2. Literature Review

This chapter is an interdisciplinary investigation of the current literature in four main areas drawing from the fields of music, design and gerontology. The first section, *Music and Music Making* examines various aspects of music and music making in relation to the thesis topic. Specifically, how music and music making can positively affect well-being and the current applications being used in the area of health and exercise. The section lays the foundation for how design can be applied to the context of music making and well being. *Aging and Older Adulthood*, explores the effects of aging on health and quality of life during older adulthood and strategies, focusing on physical exercise, which can contribute to better health and independence. *Designing for Older Adults* explores the current approach to designing for older adults, creating the most appropriate experiences for them based on their unique needs, while supporting their continued independence and belonging. The final section *Design Research* explores how design research methods can be used to address music making with seniors in an exercise classes and lead to valuable insights.

2.1 Music and Music Making

In western culture people listen to music regularly, using it for a variety of purposes such as relaxing and mood regulation, enhancing the background of their environment while doing chores and motivating them while exercising. This common leisure activity is also powerful enough to positively influence a person's emotions and improve their health (D. D. Coffman, 2002; Flowers & Murphy, 2001a; Laukka, 2007). This section examines these various uses and benefits of music in more detail, focusing on the applications of music and music making as a motivator, the appreciation of music and the physiological and psychological benefits of music and music making.

2.1.1 Music as Motivation

Based on the current literature about how music can affect individuals during exercise, there is the potential to explore music as a way to motivate older adults to exercise and lead a healthier life. Several studies have found that music has motivational qualities during exercise, the melody and rhythm in music makes the exercise more enjoyable and diverts attention away from any discomfort or pain (Kennedy & Blair, 2014; Tenenbaum et al., 2004; Van Der Vlist, Bartneck, & Mäueler, 2011). Research has found that listening to music while exercising reduced perceived effort and led to a more positive experience while completing aerobic exercises (Seath & Thow, 1995; Van Der Vlist et al., 2011). These positive effects are also true for older adults taking part in exercise. Johnson et al. (2001) conducted a study where older adults listened to music during exercise. Similar to the other literature, they found that music was associated with a decreased perception of effort, discomfort and monotony.

The level of motivation achieved through listening to music is affected by the type of exercises being completed and personal music preferences. The type of music, or specifically its tempo, melody, lyrics and rhythm can have an effect on its motivational qualities (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 1999). In order to get the highest level of motivation, the type of music should match the level or type of exercise, as well as, the preference of the individual. Individuals' music preferences depend on their personal favorites and cultural background (Karageorghis et al., 1999). Older adults tend to prefer music that was popular while they were young adults (Flowers & Murphy, 2001; S. Hallam et al., 2016). Flowers & Murphy found that there was a negative correlation between preferences for high intensity music and age, suggesting that older adults prefer quieter music.

2.1.2 Benefits of Music Making

While health benefits are associated with listening to music, positive mental and physical effects are also connected with actively engaging in creating music (Creech et al., 2013; Hallam et al., 2014; Robb et al., 2008). Many individuals of all ages participate in active music making, through group activities, such as being in a band, an improvisational group or choir, as well as individually playing a musical instrument or singing.

Research has consistently found that creating music has positive psychological effects for all ages from children to older adults. Music makers have improved self-esteem, perception of self-worth and perceived quality of life; this may be because of an increased sense of purpose, accomplishment and identity associated with music making (Barrett, 2014; Croom, 2014; Hallam et al., 2014). Performing and creating music in groups can provide additional benefits for individuals, giving participants an increased sense of pride and accomplishment, increased social satisfaction and affirmation, which includes positive social relationships (Bailey, 2005; Susan Hallam et al., 2014). Learning to make music in older adulthood has been found to enhance social interactions (Perkins & Williamon, 2013). Music making can have a positive impact on health and well being by contributing to healthy social relationships. Literature shows that social support and interactions in older adulthood and related higher levels of subjective well being and physical health (Seeman, Lusignolo, Albert, & Berkman, 2001; Uchino, 2009)

Several physical benefits are also associated with music making, due to the physical demands from creating music. For example, Clift and Hancox (2001) found that university students participating in choral singing had several perceived physical benefits, which included increased lung capacity, improved breathing, strengthening of the diagraph and improved posture. Singing has also been found to help increase lung capacity in older adults (Gick, 2010).

2.1.3 Music Therapy

Music Therapy is a clinical example of using musical interventions with individuals to provide emotional, social, cognitive or physical benefits. The field of music therapy encompasses a variety of different interventions, which can be classified as either receptive or active. Passive music therapy includes listening to music in order to relax, improve mood or develop coping skills (Wheeler, 2015). In active music therapy, patients participate in creating music, through composition, playing instruments or singing. The research on active music therapy provides evidence of how music making can have positive effects on an individual. Music therapy has used music making, in both solo and group settings with patients of all ages (Bailey, 2005; Lindenfelser et al., 2012; Perkins & Williamon, 2013; Robb et al., 2008).

Inclusive Musical Instruments

Many individuals are not able to use traditional instruments or participate in music making due to disability, this can be because they are physically unable to use the instrument or have difficulty learning the skill because of cognitive impairments. Music making can become more accessible by using adaptive music instruments. Some of these instruments use electronic music technologies, which have more user-friendly input methods, in order to produce sound feedback (W. L. Magee, 2011). Most traditional instruments require the musician to mechanically create sound through vibrations made by mechanism such as strings, keys or mouthpieces. Electronic music technologies use sensors instead of these mechanisms, sending digital information to a computer which processes the sensor information into sound information, which in turn is broadcast through speakers (Hunt, Kirk, & Neighbour, 2004).

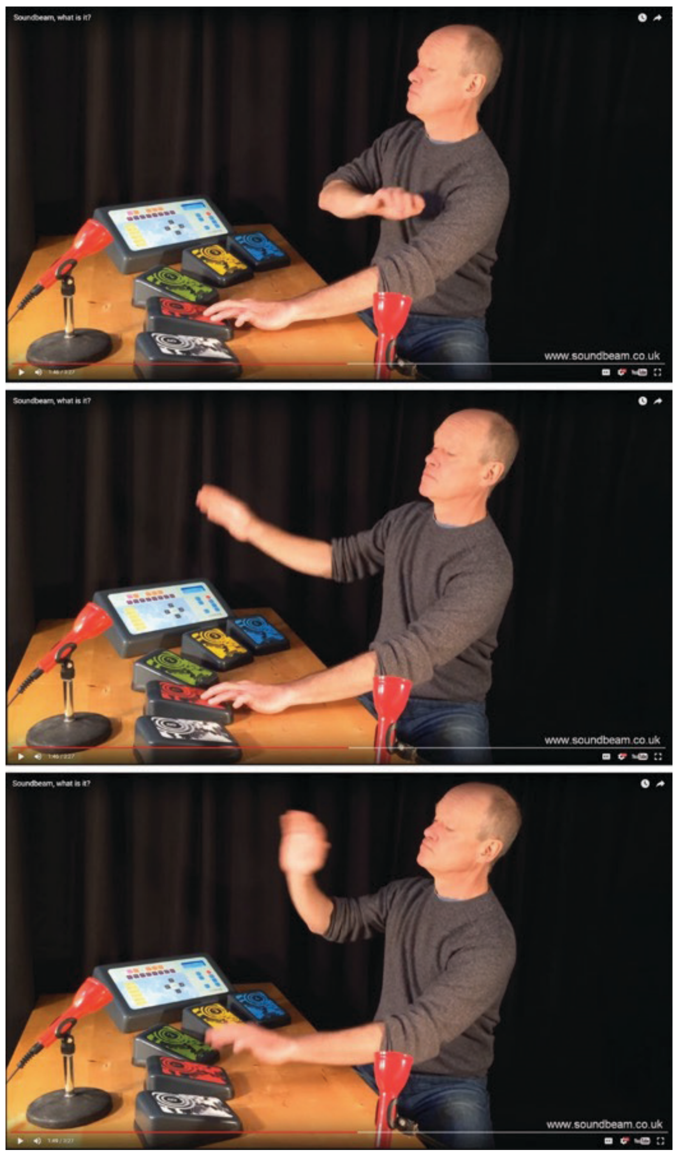


Figure 2-1 Using Soundbeam 5 with hand movements (soundbeam.co.uk)

Many electronic instruments use a MIDI (Musical Instrument Digital Interface) to control and create the music. For example, the commercially available SoundBeam device translates body movement into MIDI messages using ultra sonic sensors ("What is Soundbeam," n.d.)

Types of Interfaces and Output

Adaptive Electronic Musical instruments are able to have a variety of different interfaces and musical outputs because they use a computer to process the information. One type of user interaction uses a touchless interface that senses the user's movement. The user does not need to touch a screen or keyboard because the system senses their movements using cameras or motion sensors. Examples of projects using this type of interface are Adaptive Use Music Instrument (AUMI), Soundbeam and Movement-to-Music software (Lem & Paine, 2011; Oliveros, Miller, Heyen, Siddall, & Hazard, 2011; Tam et al., 2007).

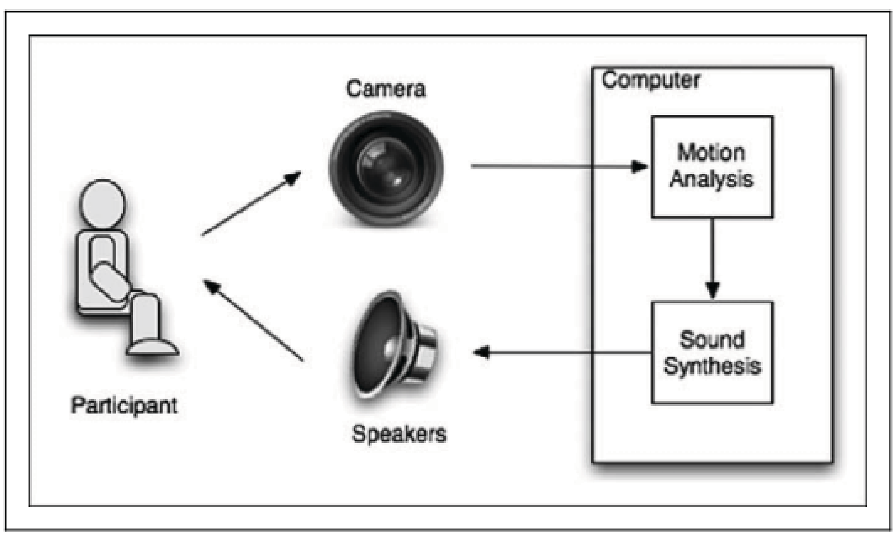


Figure 2-2 System using Movement-to-Music Software (Lem & Paine, 2011)

Another type of user interaction with the instrument uses direct physical contact; for example, Lee & Nantais (1995) used sensors in devices to physically detect different positions of body parts. One device attached to the elbow and measured the range of motion of the joint, where the different angles of the joint correspond to different notes (see Figure 2-4).

Figure 2-3 Movements being tracked by the camera (Lem & Paine, 2011)

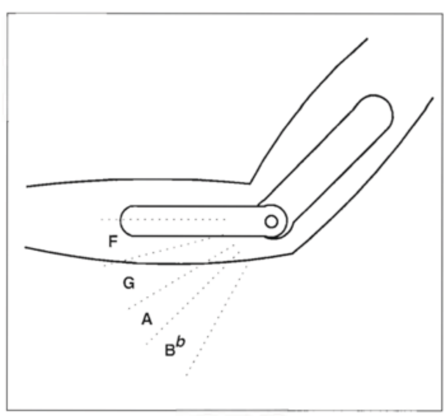


Figure 2-4 Mapping the elbow position to musical notes (Lee & Nantais, 1995)

Some of the music created with electronic music technologies can be more chaotic and random sounding. Users cannot play a specific song but can improvise. Two examples of this are AUMI software and the gestural software used by Lem & Paine (2011). Other systems allow people to play some songs by using technologies such as MIDI, in which different sensor inputs correspond to specific musical notes, for example, SoundBeam and the interface used by Lee & Nantais (1995).

Physical Benefits

Music making during exercise can have physical benefits for participants. The movements used to make music can strengthen muscles and increase range of motion (Lee & Nantais, 1995). Creating music with body movements can be an exercise routine in itself that is beneficial to participants (Giovagnoli, 2014; Hallam et al., 2014). The added purpose of the music making can increase motivation and pleasure, which may encourage participation in exercise (Lee & Nantais, 1995; Paul & Ramsey, 1998).

In a 1998 study, Paul & Ramsey used electronic music making with individuals with hemiplegia whose upper extremities were affected. The participants created music by reaching with their arms; they found these movements increased the range of motion in their shoulders and elbows. In a similar project, group music sessions were aimed at improving movement of the upper extremities of individuals with Spinal Cord Injuries (Lee & Nantais, 1995). In both studies, they found that music making was not only motivational for exercise, but also, according to the participants, more enjoyable than their regular exercise. Both of these studies involved adults with physical impairments, over a relatively short period of time.

Psychological benefits.

Another goal of inclusive music-making is to provide psychological or social benefits, and in turn, a higher quality of life. When individuals have a disability, the act of creating music can help make them feel normal and that the disability is secondary (Tam et al., 2007). Tam et al. used music-to-movement software with disabled children, to promote physical, cognitive and social development through engagement with music making. The children were also able to play and engage with other non-disabled children, because they were able to participate in the same activity. With the improvisational software AUMI, Oliveros et al (2011) found that disabled children were able to engage with peers in a group music session, benefitting from the social interaction and inclusion in the group music setting. Lee & Nantais (1995) found psychological benefits for the individuals with spinal cord injuries, in addition to, the physical benefits. Their participants enjoyed playing music, finding it a purposeful, creative, therapeutic activity and reporting improved self-esteem.

Ramsey (2011) considers the difficulty of modifying current electronic music technologies to accommodate the specific abilities of the individual a limitation in creating inclusive music. Another limitation is that users also have a lower level of control compared to traditional instruments.

Summary of Music and Music Making

The literature discusses substantial health benefits, both psychological and physical, associated with music and music-making. The results of studies in this area, some using inclusive musical instruments and electronic music technologies with specific populations, show promising applications. In particular, the potential to use music making with older adults to encourage and motivate during exercise and the social aspects associated with group making and how that can be beneficial.

2.2 Aging and Older Adulthood

Canada is currently undergoing a major shift in demographics, the population is aging and it is estimated that by 2036, up to 25% of the population will be over the age of sixty-five (Statistics Canada, 2015). This shift represents a new challenge for society as this large population faces the issues surrounding aging, including health related problems. It is becoming increasingly important to support ways for seniors to remain healthy, by maintaining physical functioning (Martin, Freedman, Schoeni, & Andreski, 2010; Vaughan et al., 2016). Improving health and physical functioning in older adulthood will support a higher quality of life and allow individuals to live independently longer (Fausset, Mayer, Rogers, & Fisk, 2009; Vaughan et al., 2016)

2.2.1 Health in Older Adulthood

Many of the challenges faced by older adults are a result of deteriorating health associated with aging. Physical changes in older adulthood include decreased senses of touch, smell, taste, vision and hearing, as well as, decline of gross and fine motor skills, which can affect mobility and dexterity (Huppert, 2003; Mann, 2005). Many older adults can also suffer from medical conditions, such as, stroke, heart disease, arthritis and joint replacement, which can greatly affect their physical abilities and mobility (David Seidel et al., 2009).

As sensory and physical capabilities change, it may be more difficult for older adults to function in their day-to-day life, and maintain independence (Diener, 2000). Older adults and their caregivers are encouraged to focus on their own sense of subjective well-being and quality of life, rather than the statistics related to their chronological age (D. D. and A. M. Coffman, 1999; Friedman, Kern, & Reynolds, 2010). Some of the factors influencing quality-of-life and subjective well-being include having social supports and sense of purpose (Diener, 2000). As a person ages, that purpose may be centered on his or her ability to complete activities of daily living (ADL) and the instrumental activities of daily living (IADL). ADL and IADL include tasks such as preparing a meal, washing, getting groceries, and doing laundry that are necessary for living independently (Lawton & Brody, 1969).

2.2.2 Exercising in Older Adulthood

By engaging in physical exercise, older adults can remain healthier, contributing to their ability to complete daily tasks. Exercise and activity have been shown to have positive benefits for both healthy older adults and those in poor health (Grove & Spier, 1999; Young & Dinan, 2005). Regular activity can help to increase strength, endurance and flexibility; these skills in turn, may help older adults maintain independence and perform ADL (Grove & Spier, 1999; Judge, Schechtman, Cress, & Group, 1996). It is recommended that older adults engage in thirty minutes of exercise on most days (Young & Dinan, 2005). Unfortunately, two-thirds of older adults do not engage in regular activity (Grove & Spier, 1999). Research has attempted to understand the nature of the barriers and motivations experienced by older adults that influence their exercise behaviors (Bennett & Winters-Stone, 2011; Biedenweg et al., 2014; Schutzer & Graves, 2004).

Barriers and Motivations

The most common barrier that prevents older adults from exercising is poor health. Disability and decreased mobility can make it more difficult for older adults to exercise independently (Newson & Kemps, 2015; Schutzer & Graves, 2004). Many gyms do not account for the potentially unique needs of older adults, requiring a specialized fitness class or adapted equipment. Other barriers for seniors are access to exercise facilities, transport to an exercise class, and perceived safety of the neighborhood (Schutzer & Graves, 2004). For many older adults who do decide to participate in an organized exercise program, adherence is a problem, with many discontinuing within the first six months (Jancey et al., 2007).

While barriers concerning accessibility need to be addressed, factors motivating older adults to exercise should also be understood. In addition to being the largest barrier, health problems are also the largest motivator for older adults to engage in exercise (Newson & Kemps, 2015; Schutzer & Graves, 2004). Having a physician's advice also greatly increases the likelihood that an individual will exercise (Schutzer & Graves, 2004). Older adults value inexpensive exercise programs, with an experienced instructor who can lead them in performing simple and moderate-intensity exercises. Older adults, particularly women, also appreciate having a social component to the exercise programs (Hallam et al., 2014; Schutzer & Graves, 2004).

Research shows that individuals prefer exercises that have an added purpose, meaning that they have a goal or outcome that the individual can focus on such as jumping rope or throwing a ball into a hoop (Kircher, 1984; Zimmerer-branum & Nelson, 1994). Multi-purpose exercises are more effective in therapy, such as accomplishing a simple task while exercising (Paul & Ramsey, 1998) As previously discussed, research has shown that music has the potential to motivate older adults in exercise (Kennedy & Blair, 2014; Tscherne, 2014). Clair et al. (Clair et al., 2011) found that cueing seniors' exercise routines with music had a positive effect on their satisfaction with the exercise and with many reporting that it was easier for them to complete.

Technological Interventions

New technology has created opportunities for technological intervention in senior's exercise activities. Using somatosensory videogames with the Xbox Kinect, Chen et al. (2012), found that participants had improvements in both physical health and quality of life. Gerling & Mandryk (2014) highlight that there is still a gap in research for games designed for older adults, as commercially available games often need to be modified for use by seniors or only used under the supervision of nurses or caretakers. Deutsch et al. (2011) also found that using Wii Sports and Wii Fit for stroke rehabilitation needed to be used under supervision of therapists for best results. Wii Fit training was found to improve balance in a study by Bieryla & Dold (2013); however, it is noted that chairs were needed to provide extra safety and only healthy older adults were used in the test group.

2.2.3 Summary of Aging and Older Adulthood

In older adulthood, a variety of changes occur as an individual ages; in particular aging adults may undergo physical changes, which can include sensory decline and loss of motor skills and mobility. As this segment of the population continues to increase in number, it is vital to provide encouragement and support for them to stay healthy. Exercising can contribute to maintaining health and well-being, but many older adults do not exercise on a regular basis. Barriers such as poor health may prevent them from participating in activities and exercise. However, several factors can motivate older adults to exercise, such as physician's advice, social contact, a good instructor and music. This indicates that there may be an opportunity to increase older people's motivation to exercise by incorporating music making into an exercise activity.

2.3 Designing for Older Adults

Older adults and people with disabilities often have trouble using mainstream products designed for the general population. Many products can be inaccessible or difficult to use for those with vision impairment, decreased mobility or other special needs (Welch, 1995). This creates a challenge for those individuals, as specialized products are often more expensive, unavailable, or have unwanted stigma attached to them. Given that older people will be living longer, with a range of different needs than younger people, there are many opportunities for the design profession to consider the unique needs of older adults (Choi, 2009; D. Seidel, Richardson, Jagger, Brayne, & Clarkson, 2010). Design can play an important role in maintaining independence of older adults, accounting for the physical challenges, decreased vision, hearing and other senses (Huppert, 2003).

2.3.1 Inclusive and Universal Design

Inclusive Design is the concept of designing for everyone, including outliers. These outliers can be people with disabilities or aging individuals who would have difficulty using traditional products. This main focus of inclusive design is to expand the target demographic to include as many people as possible (Coleman, Lebbon, Clarkson, & Keates, 2003). When designing for the outliers, people who have trouble with mainstream products, it is possible to innovate in ways that make the user experience better for everyone (Choi, 2009). An example of inclusive design is the OXO good grips potato peeler and subsequent products in that line, which were designed for individuals with arthritis, but arthritis was not referred to during marketing. The design became widely popular with all kinds of people due to its ease of use ("Inclusive Design: Better Design Examples," 2005). Designing adaptations of products for individual limitations is not economically viable, but inclusive design becomes a profitable business strategy when addressing a wider target market. This creates better products for everyone, and has the potential to contribute to a more equal society.

While the concept of inclusive design emerged largely from the UK and other European countries, in the United States, the term *Universal Design* is used to describe a concept that is similar to inclusive design, focused on universal accessibility. Good universal design should be "Supportive, Adaptable, Accessible and Safety oriented" (Welch, 1995). Both concepts have a place in industrial design, architecture and interaction design to ensure that products and experiences are accessible to everyone.

2.3.2 Designing for the Senses

An inclusive design perspective highlights the importance of considering all sensory modalities when designing for the degrading senses often experienced by older adults. For example, using only one modality may be unsafe if a user is impaired in that particular sensory modality. A multi-sensory design approach interacts with the user through a range of the senses including vision, audition, touch and sometimes chemo sensation (taste and smell). Multiple modalities may involve a richer user experience by providing additional feedback; for example, when using a computer keyboard, one can feel the buttons being pressed, hear a click when typing and see the words appearing on the screen (Schifferstein & Spence, 2008). It is increasingly necessary to consider a range of sensory experiences in products, as technological advancement takes away many natural sensory aspects, such as tactile and auditory feedback. The sensory aspects of product interaction, such as the tactile, audio and visual experience affect the user's perception, behaviours and experience (Schifferstein & Spence, 2008). As an individual ages and their senses evolve, a reordering of the senses takes place. This reordering changes the hierarchy in which users experience visual, audio and tactile aspects to a product, leading to a different product experience (Frankel, 2015).

Keay-Bright & Gethin-Lewis (2011), take an inclusive design and multi-sensory approach to create a unique experience for children with autism. They created several interfaces, which responded to touch, sound and movement by different visual, and auditory outputs, aimed at engaging the children, who can have difficulty with engagement and communication. This enhanced user experience may be useful in engaging older adults in music making while exercising.

2.3.3 Summary of Designing of Older Adults

Older adults can have a unique set of needs that should be considered when designing products for them. The Inclusive or Universal design philosophy involves considering those with limited abilities, such as older adults, when designing. In doing so the design of functional and beautiful products, experiences or services that are appropriate for a wider range of people, can include those who are often excluded when design does not consider their unique needs. When designing new products or experiences, it is important to consider older adults, and address their needs based on the fact they may have limited abilities, such as reduced mobility, vision or hearing.

2.4 Design Research

Since design emerged as a new field of research, in the mid-twentieth century, researchers began to apply theory from fields such as cultural anthropology, psychology and ergonomics to design (Bayazit, 2004). Borrowing from these fields, design researchers have adapted and developed research methods, for example co-design emerged from participatory action research in the social sciences, and design probes from cultural probes used in cultural anthropology (Hutchinson et al., 2003; Sanders & Stappers, 2012). This section will look at how these practices emerged and developed into the current methods used by designers, and what they can contribute to the current research.

2.4.1 Participatory design and Co-design

Early in the history of design research, researchers attempted to use a scientific method to obtain information about their users, using methods such as secondary sources and structured interviews. Over time, researchers wanted to have a deeper understanding of their user population and be able to tackle more complex problems, which led to using methods which supported these objectives (Bayazit, 2004). They began using participatory methods, where the user was involved in identifying their needs and having input into design development decisions.

The participatory approach to design research emerged from Participatory Action Research originally used in the social sciences. In participatory action research, participants and researchers work together to identify problems and initiate research, which can result social change. The underlying idea is that the participants have unique knowledge different from the researchers' (Kindon, Pain, & Kesby, 2007). Using this approach, design researchers involve the end-users, because they have more knowledge about the problem than the design research experts do.

Co-design is an approach to design research that is a subset of participatory design (Sanders & Stappers, 2012). In co-design, the emphasis is on the researchers, designers and users all working together as equal participants during the design process (Sanders & Stappers, 2012). The participants and researchers make artifacts together, with the participants as the experts whose knowledge informs the design, and the designers as facilitators who provide insight into design issues (Sanders & Stappers, 2008, 2012).

2.4.2 Design Probes

Another qualitative method used to gain design research information about the users and their experiences are probes. Design research probes are tools used to evoke responses. There are different types of design probes; one type, cultural probes can be in the form of postcards, diaries or cameras, where the participants are able to express their attitudes or values. The participants' response to these artifacts allow the researchers to understand the users' subjective points of view. Gaver, Dunne & Pacenti (1999) introduced the idea of `cultural probes,' which can be used to understand the cultural context to a design problem.

Technology probes, involve taking a piece of technology, such as software application, and inserting into a context with users. The participants are able to use and respond to the probe in order for researchers to discover how they use it over a period of time. Technological probes can be used to understand user needs and to test different technologies (Hutchinson et al., 2003)

Both cultural and technology probes have the goal of providing inspiration for the researchers and gaining an overall impression of the users' beliefs. This qualitative approach gives researchers fragments of information and must be interpreted, rather than more one dimensional results which would emerge from quantitative methods (Gaver et al., 1999; Graham et al., 2007).

2.4.3 Summary of Research Methods

This research study focuses on the users and the experience of older adults. There is an opportunity to use design research practices to understand the older adult users, and how they could be able to use music making devices. Co-design focuses on the end users as the expert, involving them in the design process in order to gain greater knowledge about the user and the design problem. Designs probes, specifically technology probes, can be used to evoke responses from the users, leading to deeper understanding of the user perspective.

2.5 Literature Review Summary

According to the literature, older adults who participate in regular exercise experience health benefits that allow them to stay independent longer (Manini & Pahor, 2009; Vaughan et al., 2016). Many older adults fail to exercise on a regular basis, which may be due to the barriers and lack of motivators to exercise. Research has shown that there is potential for, and some success with, using inclusive music making strategies, to benefit the users' sense of well being and physical abilities, and to provide them with added motivation to exercise (Wendy L. Magee & Burland, 2008; Paul & Ramsey, 1998). There is currently a gap in research concerning using music making with older adults, and how to create a more rewarding exercise experience for seniors. There is an opportunity to explore how design and design research could address the application of music making in a seniors' exercise.

Therefore the main question in this study is, *"How can design contribute to developing responsive music making objects which create positive exercise experiences for seniors?"* Understanding how having an added level of social interaction and sensory feedback, through music, affects the user may help inform the design of potential applications (systems- software & hardware) to be used in seniors' exercise settings to promote engagement, motivation and positive experience. Insights into how seniors respond to creating music through movement may also help inform the design of future products and interfaces using music and movement. These topics will be addressed in the following sub-questions:

- How do seniors respond to musical feedback during their exercises?
- What is the role of the musical object and how is the object used during exercises?
- How does the additional social interaction arising from co-creating music affect the experience of the fitness class?

Chapter 3. Methods

This chapter will detail the research methods used for this study. As discussed in the previous chapter, there is a gap in research regarding using music-making as a way to engage and benefit seniors while exercising. Using an exploratory approach, the goal of this study was to investigate how to design responsive music-making devices for a seniors' exercise class. This was examined using methodological triangulation and qualitative research methods within a constructivist framework. A constructivist framework refers to the process of using qualitative research methods to discover and interpret the experiences of the participants. Theory is developed based on the subjective understanding and meanings people hold (Creswell, 2009). Using qualitative research methods is ideal for this type of exploratory study, allowing for the investigation of a general theme rather than proving a particular hypothesis. Each research method was designed and conducted after the initial data collection and analysis was finished for the previous method, and the findings were synthesized after the final method was complete to solidify the insights.

3.1 Triangulation

The overall research approach used methodological triangulation, which involved employing three different methods. Triangulation is important when using qualitative research methods in order to achieve rich, multi-layered data from various sources (Patton, 1990). Due to the small sample size of participants, it was important to approach data collection through different methods in order to be able to make comparison. Three complementary methods: the use of design probes, an in-depth interview, and a co-design workshop were used to triangulate the data from different perspectives, allowing for comparisons and validation of the data. These methods were chosen prior to research, in order to have the three different perspectives of the researcher, an expert and the users themselves. Each method built upon the experience and findings from the previous method.

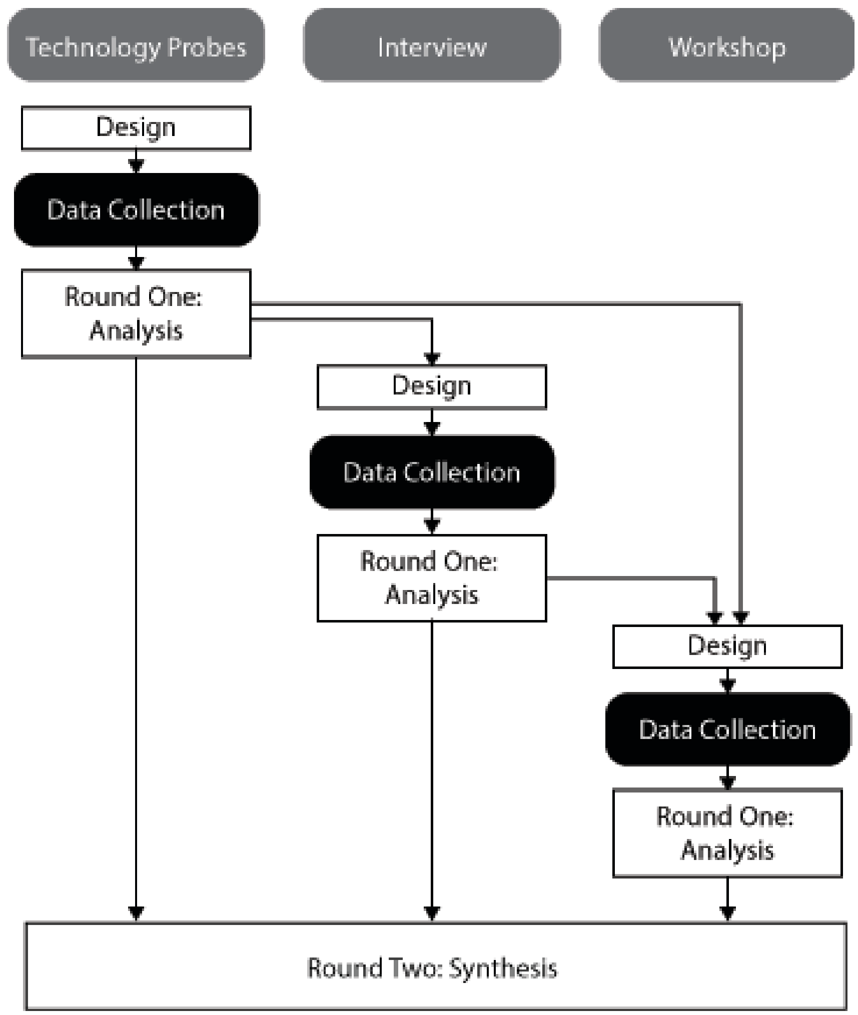


Figure 3-1 Research Steps

3.2 Ethical Considerations

This research study was submitted to and approved by the Carleton Research and Ethics Board (see appendices). The study was found to be minimal risk to participants, but precautions were taken to ensure their safety, especially considering the age and physical capabilities of the participants. Participation was completely voluntary and participants were instructed that they could withdraw their participation at any time. When they were participating in physical activity during the technology probe session, a fitness instructor, who was familiar with their physical and cognitive capabilities, monitored them. To minimize discomfort, the sessions took place in a setting that was familiar to them, participants were supplied with water, told to take frequent rests and not to over exert themselves. All participants consented to being video and audio recorded for research purposes.

3.3 Technology Probes

The first research method involved using exploratory technology probes with a group of seniors in integrated fitness classes. This was chosen as the first method because the following methods built upon the participants' experience using the technology probes. The purpose of these probes was to invoke a response from the participants. The intention was to prompt the participants to express themselves through movements, comments and reactions such as laughter and smiling. From observations, the researcher would be able to gain an impressionistic understanding of the participants' experience, as well as, their beliefs and desires more generally. The technology probes included two types of movement-to-music devices, which are described in more detail below. Prior to the research sessions, the instructor of the class was consulted and appropriate activities were chosen to use with the different probes. These were exercises already done during the class that the instructor believed would work well with music-making and the two probes.

3.3.1 Participants

The participants were recruited through Churchill Seniors Centre in Ottawa, Ontario. They were all seniors who participated regularly in the integrated fitness classes at the center. Integrated fitness classes at the Churchill Seniors Centre are small classes, with up to eight people, who all have individualized programs based on their fitness level and goals. The small size and customized nature of the classes made them ideal for hosting the technology probe research sessions. Individuals in these fitness classes are all post-rehabilitation, now wishing to continue their exercise routine to improve or to maintain their health and physical capabilities. Many previously suffered from an incident affecting their mobility, such as a stroke or a fall, and have some mobility or strength issues. A total of nineteen participants took part in the technology probes portion of the study. There were ten men and nine women; three of the participants attended two of the research sessions, two male and one female.

3.3.2 Probes (AUMI and SAMI)

One of the technology probes was the Adaptive Use Musical Instrument (AUMI) software, an iPad app which is an accessible musical instrument, creating music from the users' movements. The app was originally developed for people with limited voluntary movement, such as someone with severe disabilities. It uses the camera function of the iPad to track the user's movements. The iPad interface screen consists of different zones, the number and size of which can be changed, each representing a different musical tone or sound (See figure 3-1). The configuration of the zones can be changed, as well as the type of musical scale and instrument (see Figure 3-2).

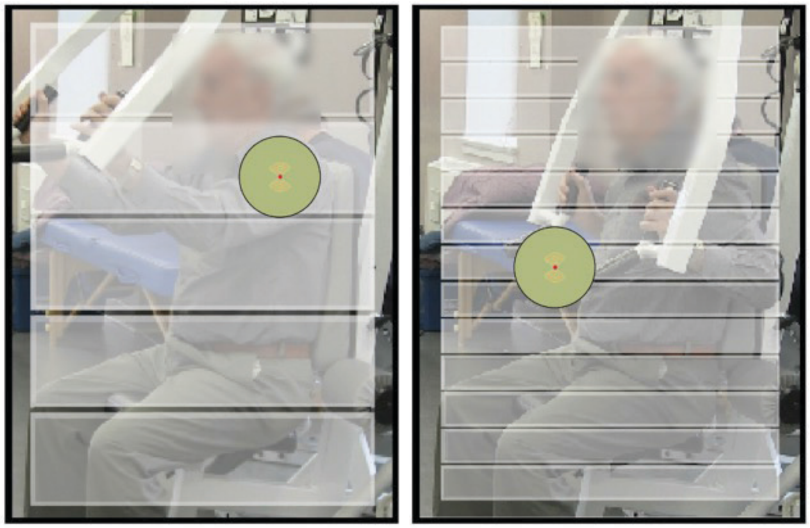


Figure 3-2 AUMI Screenshots using five and thirteen notes.

The user's movement is illustrated by a dot moving around the iPad screen, into the different musical zones, resulting in sounds and music that seem to correspond with the movements.

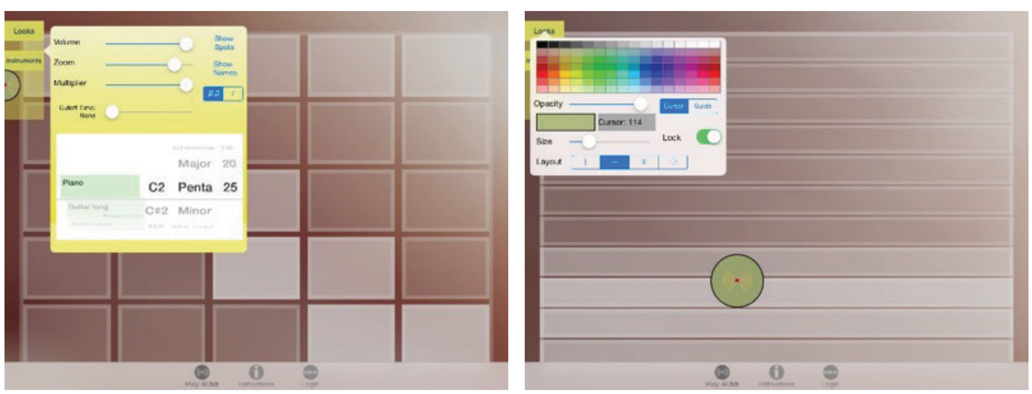


Figure 3-3 Menu Options in AUMI Software

The AUMI can be used with a microphone stand or be clamped to a table or chair, and works at almost any distance from the individual (see Figure 3-3). The AUMI software was chosen to use as a technology probe based on its successful use with adults and children with limited mobility; however, it had not been used extensively in the context of older adults.

Figure 3-4 Wrist extensions while using the AUMI iPad clamped to a chair.

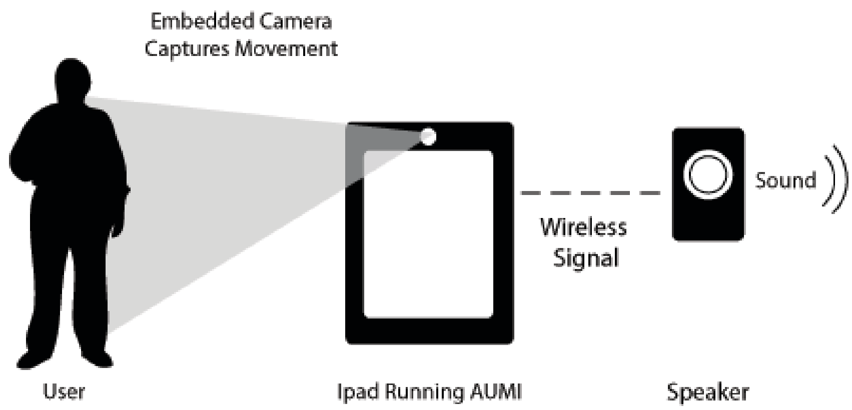


Figure 3-5 AUMI Overview

The second and third probes used a system called SensAble Adaptive Music Interface (SAMI), developed by Carleton University Professor Adrian Chan, department of Systems and Computer Engineering, and a team of undergraduate Biomedical and Electrical Engineering students. SAMI is a specific application of their Generic Human Interface Device (GHID) System, which allows sensors to be used as an alternative input control for a keyboard, mouse or joystick. The first of the SAMI probes is a foam ball for users to pass and throw, and the second a wristband that they would wear while completing exercises (Figure 3-5 and 3-6).

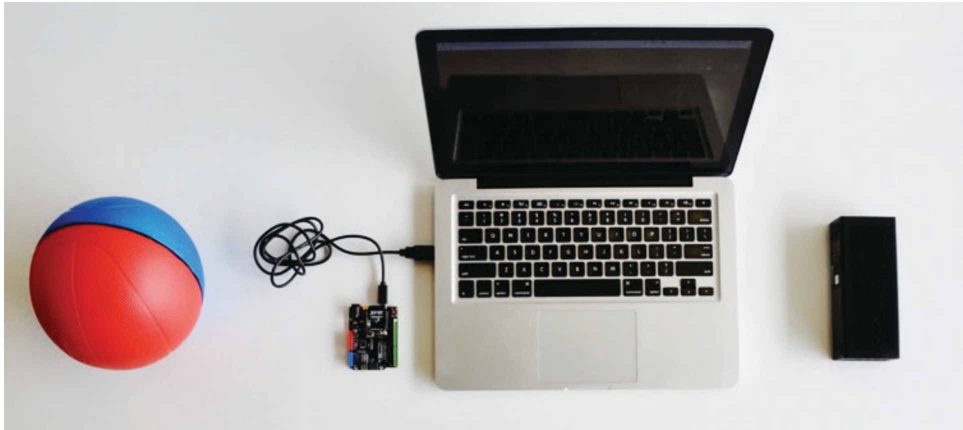


Figure 3-6 SAMI System with foam ball

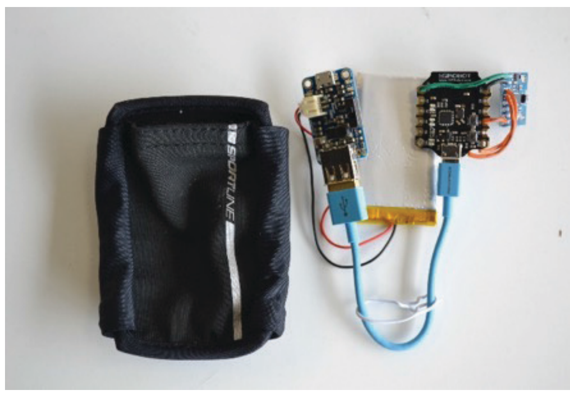


Figure 3-7 SAMI Wristband, with Sensors and Battery

SAMI uses a gyroscope and an accelerometer, embedded within the foam ball or wristband, which wirelessly connect to the GHID hub to control the keyboard of a computer running the “DIN is Noise” synthesizer software (See Figure 3-7). Rolling, passing, or moving the ball triggers audio responses from the computer that are picked up by the sensors inside the ball. On “DIN is Noise”, each sound produced is visually represented by a colored square which shrinks in size as the sound decays (See Figure 3-8).

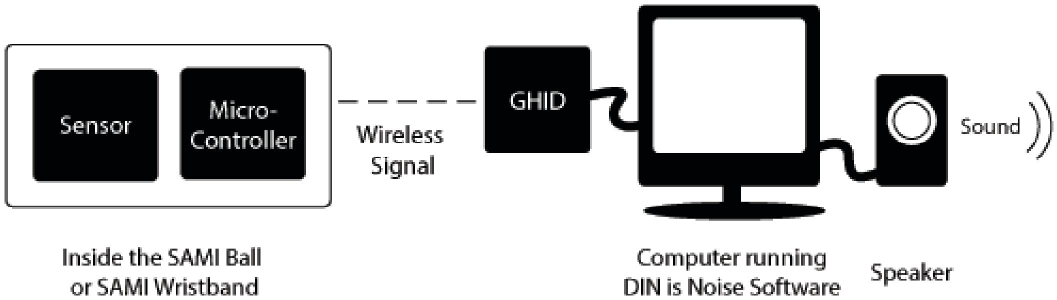


Figure 3-8 SAMI system overview

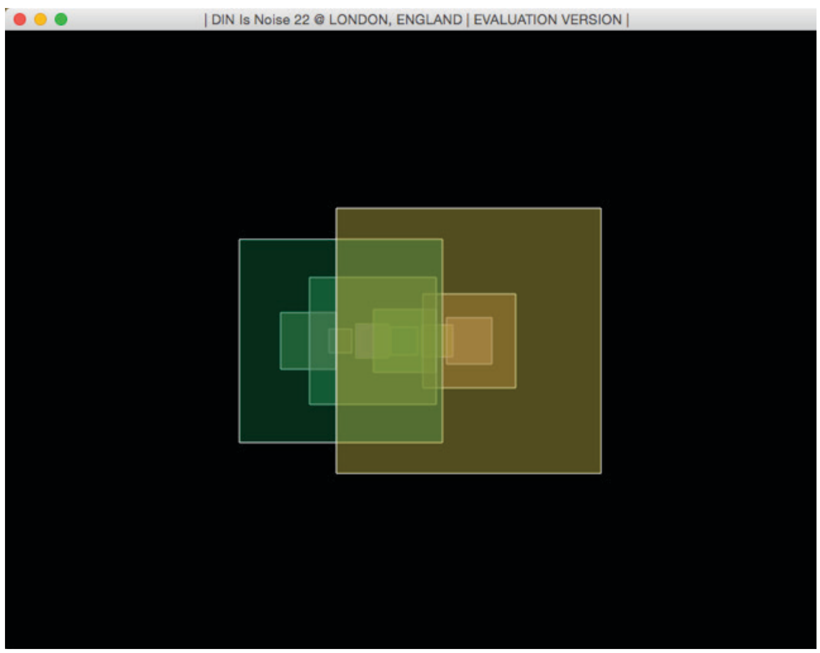


Figure 3-9 Screenshot of DIN is Noise Software

Depending on the speed and direction of the ball or wristband, the sensors will trigger different keystrokes, and in turn, output different musical pitches, the tuning and timbre of which are customizable within the DIN software. SAMI was chosen as a technology probe because it requires the user to interact with a physical object to create music, in contrast with the AUMI.

3.3.3 Data Collection

Four different technology probe sessions took place at the Churchill Seniors center, each of which were video recorded for transcription and analysis. Each session took place during an existing one-hour fitness class, with about fifteen to twenty minutes of group warm up, thirty minutes of individual exercise, and ten minutes of cool-down. The probes were used for the exercises that had previously been determined with the instructor.

Figure 3-10 Set-up during warm-up using AUMI and SAMI ball.

During the warm-up participants were seated in a circle, with the iPads running AUMI software set-up on the outside of the circle to catch the participant's movements. The warm-up started with seated stretches and exercises as a group, and was followed by passing the SAMI ball around the circle, and then throwing and catching the ball across the circle.

During the individual exercises, iPads running the AUMI software were positioned to catch the movement of either the exercise machine or the participant's movement while completing exercises, such as lifting weights or using a cardio machine (see Figure 3-3 & 3-10).

Figure 3-11 AUMI used with the weight machine and Nu-Step Cardio Machine

Figure 3-12 Wristband and AUMI used with resistance band.

The SAMI armband was used for individual exercises that required repetitive movement of the arm, such as pulling on a resistance band, or pull-down exercises on the machine. These exercises were chosen because the researcher believed they would be more easily picked up by the sensors. The SAMI armband was only used during two of the one-hour classes, because of technology issues in which the researcher could not make the band respond to the movements as reliably during the arm exercises.

In two of the four sessions, during the cool down, participants were again seated in a circle, with IPads running the AUMI software outside the circle, in the same set-up as during the warm up (Figure 3-9).

3.3.4 Analysis

After data collection, NVivo software was used to transcribe and code the video recordings. The researcher examined the videos, and selected sections to transcribe. The sections selected to transcribe were chosen because it was when participants were responding, either verbally or non-verbally, to using the probe. The transcription included speech, the type of probe used, the actions and gestures of participants. Directly after transcription, the researcher used first cycle coding methods: initial coding was done in order to reflect on the content of the technology probe sessions. During this initial coding, descriptive and process codes were used to label the main topics and actions in the research session (Saldana, 2013). From this first round of coding, the common themes were uncovered. Certain themes, such as those about the issues participants had using the probes, led to questions used in the next methodology, the expert interview, so that a more thorough understanding could be achieved.

3.4 Expert Interview

The second research method was an expert interview, conducted with open-ended questions so that experts would not be restricted in their answers, allowing for more data. The goal of the interview was to further understand the findings from the previous method. It was used as an exploratory tool to uncover more key themes leading to the development of the content for the third research method, which is described later (see section 3.5). One interview took place with a fitness instructor at Churchill Seniors Center. Only one interview was conducted because she was the only instructor present during the first research method using the technology probes, and it was important that the instructor should be familiar with the probes and had seen how the participants used them.

The interview questions were generated after the researcher had reviewed and identified themes from the previous research method (see Appendix B). Problems with using the probes and social interactions between participants arose as themes. These led to questions about the difficulties seniors have using the ball and the value of the social aspect of the class.

The questions focused on the experience of seniors who attend exercise classes and the reaction to the technology probes used in the classes. Based on the data from the technology probe sessions, the researcher was able to ask about specific reactions that the participants had to the probes. For example, one question addressed the negative reactions that some participants had to the type of music.

The interview took approximately 30 minutes and took place at Churchill Seniors Centre. The interview was audio recorded and manually transcribed. The researcher reviewed the transcript and initial coding was done using Nvivo Software.

3.5 Co-Design Workshop

The final research method was a co-design workshop to develop concepts for the types of music creating devices they would want to use in their exercise class. This method was chosen because, as discussed in the previous chapter, co-design has been shown to be a useful tool in design research to provide insights about the user and their needs through the discussion and process involved in creating the designed artifacts (Sanders & Stappers, 2012). In this case, the artifacts were sketches created by design students who helped to facilitate the workshop. The workshop was originally planned with an expectation that the outcome would include design concepts or rough prototype-models exploring designs and forms for music making devices. The design of the workshop itself needed to be changed for two reasons. The first was a logistical scheduling issue with Churchill Seniors Center and the participants that resulted in a one-hour limitation for the workshop. The second reason, after completing the analysis of data collected in the first two methods, it became apparent that it would be overly optimistic to expect complete design concepts. Based on the participants' level of understanding of the technology probes and limited ability to express verbally or through drawing or modeling due to the limited dexterity of many of the participants.

3.5.1 Participants

The participants were two undergraduate design students and four seniors who regularly attended integrated fitness classes at Churchill Seniors Centre. The design students were recruited through the Carleton School of Industrial Design. They were instructed to sketch and visualize the seniors design ideas and prompt them when necessary. Both design students were in their second year of industrial design and female. Three of the four senior participants had been participants of the technology probe research sessions. Unintentionally, all four senior participants in the workshop were male, which may have had an effect on the data, but it is impossible to determine what that effect would have been. Due to scheduling conflicts and availability of participants it was not possible to schedule a second workshop to increase the sample size, because if the workshop was held too long after the technology probe session, the participants may not have been able to recall their experiences.

3.5.2 Data Collection

The workshop consisted of three parts. In the first, which lasted around fifteen minutes, the group of four senior participants in one large group were asked to describe what a typical fitness class session is like to the two industrial design students. The students took notes to understand the senior's perception of what they did in the class. This acted as a bridging exercise to get the participants comfortable with each other, and provide perspective about how the seniors viewed and experienced their fitness classes.

During the second portion, participants were split into two groups. Each group consisted of one industrial design student and two seniors. Using markers and large sketch paper, they were then asked to spend twenty-five minutes to generate ideas about what they would like in a device that would produce music from their exercise movements during fitness class. The design students were asked to try and formulate the ideas into rough concepts to get feedback from the seniors. They were supplied with markers, pens and large paper to generate ideas.

The final portion involved asking the seniors for their feedback on the design ideas and using music generation during a fitness class. The goal from gaining the feedback was to discover what preferences, likes and dislikes the participants had for the music making devices and if they would want to use the devices. This was done through a paper questionnaire (See appendix C) that the students helped administer, as some of the senior participants had trouble filling it out. A paper questionnaire was chosen because it would be quicker and more focused than a discussion. It also had the advantage of anonymity: participants' answered without knowing the others' answers. However, the anonymity was mitigated by the fact that three of the participants needed help to complete the questionnaire and completed it verbally within earshot of the others.

Two camcorders were used to capture video and audio information during the workshop. While the group was split in two, iPods were used to capture audio information to ensure accuracy. The participants' answers to the survey questions were written on the survey questionnaire.

3.6 Data Analysis

Directly after data collection for each method, the first layer of data analysis was to code the transcripts to help develop main themes and ideas. During this stage, initial coding was done using descriptive and process codes simultaneously to identify topics and actions (Saldana, 2013). From the codes, the data from each of the three methods was themed directly after the data collection.

After this first round of analysis was complete using all three research methods, the synthesis took place through analytical triangulation. By combining the data from all three methods it was possible to see where the findings overlapped. During this stage, all the video, audio, and coding information from each of the three research methods was consolidated by entering the raw data into the Nvivo Software application. The next step was to organize and prioritize all of the information in a second cycle of coding. The data was then exported to excel, where it was possible to prioritize the data and cluster it into relevant concepts. Common themes that were consistent across multiple methods were identified. An affinity diagram was created to describe the different clusters and structure of the relationships between them.

Chapter 4. Findings

This chapter presents the findings from the technology probes, expert interview and design workshop. The results are organized chronologically by research method and separated into the themes that emerged during analysis.

4.1 Findings from Technology Probes

The technology probe sessions revealed how users interacted with music making probes in a fitness class environment, providing information on how their exercise experience changed when using the probes, and what their reactions were to a music making activity during the class. From these observations, an affinity diagram was created and several subthemes emerged within the main themes (See Table 4.1). This section will review the findings within each of these themes.

Table 4-1 Technology Probes Affinity Diagram of Main Themes and Sub-Themes

Interactions with Probes	Changes in the Exercise Experience	Reactions to the Music
Physical Interactions How the participants physically interact with the ball and wristband.	***Bodily Awareness*** How participants are aware of their bodies and capbablities	***Comparisons*** Comparing the music to sounds that are familiar
Interaction through Camera How the participants move to produce sound feedback	***Changing Movements*** How the participants change their exercise movements	***Negative or Indifference*** Participants negative comments or indifference to the music being created
Creating Sound The relationship between movement and sound	***Social Experience*** Between two participants and between the participant and the instructor	***Postive Reactions*** Postive comments and reactions from participants to the music being created.
Visual Interface Participants engaging in the visual interface		

Table 4-2 Summary of Activities and Participants

Warm Up Stretches (Group of 4-7)

Probes Used	Total participants
AUMI	13

Ball Passing (Group of 4-7)

Probes Used	Total participants
AUMI, SAMI Ball	13

Ball Throwing (Group of 4-7)

Probes Used	Total participants
AUMI, SAMI Ball	13

Nu Step Cardio (1-2 People)

Probes Used	Total participants
AUMI	4

Upper Body Weight Machine

Probes Used	Total participants
AUMI	5

Lower Body Weight Machine

Probes Used	Total participants
AUMI	2

Seated Exercises

Probes Used	Total participants
AUMI	5

Arm Exercises

Probes Used	Total participants
AUMI, SAMI Wristband	2

4.1.1 Interactions with the Probes

During the technology probe sessions, participants interacted with the probes in several different ways. Participants interacted with the SAMI ball by physically holding, passing and throwing the ball, without any visual interface to physically interact with. Participants used the SAMI wristband by wearing the wristband like a bracelet and moving their wrist up and down to elicit the musical feedback, while using the wristband they could also see the visual feedback from the “DIN is noise” on the laptop computer (see Figure 3-8). All interactions between the participants and the AUMI were touchless, as the researcher set-up the probe, and the AUMI used the iPad camera to track movements, and the participants were able to see the visual display on the iPad screen. During the technology probe sessions, not all nineteen of the participants were able to use all three of the probes, see table 4-2 for a summary of the activities and number of participants.

Physical Interactions

Two warm up exercises used the SAMI ball: the first involved passing the ball to the next person in the circle; the second was throwing the ball to anyone else in the circle. During the passing exercises, most participants used one hand to grip the ball as the instructor had demonstrated. When using one hand, they either used their entire palm, or dug their fingers to into the ball like a claw.

Figure 4-1 Participants using fingers to claw into the ball

Seven of the thirteen participants had trouble keeping a grip on the ball, they tried to overcome this by either using two hands to hold the ball, or balancing the ball on one hand instead of gripping the ball using their fingers. Five of the thirteen participants who took part in the passing exercises had reduced strength or dexterity in one of their hands, which meant they had only one fully functioning hand with which to interact with the ball. Of those five, three had trouble gripping the ball.

Figure 4-2 Balance the ball on the hand instead of gripping

Participants who had trouble gripping the ball often had to readjust their grip. The ball was passed over a hundred times between participants. Three different participants dropped the ball during the passing exercises. Two of the drops happened when the participant was balancing the ball and not using their fingers to claw into the material.

One participant commented, “we need a handle on it” in response to having difficulty gripping it and needing to readjust.

Figure 4-3 Warm up session tossing the SAMI Ball.

During the SAMI ball tossing exercise, if participants were able to use both hands, they did so for both catching and throwing the ball. If a participant had limited use of one of their hands, they would use their hand, arm or body to provide extra support when catching the ball.

The SAMI wristband was used during several individual arm exercises. The wristband was put on the wrist of the participant with the help of the researcher. Once it was on the wrist, the participant didn’t pay any attention to the physical band, only to the musical feedback.

Interaction through the Camera

Participants used their movements to interact with the AUMI software to produce audio feedback. Many participants used movements to interact with the iPad outside of their instructed exercises. This happened during both during the group and individual exercises. Movements made by the participants included waving their hands in front of the iPad camera, making familiar gestures, such as the motions of playing piano or drums in the air, or making the motions of an exercise using no weights or doing only part of an exercise. For example, after one participant had finished their lower body weight routine using the AUMI, he continued to move in order to play different sounds on the AUMI. When the instructor saw he was still moving on the machine and asked what he was doing he replied, "I'm playing a tune."

Creating Sound

When participants interacted with the probes through movements, either by moving in front of the camera of the AUMI, or by physically moving SAMI ball and the SAMI wristband (which have embedded sensors), the main feedback was the sound. Participants were aware of the relationship between the sound and their movements: noticing that when they moved faster, the music mimicked that rhythm; when they stopped, the music stopped; and when they repeated the same motions, the music would also create a pattern.

The SAMI wristband created a very straightforward sound and movement relationship, because the exercises done with the wristband were repetitive and used simple motions. The result was roughly one note each time the wristband switched directions. Participants were able to understand the feedback was coming from their movements, as they reacted to the sound by moving their arms more. When there were technical difficulties and the wristband wasn't creating sound, the participant expressed dissatisfaction, saying "I just want [the music] to go!" and then attempted to change their motions to make the feedback occur.

When using the SAMI ball, it was harder to isolate the SAMI musical feedback, because the SAMI ball and AUMI probes were used at the same time, but produced music independently of each other. The SAMI Ball created sound from its movements and the AUMI created sound when the camera captured movement from any of the participants. During the passing and throwing exercise, there was relationship between the exercise and the sound. A musical pattern emerged because the SAMI ball and AUMI iPads would make more music when the participants were either catching or throwing the ball.

When using the AUMI software on the iPad during their individual exercises, participants created sounds using their natural exercise movements. The relationship was straightforward, and seven of the eleven participants experimented with their movements during their individual exercises to see how they would be able to change the sound feedback from the iPad.

Visual Interface

Another way for AUMI and SAMI to interact with participants was through the visual interface on the computer or iPad. The AUMI software had a display showing what the camera was capturing overlaid with the zones, which would produce different sounds, and a yellow dot which responded to the movements tracked by the camera. While using the SAMI wristband, the computer displayed the DIN is noise software, which used colored boxes to represent each sound that was being output. The size of each square is correlated with the volume of each pitch: as the sound of the pitch decays, the squares get smaller.

While creating audio feedback during exercises, participants were often engaged in watching the visual display on the iPad and computer. Participants watched the iPad screen, which showed their own movements and the dot moving through the different zones on the screen. When using the wristband, participants watched the squares being created from their movements and one participant commented on the colours that they were making on the DIN interface.

Figure 4-4 Participant engaged with AUMI interface

4.1.2 Changes in Exercise Experience

When making music using the technology probes, changes to the exercise experience were observed. Participants changed the movements of their exercises, were aware of their body, and their physical capabilities and the music making acted as a catalyst for them to interact with others socially.

Change in Movements

When making music during individual exercises, users were observed changing their exercise movements. This included changing the speed of the exercises and modifying how far they reached, and sometimes changing both at the same time. Participants were quick to realize how changing their movements would affect the musical feedback. Five participants used the AUMI for exercises at the upper body weight machine, and during exercises that required pulling down, three of them were observed making short quick up-down motions to create a different pattern than if they were doing the exercises regularly. When doing wrist exercises, one participant was observed increasing the range of one of their hands, attempting to match the range of the other hand, based on the feedback they were getting on the iPad.

Some users also did the exercises for longer than instructed. Two of the participants became distracted by the music making and forgot to count the number of repetitions that they had completed. During the downtime between exercises, while waiting for the instructor to help them with the next exercise, some participants continued to use the probes by making movements or using the machine to create musical feedback.

Rewards

During the probe sessions, the instructor used music making as an incentive to get the participants to exercise more or to do their exercises with a larger range of motion. The goal that the instructor presented was to create more music, which required more body movement. Three participants were willing to do more exercises in order to use the music making devices. One participant commented that having an AUMI iPad would motivate her to do exercises every day.

Bodily Awareness

When users interacted with the probes and received musical feedback from their movement, they became aware of what their bodies were doing. Participants could hear and see feedback when their bodies moved, bringing awareness to what their bodies were doing and also what their bodies were capable of doing. One participant commented on the tracking dot on the AUMI interface saying, “It makes you realize that you are getting up there, wish I could get my left arm up”. In that example, she was able to see that her right arm was able to move farther than her left. The audio and visual feedback made it easy for the participant to realize if one side of her body was capable of a larger range of motion.

Social Interactions

Creating music in the exercise class also served as a catalyst for social interaction. The music making facilitated social interactions between the instructor and the participants, as well as between participants. The instructor commented on how nice the music sounded, encouraging the participants. Among participants, the music making prompted them to cheer each other on during group work and to comment on how the music sounded when others were making music during individual work.

4.1.3 Reactions to the Music

Participants had many different reactions to the music produced using the technology probes. The most common comments about the music feedback were comparisons to familiar sounds. The iPad running AUMI produced several different sounds, ranging from wood-blocks and piano to kitchen percussion and drums. When using the probes, the musical output was in a major pentatonic scale, which uses five notes instead of the seven-note major scale that underpins the vast majority of Western music. The pentatonic scale was chosen because it results in highly consonant music when its notes are sounded in a somewhat random way; by eliminating the fourth and seventh scale degrees from a major scale, a pentatonic scale eliminates two intervals that are widely perceived to be highly dissonant--the tritone and semi-tone. Three participants commented on the tuning, and how it sounded different culturally. One participant suggested that it “sounds like a Chinese opera”. Some of the participants seemed to have a difficult time connecting with the music which may have been a result of the perceived cultural distance from the pentatonic scale, they commented on how it did not sound like the music they normally listen to.

Three participants made positive comments about the AUMI sounds, one participant describing them as "beautiful" and "very pleasant". Thirteen of the participants were observed laughing or smiling during music making.

4.2 Findings from the Expert Interview

The data collected from the expert interview with the fitness instructor revealed information about the context of a senior's fitness class and the experience of using music making in an exercise class setting for users. When coding the interview, several sub-themes were revealed and organized using an affinity diagram.

Table 4-3 Main Themes and Sub-Themes from Expert Interview

Context of Exercise Class	Interactions with the Objects	Changes in the Exercise Experience	Reactions to the Music
Goals Participants' goals in the fitness class.	***Physical Interactions*** The users physical interactions with the ball and wristband.	***Incentive*** Using the music making as an reward to do more exercise.	***Reactions*** How the participants reacted to the music being created.
Motivators What motivates the participants.	***AUMI interaction*** AUMI interactions with the participants and eqiupment	***Increased Engagement*** Participants engaging or trying harder during the exercise class	***Improvements*** Aspects that could be improved upon for a better experience
Challenges What are the difficulties associated with fitness class			

4.2.1 Exercise Context

The clients at the Churchill Seniors Centre have a variety of different goals when participating in the integrated fitness classes. Many have a specific exercise goal based on rehabilitation from an injury or event. This goal could be to improve range of motion, or build strength. Some clients at the center aren't hoping for improvement, but to maintain strength and mobility as long as possible in declining health. Strength is one of the main focuses of the class, but balance and coordination are also areas that clients work on.

There are several things that motivate clients during exercise class. The main motivators are the satisfaction from seeing their improvement and doing something that they didn't think that they would be able to do. One of these accomplishments includes being able to use the exercise machines, something that many people had never used before coming to the classes. In order to make attending class the most rewarding for the participants, keeping a record of progression is helpful, so that the client can see their improvement and get motivation and satisfaction from that. When a client is trying to sustain their physical abilities, rather than improve, then it can be more difficult to get the same reward as they can't see measurable improvement.

The social interaction is another large motivator for the clients. Many of the exercises done in the class are ones they could do at home, but they often fail to do so, despite advice. The class provides a group atmosphere and social interaction that motivates the clients to come and to participate.

There are challenges for seniors who want to exercise or attend exercise classes at Churchill. In general, going to the gym might be a big deal and intimidating for the seniors if they have not gone to a gym before. Getting to the center can be an obstacle for many people, as it requires a certain amount of independence and mobility; if they require special transportation, it can take hours to commute. Not many clients at the center exercise outside of the fitness classes, as they don't have an incentive to do exercises at home and they feel like their needs are being met in these classes, even though it is recommended that older adults engage in more frequent exercises.

4.2.2 Interactions with Probes

The interview provided an instructor's perspective about two considerations: how the individuals in the class responded to the technology probes in the first research method and how music making could be integrated into fitness classes and used to create a more positive experience for seniors.

Adaptive Use Musical Instrument (AUMI)

According to the instructor, it was beneficial to have the AUMI software track the participant's movement when he or she was doing individual exercises. She said that it was particularly useful with the weight machines such as the chest press and sit-to-stand exercises. She noted that when using the iPads, clients seemed more motivated and worked more than normal.

SensAble Musical Interface (SAMI)

Using the SAMI ball in the warm up was good for getting people moving; participants were more engaged in that activity than their warm-up in a regular fitness class. Some participants had trouble gripping the ball, but if it were squishier it would be easier for those participants. If it were heavier it would also align more with the goals of the class, which is to build or maintain strength, and could be used during the other portions of the class.

4.2.3 Changes to the Exercise Experience

According to the interview, most of the senior participants in the technology probe session were intrigued by the music, and it did act as a stimulus to do more activity. However, the instructor said that it may have been the novelty of the music making that engaged the seniors more than normal, and this novelty could fade if it were used on a regular basis. If the participants could have a goal, or a measurable outcome from creating music, such as creating a recognizable tune or achieving specific patterns or notes, it could act as an incentive, making it a more rewarding activity for them.

4.2.4 Reactions to the Music

The type of music that was created didn't seem to connect with all the users when using the technology probes in the fitness class. The music might be more appealing and engage users more if it was a sound or a tune that they could relate to. The instructor did express that the students were surprised at how good the music sounded, especially when several AUMI iPads were running at the same time. Having too much music going on would be a risk; it is important not to have too much going on for them to enjoy the experience.

4.3 Findings from the Workshop

The design workshop provided the older adults with an opportunity to express how they would want to use music making objects in the exercise class and what they would want them to look like. One of the other outcomes of the workshop was a new perspective on the seniors' experiences during the exercise class and using the technology probes, which was not obtained from the other research methods.

Table 4-4 Main Themes and Sub-Theme from Workshop

Context of Exercise Class	Interactions with the Objects	Changes in the Exercise Experience	Reactions to the Music
Goals Participants' goals in the fitness class.	***Physical Considerations*** Considerations based on the physical needs.	***Music in Class*** What would they want from the music in the class.	***Musical Preferences*** How individual musical preferences affect the experience.
Motivators What motivates the participants.	***Movement/Sound Relationship*** How the music should respond to movements.	***Engagement*** Participants engaging or trying harder during the exercise class.	***Relating to Music*** How relating to the music affects the experience.
Challenges What are the difficulties associated with fitness class.			

4.3.1 Exercise Context

During the workshop, the participants expressed what they think attendees of the fitness class gain from the class and why they attend. One participant explained that some of the clients attending classes want to improve their fitness level, and others want to sustain their physical ability. One of the workshop participants said that many of the clients who attend the classes have specific goals, for example, to strengthen specific body parts or heal from a surgery. Another participant said, "I just want to get this hand stronger and more flexible".

One participant said that the exercise class presents the challenge of coping with the reality that they are older and may not get better, or it will take them a longer time to recover from injury, saying that he believes that it is a common challenge for clients at the Senior's Centre. The participants expressed how all the clients in the classes have different abilities and everyone has their own individual exercise programs. This means that there needs to be coordination from the instructor so that all the clients are able to use the exercise equipment that they require. In order to accommodate everyone, sometimes the clients need to compromise and are unable to use their first choice of equipment. One participant in the workshop said that for many fellow clients, getting to the center is a challenge, but they attend the class because they feel that they gain enough and enjoy it enough to motivate them to make the commute.

One of the large motivators for seniors to attend and participate in the exercise classes was that it was a social gathering for them. Many of the participants recognize that they would be able to do the exercises at home, but they enjoy the company of the class, as many live alone or have limited opportunity for social contact. They appreciate that the instructor is there to provide them with leadership, which makes it easier for them to complete their exercise programs.

4.3.2 Interactions with the object

In terms of physically interacting with the objects, considerations need to be made based on the unique needs of older adults. One of the participants expressed that he has trouble gripping and releasing his grip on one hand because of a stroke, and would need any object to be easy to hold. As illustrated in figure 4-5, one of the ideas was to have the object that would make music when squeezed, which would help to improve grip strength. Senior clients may have reduced vision and hearing, which impacts their experience in the class and would impact how they experience music making and the music making devices. Every client in the class has different needs with individual capabilities and challenges. Some have greatly reduced mobility and dexterity, making it more difficult for them to complete exercises and hold onto objects. Creating music should be accessible to everyone, but still challenging enough so that it is a beneficial exercise experience.

Workshop participants generated ideas on how they would want the sounds to respond to their movements when they are exercising. The movement should have more control over the sound than AUMI and SAMI, the devices that were used as technology probes. The sounds should mimic movement and have dimensions of melody, rhythm and harmony, creating a more complete piece of music. The participants suggested that the feet should determine rhythmic patterns, justifying that it is natural for us to tap our feet to a beat, so it would be a natural movement.

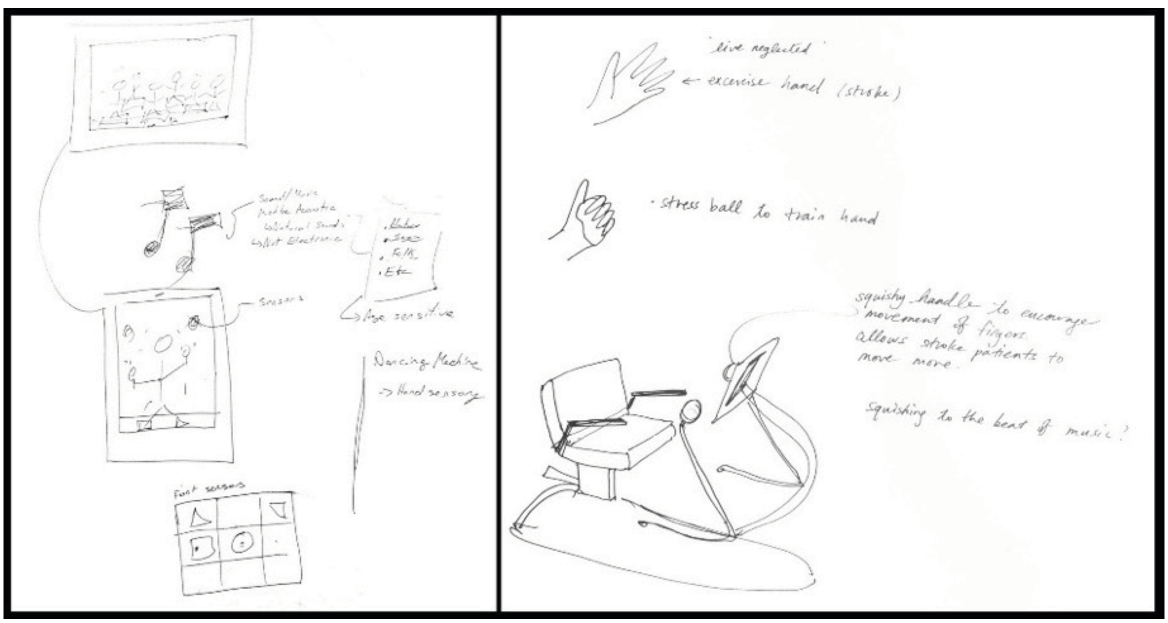


Figure 4-5 Two Sketches from the Workshop

It was also suggested that the music should provide an incentive to do more movement and use a larger range of motion, having the sounds respond to their range of motion, for example having the volume increase. One of the concepts was an iPad app which would have targets on the screen to guide the individual’s movements, and giving them points for the correct movements, providing a goal and reward (See Figure 4-5).

Another incentive would be integrating a communication or play aspect into making music, such as an echo (call) and response, where different participants could build music together, further contributing to the social dimension of the fitness class.

4.3.3 Changes in Exercise Experience

Three of the four participants in the workshop were enthusiastic about using music making to create a more positive experience in the fitness class. There are various qualities of music making which would translate into a better fitness class experience. From one participant's perspective, music would make the repetition of exercise less boring, and encourage them to do it more often. Making music could be used to have the exercise engage the whole body, in the way that dancing does. One participant wanted the music "to get the body to move, and your mind to go with it, so there are two aspects to it."

One aspect of the class that one of the participants thought should not be changed was that the fitness class focuses on participation, not performance. The focus shouldn't be to perfect a specific choreography or music composition, the reward for them is the act of participating in the class, not simply the end result.

4.3.4 Reactions to the Music

It became evident that every individual had unique experiences and preferences, which lead to different opinions about the music created using the music making devices, and having a different music making experience. Two of the older adults reflected that they did not connect culturally when the technology probes used electronic sounds. "I have some objection to the sounds used […] the younger generation has been fed on electronic sounds, it doesn't touch our hearts" Three of the workshop participants would prefer being able to make music that is culturally relevant to them and that they are familiar with.

One aspect that the participants viewed as important was that if the music emotionally moved the individual, then it would also motivate them: “what is important about music is what moves you, what moves you emotionally, what moves you physically”. Individuals will be emotionally moved depending on the different meanings music has for them. Not everyone would enjoy the same types of sounds. The type of exercise should also be reflected in what type of music is created, as different music can make people have different feelings.

4.4 Summary of Findings

Using three different research methods allowed the findings from one method to be supported when similar findings emerged from other methods (See Table 4-5). According to the interview and workshop, seniors attending the fitness classes have different goals, depending on their ability level and situation, the goals can be either to recover and improve or to sustain their physical abilities. There are also different motivators for them in the class, the reward of seeing their progress, having the leadership of the fitness instructor, as well as, the social interaction they receive when attending the class. The benefits were enough motivation for the clients to overcome challenges, such as the commute to the class.

There are various ways to interact with music making objects in the fitness class. When interacting physically with the objects, the physical limitations of certain individuals need to be considered, such as their ability to grip the object and what range of motion that they are capable of. A reduced sense of sight and hearing may impact the experience of making music during the class. Participants responded well to a direct sound-movement relationship, where the movements have a large amount of control over the sound feedback.

Table 4-5 Summary of Findings

<table>
<tr><th>Theme</th><th>Probes</th><th>Interview</th><th>Workshop</th></tr>
<tr><td colspan="4">Exercise Class Context</td></tr>
<tr><td>Goals</td><td></td><td colspan="2">Clients have personalized goals, some are specific improvements, others to sustain current ability</td></tr>
<tr><td>Motivations</td><td></td><td colspan="2">Motivators include seeing progress, having leadership, exercising in group setting</td></tr>
<tr><td>Challenges</td><td></td><td colspan="2">Challenges are getting to the centre for class and mobility in class</td></tr>
<tr><td colspan="4">Interactions With Probes</td></tr>
<tr><td>Physical Considerations</td><td colspan="3">Due to the limited dexterity of the clients, it can be hard for them to interact with the objects. Too much sensory stimulus might be distracting. Everyone has different abilities</td></tr>
<tr><td>Interaction through Camera</td><td>Participants intereacted with AUMI outside exercises</td><td>It was good that the probes caught the exercise movements</td><td></td></tr>
<tr><td rowspan="2">Creating Sound</td><td>Participants reacted to the sounds by experimenting with their movements</td><td rowspan="2"></td><td rowspan="2">The participants want to have more control of the musical feedback</td></tr>
<tr><td>When in a group, it can be hard to distinguish individual musical contributions.</td></tr>
<tr><td>Visual Interface</td><td>Visual Interface engaged the user.</td><td></td><td></td></tr>
<tr><td colspan="4">Changes to the Exercise Experience</td></tr>
<tr><td>Bodily Awareness</td><td colspan="2">Were able to see and hear feedback based on where their body was.</td><td></td></tr>
<tr><td>Changing Movements</td><td>The musical feedback has the ability to change movements and behavior</td><td></td><td></td></tr>
<tr><td>Social Experience</td><td>Music making fueled social interactions during class</td><td></td><td>Music making could allow communication during class</td></tr>
<tr><td>Incentive</td><td colspan="3">Music making can be an incentive get people to move more. Some Participants were willing to do more exercise while making music
The music making got people moving more</td></tr>
<tr><td>Music in Class</td><td>Creating music can be a distraction, participants can lose count of their exercises</td><td></td><td>Music may make the repetitive exercises less boring</td></tr>
<tr><td>Engagement</td><td></td><td>The novelty of music making may dimish over time</td><td>Music should be engaging to the mind and whole body</td></tr>
<tr><td colspan="4">Reactions to the Music</td></tr>
<tr><td>Negative</td><td colspan="3">Some participants did not like the electronic sounding music</td></tr>
<tr><td>Positive</td><td colspan="2">The music from the different probes sounded nice together.</td><td></td></tr>
<tr><td rowspan="3">Improvements</td><td rowspan="3"></td><td colspan="2">The type of music should be something that the individual can relate to (familiar, like acoustic sounds).</td></tr>
<tr><td colspan="2">Participants want to have more control over more aspects of the music</td></tr>
<tr><td></td><td>What music motivates individuals can be different</td></tr>
</table>

Music making in the fitness classes has the ability to change the exercise experience in several ways. Music making can be an incentive to engage in exercise and become motivation for participants, however some participants were distracted by the music, leading them to do more exercise than instructed. Because of the visual and audio feedback, participants were able to have more awareness of what their bodies were doing and their fitness ability. Music making can provide a new social and interactive dimension to the class, facilitating social interaction.

Many participants had positive impressions of the music created during the class, even when multiple participants were making music at the same time. Some participants did not feel that they connected when the music sounded electronically produced or in the pentatonic scale, and did not have the same positive response to the music.

Chapter 5. Discussion

This chapter synthesizes the research findings with the literature review and discusses how the findings relate to the original research questions. The exploration revealed new insights concerning how to design music making devices for seniors to use while exercising. This chapter begins by revisiting the research questions introduced in the literature review and the insights that were revealed during analysis. The main research question is addressed by discussing the co-creative and exercise experience and by providing several design recommendations, which were informed by the research findings. This chapter ends with a discussion of the potential for future research and the limitations of the study.

5.1 Research Questions

In order to answer the main research question, *"How can design contribute to developing responsive music making objects which create positive exercise experiences for seniors?"* the following three sub-questions emerged:

1) How do seniors respond to musical feedback during their exercises?

2) What is the role of the musical object and how is the object used during exercises?

3) How does the additional social interaction arising from co-creating music affect the experience of the fitness class?

5.1.1 How do seniors respond to the musical feedback during their exercises?

During the research, participants responded to the music they were creating in different ways. Based on observations during the technology probe sessions and feedback through the expert interview, most participants responded positively and seemed to enjoy creating music; fourteen of the nineteen participants either smiled, laughed or made positive comments about making music.

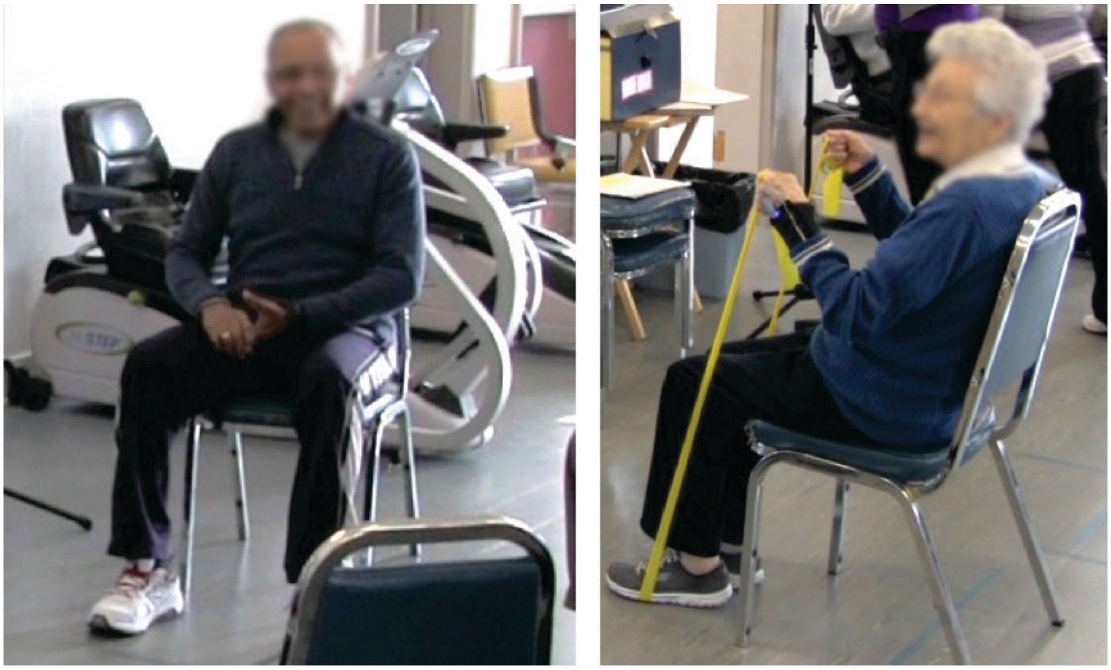


Figure 5-1 Participants smiling when creating music

Participants were able to understand the relationship between their movements and sound feedback. This understanding was demonstrated through participants making movements to get a musical response (see Figure 5-2) and verbal comments. For example, one participant said, “we got to move so we can make some music,” another participant commented to a fellow participant about the AUMI’s musical response “when you do it, it goes wholulu.”

Creating music sometimes resulted in the participants changing their movements or doing more exercises than instructed. This was observed during individual exercises, for example, when using the upper body weight machine; one participant started to do the exercise normally, but then responded to the music, by trying to reach higher in order to attain another note on the AUMI software.

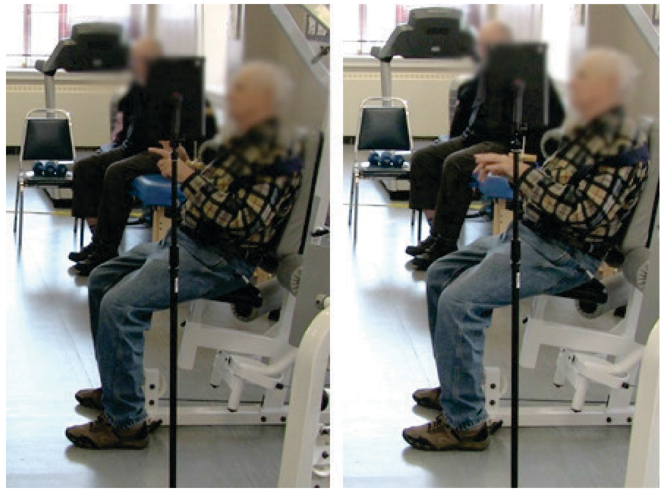


Figure 5-2 Participant moving hands in from of AUMI between exercise sets.

Other participants changed the speed in which they were completing the exercise: making quick short movements so that the AUMI would make fast sounds. They enjoyed the familiar sounds made by the AUMI software, and disliked when the sounds generated were less familiar to them and sounded more electronically generated. During the workshop, a participant said “You have to use sounds that seniors relate to, which are natural sounds, like a wood block. It’s better to do something acoustic, rather than electronic,” another participant, described the SAMI feedback, which is electronically generated, as “bing bang-bing bang” and expressed that he preferred soft music from the forties.

Exercise Engagement

Through the literature review, it was found that having an added purpose, such as creating music, could improve people’s enjoyment of exercise (Kircher, 1984; Paul & Ramsey, 1998). The instructor noted that the technology probes were a stimulus to do more activity, and “most seemed to enjoy themselves.” This suggests that the musical feedback increased the users’ engagement in the exercises. During the workshop and interview, it was discovered that, currently, the instructor tries to keep a record of progression so they are able to feel accomplishment. This can be difficult as many of the seniors who come to classes are looking to sustain their current health and may not improve much. Findings in this study suggest having a music-related goal could add to the seniors' exercise experience, and making progress on a goal may give them a sense of accomplishment. In the expert interview, it was suggested playing a specific piece of music through the exercise could be the goal.

Having added purpose and increased engagement may lead to improved exercise participation for seniors, a group who should be exercising on a regular basis (Paul & Ramsey, 1998). When using the AUMI IPad software, one participant commented, "If I had one of these I would do exercises every day […] I didn't do exercises very well this week, I was very lazy this week." Similarly, current research is using exercise videogames to promote health and physical activity for seniors (Chen, Huang, & Chiang, 2012; Gerling & Mandryk, 2014).

The expert interview revealed that the participants were working harder when the music was added, "I think that most people worked more, and that was evident because afterwards a lot of them were tired." During the technology probe session, two of the participants asked the instructor how they could modify their movements in order to make more music. This agrees with the literature, which had found that listening to music and making music during exercise reduces the perceived effort (Ramsey, 2011; Seath & Thow, 1995). The addition of music making devices could be valuable to get them moving more in the classes, thus gaining more exercise value. However, when using the probes, the instructor warned two of the participants not too overexert themselves when they were making music during individual exercises “I don't want you to do too many of the same thing. At the end of the day you'll say, I'm exhausted, but you just did fifty bicep curls!”

Music Type

According to the literature, individuals have different musical preferences, based on different cultural and personal experiences (Karageorghis et al., 1999). People enjoy music that they are familiar with, and gravitate towards music that was popular when they were young adults. Findings from the research study support the literature, with the participants wanting music that is familiar and culturally relevant for them. All four of the participants in the workshop noted that they preferred music from when they were younger, rather than the current popular music. As one participant explained: “Music, although it is a universal language, as so many dialects, and they don’t like each other […] rap, the classical person says ‘that’s not music,’ so it doesn’t motivate them.” The older adults had a preference for acoustic, or natural, sounds over those which sounded electronically produced; one participant described the SAMI feedback as: “it’s just sound, not music.” During the workshop, one participant explained that older adults will not relate to electronic sounding music, saying that “There are sounds across generations, but the interpretation will be different [..] to me electronic sounds tell me that the doorbell is ringing.” As a result, to be able to motivate individual exercisers, the music should be familiar and enjoyable. Since everyone has unique differences, a particular sound genre might be motivating for one individual, but less so for another. This could be accounted for by allowing participants to choose what type of music they want to create.

Sensory experience

From this research and the literature, there is conflicting evidence about how the musical feedback contributes to the sensory experience. According to the current literature, older adults enjoy less intensive, or quieter, music than younger adults. In the expert interview, the instructor said “I was concerned that it would be too noisy for them. Because with an older adult, some of them lost their hearing, some of them their hearing isn’t as good. So too much stimulus can be distracting.” This highlights the potential for sensory overload, and the dislike for too much sensory stimulus during the fitness classes. When using the AUMI during group exercises, one participant asked for the volume to be turned down. Two participants were distracted by the music, and lost count of the number of repetitions when doing individual exercises. During the interview, instructor said “I think it was better received than I thought it would be, seemed like everyone had fun with it, so it wasn’t a distraction.” However, the literature provides evidence of the benefits of musical stimulus, finding that added stimulus can encourage rhythmic movements and motivation during exercise (Van Der Vlist et al., 2011).

Table 5-1 Summary of Recommendations from First Sub-Question

	Theme	Finding	Design Recommendation
Music Type	Reactions to the Music: Negative/Postive	Some participants did not like the electronic sounding music. The type of music should be something that the individual can relate to (acoustic sounds).	The music created should sound acoustic or familiar instead of electronically generated.
	Reactions to the Music: Improvements	What motivates individuals will depend on their cultural and individual experiences, which are different from one person to the next.	There should be a choice of the genre of music they are able to create.
Sensory Experience	Changes in Exercise Experience: Music in Class + Engagement	Creating music can be a distraction, having participants lose count of their exercises	The software could keep track of how many of a certain action an individual is doing
	Interactions with Probes: Physical Considerations	The audio stimulus can be beneficial to exercise, but could be overwhelming for participants if it is too loud.	Participants or the instructor should be able to control the volume of the feedback, so that it is not too distracting for them.

5.1.2 What is the role of the musical object and how is the object used during exercises?

The musical object served multiple roles during the fitness class: a sensory role, providing audio and visual feedback about their movements; a communicative role, acting as a communication tool between the instructor and the participant; and a generative role, serving as a medium for seniors to create music and co-create music together. During the technology probe sessions, all of these roles were observed. For example, participants using the AUMI software modified their movements in response to the musical object's sensory feedback; the instructor commented on participants' exercise ability based on the visual feedback on the AUMI IPad; and participants generated music using the objects, in groups and individually. These findings were reinforced by comments made by participants during the expert interview and workshop. For example, during the workshop a participant explained that "[making music] is a very basic happening to get community, and to get communication," highlighting that creating music can be used as a community building tool as well as a communication tool. The participants interacted with the objects differently, depending on their personal physical capabilities, as seven of the participants had reduced functionality with one of their hands or arms and at least nine of the participants use a mobility aid such as a walker or cane some of the time. Participants had the most trouble with the SAMI ball, as they needed to grab or hold the ball in order to make music. Grabbing and catching were the hardest for the participants, with eight of the thirteen participants who participated in the ball exercises dropping the ball at least once.

Figure 5-3 Participants dropping ball after failing to catch it.

Sensory Role

When the object is serving the sensory role, it is affecting the user's sensory experience, through audio, visual and tactile feedback. Based on this feedback and sensory stimuli, participants changed their exercise movements. This was observed with the AUMI IPad Software, where the participants used both the visual and audio feedback to change their range of motion and speed when completing the exercises.

For example, five participants used the AUMI with the upper body weight machine, and four of those participants were observed changing the speed of their arm movements, either slowing down and reaching farther up or down, or making quick short movements in order to change the audio and visual feedback they were getting (see Figure 5-4), these types of modification where also observed with one of the two participants who used the AUMI with the lower body machine.

Figure 5-4 Participant engaged with AUMI and modifying arm movements.

The technology probes used during the research session were not calibrated to provide intelligent feedback to the participants or guide their exercise in anyway. Nonetheless, the music affected the participants' behaviours. Body movement was important to the experience created by the object. This suggested that, in addition the audio and visual experience, the sensory role of the object includes the experience of the kinetic movement of the individual. The audio and visual feedback create a feedback loop effecting the kinetic aspects of the object use, especially the movement of the user's own body. A practical application of this influence of behaviour would be to use music to encourage or guide individuals to make the desired movements, increasing the benefit from exercise.

In the workshop, one senior noted how they would want the music feedback to be related to how much they were able to move or the range of motion they were able to complete, one idea they had was that the volume of the music could be related to the range of the movements, moving more would result in louder music. One example of having some sort of intelligent feedback would be the higher they are able to reach, the higher the pitch they are able to achieve. This idea is supported by the literature, where music making was used to improve the range of motion of adults with disabilities in their upper exterminates (Paul & Ramsey, 1998). In that study, the music making device was calibrated to achieve different notes based on the range of motion achieved.

Communicative Role

Currently, without any music making, the instructor and client have a straightforward relationship, with the instructor being the only source of feedback for the client. This study suggests that the introduction of a music-making device into the class could change the relationship between the instructor and the client. The device could act as a communication tool and provide feedback about how the client's body is moving. Introducing music making into class may allow for an additional feedback loop to be added, with the client adjusting his or her movements without the intervention of the instructor, giving them more independence and control of their exercise experience.

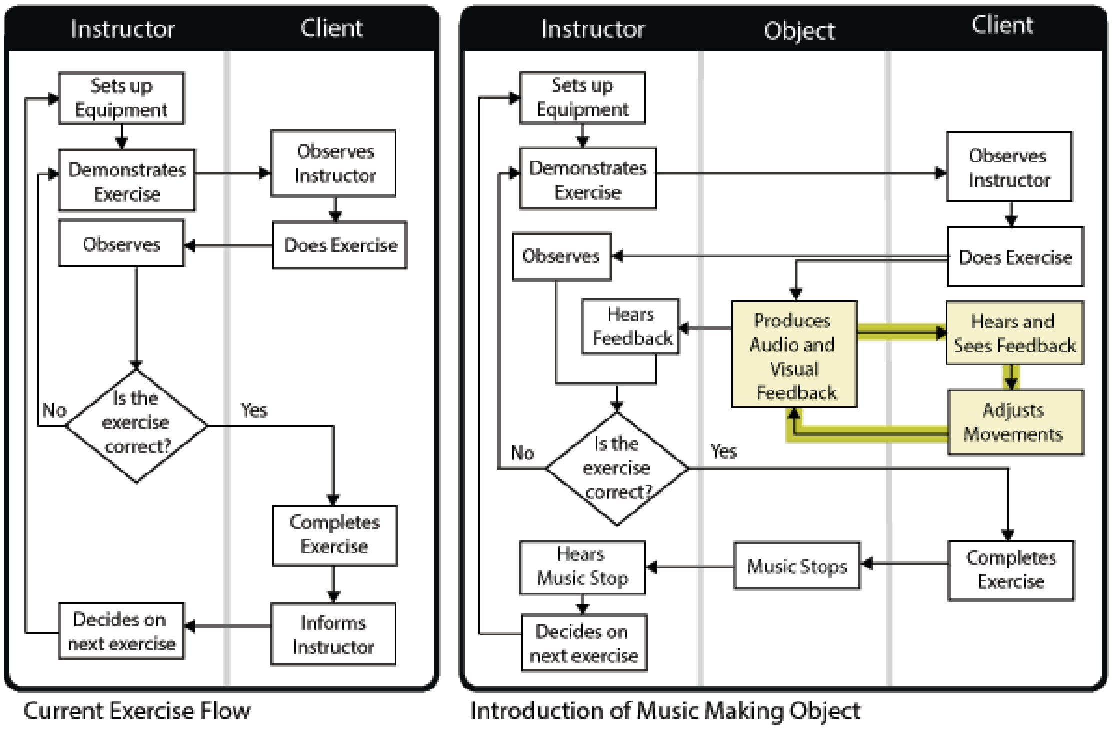


Figure 5-5 Swim lanes Diagram of Class Exercises

The swim lanes diagram (Figure 5-5) describes the flow of the exercise class with (from observed patterns) and without (projected patterns) a music-making object. In the current exercise class, the individual gets feedback from the instructor about his or her exercises: whether they have the correct form, speed and/or movement. This requires the instructor to pay attention to each participant, and to take on a leadership role, correcting them when necessary. With the proposed introduction of a music-making object, there is an added level of complexity and possible usefulness. A new feedback loop is created, which does not involve the instructor.

With the proposed solution, the music-making object provides the individual with more feedback about how his or her body is moving or positioned. If the user is doing incorrect movements, the music making object could change the audio/visual feedback to indicate this to them. This feedback could be in the form of unpleasant sounds or lack of musical response. When individuals notice these changes in the audio or visual feedback, they would be able to react and modify their movements, in an attempt to get the desired feedback. In turn, the instructor can also use the feedback to monitor the progress of clients. For example, if the volume of the music is linked the amount of movement, the instructor could notice what volume an individual is able to achieve. The instructor would also be able to get a sense of the speed in which the participants are moving without having to look at them, simply by hearing the rhythm they are creating with their body.

Another application of using audio feedback to facilitate proper exercise in the class could be when the instructor demonstrates an exercise for the client, the instructor would be creating music. When the client imitated the exercise, the music they created would be an echo of their instructor's, creating the same or similar musical feedback as the instructor did because they were using the same movements. The music would act as an additional way to communicate how the exercise should be performed.

Another potentially beneficial aspect of creating music and providing the instructor with the audio feedback would be to notify the instructor when exercise sets have been completed. In the current integrated fitness class, each client has their own program with different exercises depending on their fitness goals and abilities. This results in a scattered schedule, where individuals are moving from one exercise to the next at different and unpredictable times. Once the client has completed one type of exercise, he or she needs to get the instructor's attention in order to move onto the next exercise, which may require set-up. If the client creates music while exercising, when the music stops it would cue the instructor that the client is finished and ready to move on to the next activity. The participants could be making music with different rhythms and different types of music. For example, one could be creating piano sounds and the other wood block, this would allow the instructor to differentiate the sounds being made by different clients, as can be done when using several iPads running AUMI software.

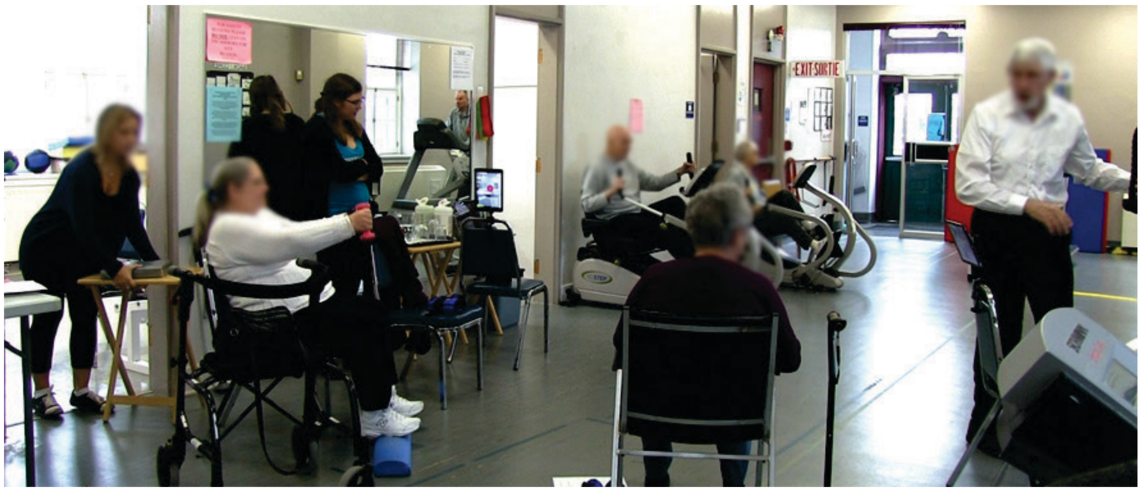


Figure 5-6 Participants doing individual exercises during class.

In addition to the audio feedback, the visual feedback provided by the instruments may also be useful for the participants. The AUMI software displays the camera image on the iPad, with a tracking dot (see Figure 3-2), allowing the individual to see how the camera is tracking them. The SAMI systems use the “DIN is Noise” synthesizer software, which notifies the participant, by creating a colored square, whenever it plays a note (See Figure 3-8). During the research session with the technology probes, the visual display engaged the user while using both the AUMI software and SAMI system.

Figure 5-7 Participant engaged with "DIN is Noise" when using SAMI wristband

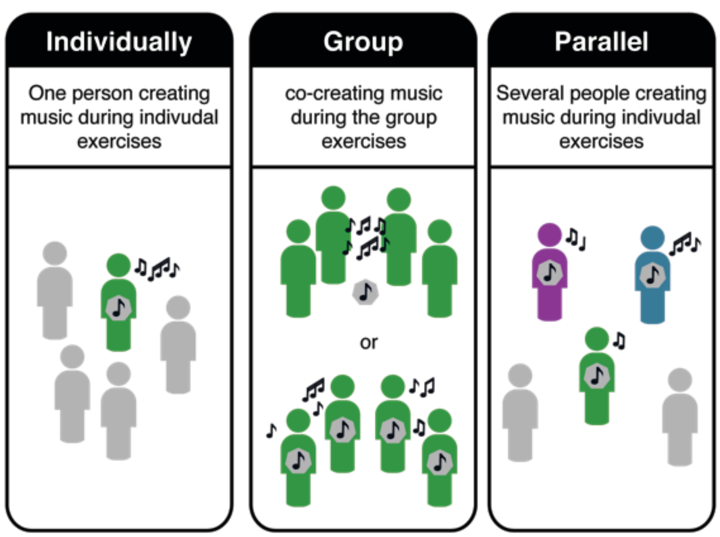
Figure 5-8 Participant watching the iPad Screen during group exercises

One of the key findings from the interview and the workshop was the importance of measurable improvements or accomplishments for the participants to be able to feel a sense of satisfaction. From the expert interview: "I try to keep a record of progression, so I think they get a satisfaction from seeing they can do something they didn't think they could, right, or that they weren't able to do a month before." During the research session, the instructor commented to one participant how his movements were moving the tracking dot moves on the AUMI interface, “Oh it's actually moving, you can see the bars it's going. When you move you are getting four bars up. Wooo ” The visual feedback could act as a reward, allowing them to see an outcome of their exercise. For example, they will be able to see their arm move the dot on the iPad screen through the notes, giving them visual confirmation in addition to audio validation of their abilities.

Generative Role

The final role that the object has is creating music. During the research, this was done individually, one person making music during individual exercises; in a group, four to seven people co-creating music during the group exercises; and in parallel, up to four people music making at the same time during the individual exercises. The social aspects associated with the co-creation of music will be further discussed when answering the third sub-question.

Table 5-2 Ways to Create Music in a Group



During individual music making, although only one person is making the music, others commented on the music being made, making remarks such as “you are becoming a star” to the music-making participant, and telling the participant to “keep it up” in order to encourage the participant to continue making music.

When making music during the group exercises, participants didn’t have as much response to the individual contributions to the music making. Only two individuals noted the musical response to a specific person’s movements, one of the comments was a question of why the AUMI iPad was registering another participant’s movement. This could be because of the nature of the set-up, the AUMI iPads were tracking the group as a whole instead of individuals, so it was more difficult to decipher whose movements were creating which audio responses. The instructor commented on how during the group stretches, where everyone was making the same movements, a pattern seemed to emerge.

When two participants were making music in parallel, the instructor commented that, “it sounds better than I initially thought, because I thought they would compete with either other, but it sounds nice together.” When designing for the purpose of co-creating music, it is important that the sounds made by different individuals sound good together. During the technology probe session this was accounted for by making all of the music making probes use the same pentatonic scale, so they would be playing the same notes.

Use of the Object

How an individual interacts with and uses the object will depend on the object’s form and the functionality. During this research study, three different probes were used, and each was used and handled differently by the participants and would require different set-up by the instructor, or during the research study, the researcher.

Table 5-3 Interactions Between Participants and Probes

Probe	Participant Interactions	Set-Up Needed
SAMI Ball	Holding, Passing, Throwing, Catching	Turning on the electronics, Syncing with Computer
SAMI Wristband	Lifting Wrist/Arm during use	Putting wristband on/off, Turning on electronics
AUMI iPad	Moving in front of the Camera	Choosing sound options, positioning correctly

The SAMI ball was unique from the other probes in that it was a piece of exercise equipment and even without the music making functionality, exercises could be done using the ball. When using the ball, the seniors were required to hold, grab, catch and toss it, which many found difficult if they had reduced function in one or both of their hands. These findings were supported by the literature concerning designing for older adults, and the unique considerations due to their physical and cognitive needs (Mann, 2005). If the object needs to be handled by the participant, the tactile experiences needs to be considered, choosing materials and shapes that make it easy for them to lift and grip the object, accounting for the fact that individuals may have reduced functionality or mobility. One participant suggested something squishier, a softer foam or a texture surface would make it easier for participants to grip. Due to the prevalence of participants having trouble using one of their hands, the object should be able to be thrown and caught using one hand.

Figure 5-9 Catching the ball using one hand.

The two other probes used during the session didn't require the participant to handle them when creating music. The SAMI wristband needed to be put onto and taken off of the participant, which the researcher did during the research session. This set-up would need to be considered when designing a wearable music-making object. It would be beneficial for users of these technologies to be able to attach the device themselves, and remove it when leaving the class. This would require design consideration, as the current probe was too tight for the client to remove with one hand. Using Velcro, or a similar fastener, to secure the wristband would allow for easy attachment and removal and could account for different wrist sizes. One solution could be using a material, such as a soft plastic, that is easy to wipe down, or having the electronics removable so that the wristband could be laundered; however, that could limit its use to one person between washes.

During the sessions, once the wristband was in place, the participants paid no attention to the actual object, but only to the audio and visual feedback that it produced. The comfort of the wristband would be important to consider when designing. It would need to be appropriate for many sizes of wrists so that it is not too tight or loose, as that could restrict movement and comfort.

Figure 5-10 Removing the wristband from participant

The breathability of any wearable device would need to be considered, seeing as they are intended for use during exercise and the wearer may be sweating. The weight would also need to be a consideration, as many of the clients may not be able to complete their exercises with much added weight to their wrist. Perhaps there is a better location for the sensor, which would make it easier to lift and attach to the body.

When using the AUMI software, the participant does not need to interact with the iPad itself. The researcher needed to change the software settings and location of the iPad for each exercise to make sure that it was in the correct position to provide the user with audio and visual feedback. This set-up would need to be considered when designing a similar gesture-based music making object. There were two set-ups for the AUMI iPads used during the research session, one used a microphone stand, the other clamped the iPad to a chair, both had wireless speaker to output the audio feedback (see Figure 5-11).

Figure 5-11 iPad clamped onto chair and iPad using microphone stand.

Both of these set-ups were hard for other participants to navigate around, and it was an extra step to move the speaker since it was not physically attached. During exercise, the iPad must be positioned in a way so that the camera is pointed at the user and able to capture the movements of the exercise, and so that user is able to see the visual display. If the object had a stand that was easier to move around, and have an attached speaker and would move with the object if might be possible for some of the clients to position the music making object for themselves. This object itself does not necessarily need to incorporate an iPad, any screen based product running similar software and capable of giving visual feedback could be considered.

The AUMI software on the iPad must also be used to change the size and number of sounds, this may need to be done for each different exercise in order to achieve a good range of different sounds. The software could be designed to have a program pre-loaded and calibrated for the particular individual according to their exercise, making the set-up easier.

Table 5-4 Summary of Recommendations from the Second Sub-Question

Theme		Finding	Design Recommendation
Sensory Role	Interactions with Probes: Creating Sound	Participants understood the sound/movement relationship.	The object should create a straightforward sound/movement relationship For example, the higher the arm goes, the higher the note is.
Sensory Role	Motivations + Changing Movements	The musical feedback has the ability to change movements and behavior	The object should be able to give the individual intelligent feedback encouraging them to exercise correctly.
Communicative Role	Interactions with Probes: Creating Sound/ Visual Interface	The audio and visual feedback can be used to communicate the individual's movements to the instructor.	The object should be capable of making different distinct musical sounds, so that the instructor can differentiate them if multiple participants are making music at the same time.
Communicative Role	Changes in Exercise Experience: Incentive	Being able to have a goal or measurable accomplishment can provide satisfaction for the participants.	The object should provide visual feedback about their exercise movement, allowing them to track progress
Generative Role	Interactions with Probes: Creating Sound	When making music as a group, it can be hard to distinguish individual contributions.	Even in a group setting, if using an object like the AUMI, each participant should have their own, so they are able to see their contribution to the group music.
Generative Role	Reactions to the music: Postive	When making music in parallel with each other, it is desirable for the music to sound nice together	Music making objects should be calibrated to be making music in the same scale or key with instruments that sound nice together.
Use of the Object	Interactions with Probes: Physical Considerations	Due to the limited dexterity of many of the clients, it can be hard for them to interact with the objects.	A ball, or other exercise equipment, should avoid needing to use both hands, and use a material that is easy to grip and hold on to, such as a foam or soft rubber.
Use of the Object	Interactions with Probes: Physical Considerations	The wristband was tight for participants to remove, as they could not do it with one hand	Wearable music making devices should to be easy to attach and remove, as well as be cleaned between uses. Using a pliable soft plastic would be ideal for comfort and cleaning but washable fabrics could be an alternative.
Use of the Object	Interactions with Probes: Physical Considerations	The clients did not set up the AUMI themselves	The object should be easy to move around the room, and set up according to the exercises.
			Software could be programed according to the different exercises, making it easier to set-up. The individual programs could be preloaded.

5.1.3 How does the additional social interaction facilitated by co-creating music affect the experience of the fitness class?

The musical objects led to positive social interactions between the instructor and clients, and among the seniors in the class. The instructor used the music making as an incentive for the participants to work hard during their exercises, by encouraging them with comments such as “Good job, did you know you were a composer?” and “You have to do it with us to make more music.” Participants also made encouraging comments amongst themselves, “good job,” and “you have to go faster to keep it up!” These interactions seemed to enhance the exercise class experience, as one of the important benefits of attending class is the social component (Biedenweg et al., 2014). Another form of social interaction could be in the act of co-creating music during the class, allowing for non-verbal interaction amongst participants.

Figure 5-12 Participants laughing and talking while using the SAMI ball.

Verbal Interactions

During the research sessions, two main types of verbal interactions happened: between a client and the instructor and among participants. When using the technology probes, the music making led to the instructor encouraging the participants and complimenting them on the music they were creating. The participants commented on the music that others were making, and during the group work cheered for each other (See Table 5-5).

Table 5-5 Types of Verbal Comments

Interaction	Type of comment	Example of Verbal Comment
Instructor to Client	Encouragement	“Good jobs, that’s it” “Excellent, so we are moving around as much as we can”
	Musical Compliment	“You are making some really good drum sounds” “Good job, did you know you were a composer?”
Amongst Participants	Encouragement	“Whoo, way to go!” “that’s very good”
	Musical Compliment	“This is why you are here today, to make music” “I loved the sounds!”

It has been found that the social component is an important aspect of group activities, such as music making or exercises classes, and provides increased social satisfaction, a valuable benefit for older adults (Biedenweg et al., 2014; D. D. Coffman, 2002). This is supported by the findings from the expert interview and workshop, where the social interaction was highlighted as one of the main motivators for the seniors attending fitness classes and was a desirable component of the class. The expert estimated that for half of the clients, they attend class for social reasons, and in the workshop one participant said, “this is a big thing that it is a social gathering. Well, we are all alone, probably most of us are alone.”

Musical Interactions

Co-creating music is another form of social interaction for the participants. During the exercise class, there are different types of interaction that happen through music, depending on if the music is being creating individually or in a group (see Table 5-2). This non-verbal interaction would create a different experience for seniors attending fitness classes, as it would give them a way to express themselves and interact with each other without talking.

One of the workshop participants suggested that having more control over various aspects of the music, such as the harmony, rhythm and melody would be more enjoyable and more motivating for individuals. The AUMI software is not able to control all of the dimensions of the music. By being able to vary different aspects of the music, and have more control over the music they are creating, individuals would be able to express themselves more accurately using music.

With respect to creating music as group, two of the workshop participants pointed out that they would be less interested in learning formalized set of movements in order to create the music, and more interested in allowing for each individual to create different music with different movements. One participant said that, “we come for participation, we don’t come for performance,” meaning they would be more interested in the social and community aspects of the class than the end result. Especially since much of the class has a focus on individual exercises, co-creating music would allow for participation in a group social experience, one of the workshop participants pointed out that the group setting was a big motivator for all of them.

Table 5-6 Design Recommendations from Sub-Question Three

	Theme	Finding	Design Recommendation
Verbal Communication	Changes in Exercise Experience: Soical Experience	Participants and the instructor commented on the music produced by other participants	To be able to decipher who is creating music, so that they are able to encourage each other based on the music creation
Musical Communication	Interactions with Probes: Creating Sound Reactions to the music: Improvements	Participants want to have more control over more aspects of the music, so they can express themselves more accurately	Be able to control more dimension of the musical piece, such as rhythm, harmony and melody

5.2 Co-Creation and the Exercise Experience

The main focus of this research was to answer the question *"How can design contribute to developing responsive music making objects which create positive exercise experiences for seniors?"* One aspect of this question is the positive exercise experience created by using the responsive music-making objects. The research has shown that the use of responsive music-making objects can lead to co-creating music in the class, during group exercise or individual exercise. The experience of generating music in a group has the potential to change the nature of exercise class. Allowing the participants to express themselves and communicate with each other through creating music and engaging with others who are creating music allows them to take an active participatory role in shaping the environment and experience of the exercise class itself. The co-creation of music extends the design-oriented philosophy of co-design, where the focus shifts from the stakeholders only participating in creating a new product, into the use of objects, where the stakeholders can participate in creating the experience and evolving the end product, which is the music. The seniors are able to continue co-creating together, being active participants in generating the type of musical and exercise experience that they want.

5.3 Design Recommendations

The main research question addresses how design can contribute to the development of these musical objects. By examining the answers to the three sub-questions, a set of recommendations for designing responsive music making objects emerges. These recommendations consider: the unique cognitive, sensory and physical needs of older adults and their capabilities, the motivations they have for exercising, the benefits achieved through exercise classes, the desires and preferences of older adults and how they responded to sensory feedback, through music and visual displays.

Table 5-7 Summary of Design Recommendations

User Experience	System Functionality	Characteristics of Music	Physical Features	Qualities of Interface	Main Considerations
Users should find the music produced pleasent to listen to	Multiple instruments should be use the same scale and be in the same key	Sounds should be familiar, and not electronic sounding		Users should be able to pick the genre or instrument	Musical preferences and auditory feedback
Users can focus on their exercises and not be distracted	Volume controlled by instructor or user			Interface reminds user of exercise and repetitions done	Sensory and cognitive needs
Instructor can keep track of different users	Distinct sounds for each different user	Different instruments played at the same time		Users can select a different sound or instrument to play	Exercise benefit and auditory feedback
Participants feel in control of music	Distinct sounds for each different user	Control of multiple dimensions of music, i.e. Rhythym, Harmony, Melody		Provide visual feedback about music being produced	Motivation and musical preference
Get feedback on exercise performance	Tracks user movement and performance and progress over time	Music feedback changes based on performance		Information about exercise performace. Number to repetitions completed	Exercise benefit and cognitive needs
Users can set up with out instructor	Individual exercises are preprogramed into system	User preferences saved	Lightweight and easy to move around. Devices can be taken on and off with one hand	Interface with minimal options and easy to use	Physical and cognitive needs, tactile experience
Device is comfortable, easy to hold and interact with			Light, comfortable materials, squishy so it it is easy to grab	Large buttons and easy to interact with. Visual feedback	Physical needs

This study demonstrates the potential for the design of a new category of product, assistive products in the form of musical exercise devices, which could be useful for seniors, benefiting their health and well-being, as well as changing the kind of exercise and exercises classes designed for them. These products could also be applicable to individuals of all ages with disabilities or who are in rehabilitation from events such as stroke, surgery or an accident.

5.4 Limitations

The limitations encountered during research include technology issues:

- the arm-band was not calibrated properly, and in turn didn't give much musical feedback. It was only used in two of the four sessions.
- one of the warm up sessions was not video recorded, so that portion was omitted from analysis.

Other limitations include:

- only one expert was interviewed because she was the only instructor at Churchill who was present during the technology probe sessions, and it was significant that the instructor be familiar with the probes and saw how the participants used them.
- all four senior participants in the workshop were male, which may have had an effect on the data, but it is impossible to determine what that effect would have been.

5.4 Summary

The findings from the three research methods (technology probes, expert interview and co-design workshop) have led to valuable insights relating to how design can contribute to music making exercise devices. These insights were discussed relating to three research sub-questions as well as the current literature in the field. The design recommendations are related to the needs and preferences of older adults, as well as the context and benefits of exercises and exercise class. These recommendations concern the sensory aspects of the object, such as the audio and visual feedback and the tactile experience, and the usability and features of the product. These recommendations could inform the design of a new type of product as well as future design research.

Chapter 6. Conclusion

This research explored the topic of designing music making devices for seniors during exercise. The topic was approached from an interdisciplinary perspective using multiple qualitative research methods. Building on a review of the literature, design research methods were used to explore the main research questions. These investigations focused on seniors making music in the context of an integrated fitness class, which led to several contributions to the field, including insights and design recommendations for music making objects for use by seniors during exercise.

6.1 Findings

The findings of the research were related to the participants' experience using music-making devices during an exercise class, and how music-making devices could be designed in the future, based on observations, the expert interview and design session with seniors.

The research revealed that the musical feedback affected the participant behaviour and exercise movements. They experimented with changing their movements and the resulting musical feedback. Participants had positive reactions to the music, and it was a motivator to engage in exercise and catalyst for social interaction. However, many felt that the electronic sounding music was less motivational than acoustic sounding music, which would be more pleasant and familiar for seniors.

Seniors attending the fitness classes have different exercise goals and physical abilities; activities and music-making devices need to reflect those differences. There are also different motivators for them in the class: the reward of seeing their progress, having the leadership of the fitness instructor, as well as the social interaction they receive when attending the class.

This study explores designing musical exercise devices for seniors. These products could be useful to seniors, benefiting their health and well-being, in addition to changing the kind of exercises and exercise classes designed for them. These products could also be applicable to individuals of all ages with disabilities or who are in rehabilitation from events such as stroke, surgery or an accident.

6.2 Contributions

The research contributes to the field by exploring the potential for a new category of product, assistive products in the form of musical exercise devices. The results of the study suggest that music making during a seniors exercise class can provide engagement and motivation for those exercises, and that having sensory feedback (audio and visual) about the exercise is important to the user providing them with positive motivation.

One of the contributions is the specific design recommendations for the user experience: the music should be pleasant for the user and not distract them from completing their exercises properly, it should also allow the users to feel in control of the music making, and give the instructors and users a tool to monitor the exercises and fitness progress. The system itself needs various features, such as user control over the sounds being produced and ability to track the user. The type of music should be familiar to the users, chosen according to their preferences, and the user should be able to control various dimension of the music. The physical qualities of the product should account for needs of seniors, using soft, easy to grasp materials. The product should have a visual interface and give the users feedback on their music making and exercise movements.

Although the study focused on seniors in an exercise class, the research and recommendations can be applied to designing music-making devices in a more general context.

6.3 Future Research

This is a qualitative study with a small sample population. Future research could further investigate design solutions based on the recommendations found in this study. It could continue this research with a larger sample size, looking at how the music-making object can be used in the class to provide the most enjoyable experience and most exercise value for all types of users.

A co-design workshop with a larger number of participants could take place, including multiple stakeholders such as exercise instructors in addition to seniors. Particular areas that could be addressed through a design investigation could be new shapes and textures for the product; exploring the potential for using more sensors so that different parts of the body are able to control music rather than only one part, which was the case for the wristband; and developing a visual interface which provides more intelligent feedback to the user about if they are completing their exercises correctly.

A longer pilot study could be conducted using the same technology probes with seniors co-creating music in a fitness class. This could address two areas outside of the scope of the original research. The first area would explore how the use of the object changes with multiple uses, which includes the novelty aspect of music making and the sensory interactions over time. The second area would be how the objects would be used between classes, investigating specific problems with cleaning, storage and set-up.

6.4 Final Comments

It is increasingly important to address the challenges associated with the aging population. Design has an important role to play in addressing these problems, with the potential to offer higher quality of life, more independence and better health to seniors. This research united the fields of music and design in an interdisciplinary study, exploring music making devices to benefit seniors through exercise. Hopefully future research will continue to focus on these problems to continue to inform products to assist older adults and all members of society.

References

Bailey, B. a. (2005). Effects of group singing and performance for marginalized and middle-class singers. *Psychology of Music*, *33*(3), 269–303. http://doi.org/10.1177/0305735605053734

Barrett, M. S. (2014). Connecting through music : The contribution of a music programme to fostering positive youth development. http://doi.org/10.1177/1321103X14560320

Bayazit, N. (2004). Investigating Design: A Review of Forty Years of Design Research. *Design Issues*, *20*(1), 16–29. http://doi.org/10.1162/074793604772933739

Bennett, J. A., & Winters-Stone, K. (2011). Motivating older adults to exercise: What works? *Age and Ageing*, *40*(2), 148–149. http://doi.org/10.1093/ageing/afq182

Biedenweg, K., Meischke, H., Bohl, A., Hammerback, K., Williams, B., Poe, P., & Phelan, E. A. (2014). Understanding older adults' motivators and barriers to participating in organized programs supporting exercise behaviors. *Journal of Primary Prevention*, *35*(1), 1–11. http://doi.org/10.1007/s10935-013-0331-2

Chen, S. T., Huang, Y. G. L., & Chiang, I. T. (2012). Using somatosensory video games to promote quality of life for the elderly with disabilities. *Proceedings 2012 4th IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning, DIGITEL 2012*, 258–262. http://doi.org/10.1109/DIGITEL.2012.68

Choi, S. (2009). Inclusive design as an enabler of product innovation. *Include 2009 Proceedings*.

Clair, A., Lyons, K. E., & Hamburg, J. (2011). A Feasibility Study of the Effects of Music and Movement on Physical Function, Quality of Life, Depression, and Anxiety in Patients With Parkinson Disease. *Music and Medicine*, *4*(1), 49–55. http://doi.org/10.1177/1943862111425680

Coffman, D. D. (2002). Music and quality of life in older adults. *Psychomusicology: A Journal of Research in Music Cognition*, *18*, 76–88. http://doi.org/10.1037/h0094050

Coffman, D. D. and A. M. (1999). The contributions of wind band participation to quality of life of senior adults. *Music Therapy Perspectives*, *28*(1), 27–40. Retrieved from http://www.newhorizonsmusic.org/news_archives/research.html

Coleman, R., Lebbon, C., Clarkson, P. J., & Keates, S. (2003). From margins to mainstream. *Inclusive Design: Design for the whole population* (pp. 1–29).

Creech, A., Hallam, S., Varvarigou, M., McQueen, H., & Gaunt, H. (2013). Active Music Making: A Route to Enhanced Subjective Well-Being Among Older People. *Perspectives in Public Health*, *133*(1), 36–43. http://doi.org/10.1177/1757913912466950

Croom, A. M. (2014). Music practice and participation for psychological well-being: A review of how music influences positive emotion, engagement, relationships, meaning, and accomplishment. *Musicae Scientiae*, *19*(1). http://doi.org/10.1177/1029864914561709

Diener, E. (2000). Subjective well-being. The science of happiness and a proposal for a national index. *The American Psychologist*, *55*(1), 34–43. http://doi.org/10.1037/0003-066X.55.1.34

Fausset, C. B., Mayer, A. K., Rogers, W. A., & Fisk, A. D. (2009). Understanding Aging in Place for Older Adults: A Needs Analysis. *Human Factors and Ergonomics Society Annual Meeting Proceedings*, *53*(8), 521–525. http://doi.org/10.1518/107118109X12524442635347

Flowers, P. J., & Murphy, J. W. (2001). Talking about Music: Interviews with Older Adults about their Music Education, Preferences, Activities, and Reflections. *Update: Applications of Research in Music Education*, *20*(1), 26–32. http://doi.org/10.1177/875512330102000106

Frankel, Lois Diane (2015) *Sensory Insights for Design: A Sensory Anthropology Approach to Industrial Design*. PhD thesis, Concordia University.

Friedman, H. S., Kern, M. L., & Reynolds, C. A. (2010). Personality and health, subjective well-being, and longevity. *Journal of Personality*, *78*(1), 179–216. http://doi.org/10.1111/j.1467-6494.2009.00613.x

Gerling, K., & Mandryk, R. L. (2014). Custom-designed motion-based games for older adults : A review of literature in human-computer interaction. *Gerontechnology*, *12*(2), 68–80. http://doi.org/10.4017/gt.2013.12.2.001.00

Gick, M. L. (2010). Singing, health and well being : A health psychologist ' s review. *Psychomusicology: Music, Mind & Brain*, *21*(1). http://doi.org/10.5084/pmmb2010/21/xxx

Giovagnoli, A. R., Oliveri, S., Schifano, L., & Raglio, A. (2014). Active music therapy improves cognition and behaviour in chronic vascular encephalopathy: A case report. *Complementary Therapies in Medicine*, *22*(1), 57–62. http://doi.org/10.1016/j.ctim.2013.11.001

Grove, N. C., & Spier, B. E. (1999). Motivating the well elderly to exercise. *Journal of Community Health Nursing*, *16*(3), 179–189. http://doi.org/10.1207/S15327655JCHN1603_4

Hallam, S., Creech, A., McQueen, H., Varvarigou, M., & Gaunt, H. (2016). The facilitator of community music-making with older learners: Characteristics, Motivations and challenges. *International Journal of Music Education*, *34*(1), 19–31. http://doi.org/10.1177/0255761415617039

Hallam, S., Creech, A., Varvarigou, M., McQueen, H., & Gaunt, H. (2014). Does active engagement in community music support the well-being of older people? *Arts & Health*. Taylor & Francis. http://doi.org/10.1080/17533015.2013.809369

Hunt, A., Kirk, R., & Neighbour, M. (2004). Multiple media interfaces for therapy. *IEEE Multimedia*, *11*, 50–58. http://doi.org/10.1109/MMUL.2004.12

Huppert, F. (2003). Designing for Older Users. In *Inclusive Design: Design for the whole population* (pp. 30–49).

Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B. B., Druin, A., Plaisant, C., … Hansen, H. (2003). Technology probes: inspiring design for and with families. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, (5), 17–24. http://doi.org/10.1145/642611.642616

Inclusive Design: Better Design Examples. (2005). Retrieved from http://www3.eng.cam.ac.uk/inclusivedesign/index.php?section=introduction&page=ex-oxo

Jancey, J., Lee, A., Howat, P., Clarke, A., Wang, K., & Shilton, T. (2007). Reducing attrition in physical activity programs for older adults. *Journal of Aging and Physical Activity*, *15*(2), 152–165.

Judge, J. O., Schechtman, K., Cress, E., & Group, F. (1996). The Relationship Between Physical Perfromance Measures and Independence in Instrumental Activities of Daily Living, 1332–1341.

Karageorghis, C. I., Priest, D.-L., Terry, P. C., Chatzisarantis, N. L. D., & Lane, A. M. (1999). Redesign and initial validation of an instrument to assess the motivational qualities of music in exercise: the Brunel Music Rating Inventory-2. *Journal of Sports Sciences*, *24*(8), 899–909. http://doi.org/10.1080/02640410500298107

Keay-Bright, W., & Gethin-Lewis, J. (2011). Co-Creating Tools for Touch: applying an inspire-create-play-appropriate methodology for the ideation of therapeutic technologies. *Include 2011*. Retrieved from http://hdl.handle.net/10369/2783

Kennedy, a. B., & Blair, S. N. (2014). Motivating People to Exercise. *American Journal of Lifestyle Medicine*, (c), 1559827614524135–. http://doi.org/10.1177/1559827614524135

Kindon, S. L., Pain, R., & Kesby, M. (2007). *Participatory Action Research Approaches and Methods*.

Kircher, M. A. (1984). Motivation as a factor of perceived exertion in purposeful versus nonpurposeful activity. *The American Journal of Occupational Therapy. : Official Publication of the American Occupational Therapy Association*, *38*(3), 165–170.

Laukka, P. (2007). Uses of music and psychological well-being among the elderly. *Journal of Happiness Studies*, *8*, 215–241. http://doi.org/10.1007/s10902-006-9024-3

Lawton, M. P., & Brody, E. M. (1969). Assessment of Older People: Self-Maintaining and Instrumental Activities of Daily Living. *The Gerontologist*, *9*(3 Part 1), 179–186. http://doi.org/10.1093/geront/9.3_Part_1.179

Lee, B., & Nantais, T. (1995). Use of Electronic Music as an Occupational Therapy Modality in Spinal Cord Injury Rehabiliation: An Occupational Performance Model. *The American Journal of Occupational Therapy*, *50*(5), 362–369.

Lem, A., & Paine, G. (2011). Dynamic Sonification as a Free Music Improvisation Tool for Physically Disabled Adults. *Music and Medicine*, *3*(3), 182–188. http://doi.org/10.1177/1943862111401032

Lindenfelser, K. J., Hense, C., & McFerran, K. (2012). Music Therapy in Pediatric Palliative Care: Family-Centered Care to Enhance Quality of Life. *American Journal of Hospice and Palliative Medicine*, *29*(3), 219–226. http://doi.org/10.1177/1049909111429327

Magee, W. L. (2011). Music Technology for Health and Well-Being: The Bridge Between the Arts and Science. *Music and Medicine*, *3*(3), 131–133. http://doi.org/10.1177/1943862111411719

Magee, W. L., & Burland, K. (2008). An Exploratory Study of the Use of Electronic Music Technologies in Clinical Music Therapy. *Nordic Journal of Music Therapy*, *17*(2), 124–141. http://doi.org/10.1080/08098130809478204

Manini, T. M., & Pahor, M. (2009). Physical activity and maintaining physical function in older adults. *British Journal of Sports Medicine*, *43*(1), 28–31.

Mann, W. C. (2005). *Smart Technology for Aging, Disability, and Independence: The State of the Science*. *Smart Technology for Aging, Disability, and Independence: The State of the Science*. http://doi.org/10.1002/0471743941

Martin, L. G., Freedman, V. A., Schoeni, R. F., & Andreski, P. M. (2010). Trends in disability and related chronic conditions among people ages fifty to sixty-four. *Health Affairs*, *29*(4), 725–731. http://doi.org/10.1377/hlthaff.2008.0746

Newson, R. S., & Kemps, E. B. (2015). Engagement in Older Adults, 470–481.

Oliveros, P., Miller, L., Heyen, J., Siddall, G., & Hazard, S. (2011). A Musical Improvisation Interface for People With Severe Physical Disabilities. *Music and Medicine*, *3*(3), 172–181. http://doi.org/10.1177/1943862111411924

Paul, S., & Ramsey, D. (1998). The effects of electronic music-making as a therapeutic activity for improving upper extremity active range of motion. *Occupational Therapy International*, *5*(3), 223–237.

Perkins, R., & Williamon, A. (2013). Learning to make music in older adulthood: A mixed-methods exploration of impacts on wellbeing. *Psychology of Music*, *42*(4), 550–567. http://doi.org/10.1177/0305735613483668

Ramsey, D. W. (2011). Designing Musically Assisted Rehabilitation Systems. *Music and Medicine*, *3*(3), 141–145. http://doi.org/10.1177/1943862111411718

Robb, S. L., Clair, A. A., Watanabe, M., Monahan, P., Azzouz, F., Stouffer, J., … Hannan, A. (2008). Randomized controlled trial of the active music engagement (AME) intervention on children with cancer. *Psycho-Oncology*, *17*, 699–708. http://doi.org/10.1002/pon

Saldana, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). London: SAGE Publications.

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*.

Sanders, E. B.-N., & Stappers, P. J. (2012). *Convivial Toolbox: Generative Research for the Front End of Design*. Amsterdam: BIS Publishers.

Schifferstein, H. N. J., & Spence, C. (2008). Multisensory Product Experience. In *Product Experience* (pp. 133–161).

Schutzer, K. A., & Graves, B. S. (2004). Barriers and motivations to exercise in older adults. *Preventive Medicine*, *39*(5), 1056–1061. http://doi.org/10.1016/j.ypmed.2004.04.003

Seath, L., & Thow, M. (1995). The Effect of Music on the Perception of Effort and Mood During Aerobic Type Exercise. *Physiotherapy*, *81*(10), 592–596.

Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology : Official Journal of the Division of Health Psychology, American Psychological Association*, *20*(4), 243–255. http://doi.org/10.1037/0278-6133.20.4.243

Seidel, D., Crilly, N., Matthews, F. E., Jagger, C., Brayne, C., & Clarkson, P. J. (2009). Patterns of functional loss among older people: a prospective analysis. *Human Factors*, *51*(5), 669–680. http://doi.org/10.1177/0018720809353597

Seidel, D., Richardson, K., Jagger, C., Brayne, C., & Clarkson, P. J. (2010). The potential impact of design changes on independent living in old age. *Gerontechnology*, *9*(1), 56–61. http://doi.org/10.4017/gt.2010.09.01.006.00

Statistics Canada. (2015). *Population Projections for Canada, Provinces and Territories*. http://doi.org/91-520-X

Tam, C., Schwellus, H., Eaton, C., Hamdani, Y., Lamont, A., & Chau, T. (2007). Movement-to-music computer technology : a developmental play experience for children with severe physical disabilities, *14*(2), 99–112. http://doi.org/10.1002/oti

Tenenbaum, G., Lidor, R., Lavyan, N., Morrow, K., Tonnel, S., Gershgoren, A., … Johnson, M. (2004). The effect of music type on running perseverance and coping with effort sensations. *Psychology of Sport and Exercise*, *5*(2), 89–109. http://doi.org/10.1016/S1469-0292(02)00041-9

Tscherne, D. (2014). Motivational qualities of music in exercise, (2001), 1–2.

Uchino, B. N. (2009). Understanding the Links Between Social Support and Physical Health: A Life-Span Perspective With Emphasis on the Separability of Perceived and Received Support. *Perspectives on Psychological Science*, *4*(3), 236–255. http://doi.org/10.1111/j.1745-6924.2009.01122.x

Van Der Vlist, B., Bartneck, C., & Mäueler, S. (2011). moBeat: Using interactive music to guide and motivate users during aerobic exercising. *Applied Psychophysiology Biofeedback*, *36*(2), 135–145. http://doi.org/10.1007/s10484-011-9149-y

Vaughan, L., Leng, X., La Monte, M. J., Tindle, H. A., Cochrane, B. B., & Shumaker, S. A. (2016). Functional Independence in Late-Life: Maintaining Physical Functioning in Older Adulthood Predicts Daily Life Function after Age 80. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *71 Suppl 1*, S79–86. http://doi.org/10.1093/gerona/glv061

Welch, P. (1995). What is Universal Design. *Strategies for Teaching Universal Design*, 1–30.

What is Soundbeam. (n.d.). Retrieved May 22, 2016, from http://www.soundbeam.co.uk/what-is-soundbeam-1/

Wheeler, B. L. (2015). *Music therapy handbook.* New York; London: The Guilford Press.

Young, A., & Dinan, S. (2005). Activity in later life. *BMJ (Clinical Research Ed.)*, *330*(7484), 189–91. http://doi.org/10.1136/bmj.330.7484.189

Zimmerer-branum, S., & Nelson, D. L. (1994). Occupationally Embedded Exercise Versus Rate Exercise: A Choice Between Occupational Forms by Elderly Nursing Home Residents. *American Journal of Occupational Therapy*, 397–402.

APPENDIX A – Technology Probes

Consent Form

This image cannot currently be displayed.

Consent Form

Title: Fitness through Music: Designing Objects to Create Electronic Music using Movements in a Senior's Exercise Class

Date of ethics clearance: 11/02/2015

Ethics Clearance for the Collection of Data Expires: 08/31/2016

I ____, choose to participate in a study on creating music using body movements in an exercise class. This study aims understand how creating music will change the experience of the class and help inform how future objects could be designed.
The researcher for this study is Alyssa Wongkee in the Industrial Design Department at Carleton University.
She is working under the supervision of Prof. Lois Frankel, School of Industrial Design, and Prof. Jesse Stewart, Faculty of Music.

This study involves using a prototype to make music during an exercise class at Churchill Senior's Centre. You will be randomly assigned one of the prototypes to use in the class. With your consent, the session will be video-recorded for research purposes only and will not be available to anyone other than the researcher and the research supervisors. With your consent, photographs will be taken and your identity will be protected in any reports.

While the risk is expected to be low, it is possible that you may over exert yourself and become tired because you are exercising. Precautions will be taken to ensure you do not over exert yourself, you are able to rest at any point and are encouraged to drink water. Measures will be taken to protect your identity, your name will not be associated with any data. In any pictures used in publications, faces will be blurred using computer software.

You have the right to end your participation in the study at any time, for any reason, up until November 25th 2015. You can withdraw by phoning or emailing the researcher or the research supervisor. If you withdraw from the study, all information you have provided will be immediately destroyed.

As a token of appreciation, refreshments are provided following the session. This is available to your even if you withdraw from the study.

All research data, including video-recordings and any notes will be password protected on a computer hard-drive. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton University. Research data will only be accessible by the researcher and the research supervisor.

All research data be securely destroyed post-publication of the research findings, once the project is complete. (Electronic data will be erased and hard copies will be shredded.)
If you would like a copy of the finished research project, you are invited to contact the researcher to request an electronic copy, which will be provided to you.

The ethics protocol for this project was reviewed by the Carleton University Research Ethics Board, which provided clearance to carry out the research. Should you have questions or concerns related to your involvement in this research, please contact:

CUREB contact information:
Professor Shelley Brown, Chair of CUREB-B
Carleton University Research Office
511 Tory
1125 Colonel By Drive
Ottawa, ON K1S 5B6
Tel: 613-520-2600 ext 1505
ethics@carleton.ca

Researcher contact information:
Alyssa Wongkee
School of Industrial Design
Carleton University
Alyssa.Wongkee@carleton.ca

Supervisor contact information:
Lois Frankel
School Of Industrial design
Carleton University
Lois.Frankel@Carleton.ca

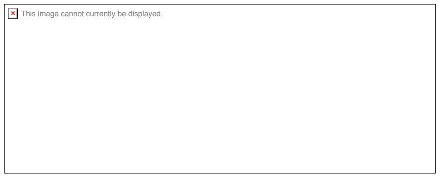
Do you agree to be photographed: ___Yes ___ No
Do you agree to be video-recorded: ___Yes ___ No

_________________________ _______________
Signature of participant Date

_________________________ _______________
Signature of researcher Date

APPENDIX B – Interview

Consent Form



Consent Form

Title: Fitness through Music: Designing Objects to Create Electronic Music using Movements in a Senior's Exercise Class

Date of ethics clearance: 11/02/2015

Ethics Clearance for the Collection of Data Expires: 08/31/2016

I ____, choose to participate in a study on creating music using body movements in an exercise class. This study aims understand how creating music will change the experience of the class and help inform how future objects could be designed.
The researcher for this study is Alyssa Wongkee in the Industrial Design Department at Carleton University.
She is working under the supervision of Prof. Lois Frankel, School of Industrial Design, and Prof. Jesse Stewart, Faculty of Music.

This study involve interviewing you about your experiences using or developing prototypes for making music during exercises classes at Churchill Senior's Centre. With your consent, the session will be video-recorded for research purposes only and will not be available to anyone other than the researcher and the research supervisors. If you choose, measures will be taken to protect your identity, your name will not be associated with any data

While the risk is expected to be low, measures will be taken to protect your identity, your name will not be associated with any data. In any pictures used in publications, faces will be blurred using computer software.

You have the right to end your participation in the study at any time, for any reason, up until January 30th 2016. You can withdraw by phoning or emailing the researcher or the research supervisor. If you withdraw from the study, all information you have provided will be immediately destroyed.

All research data, including video-recordings and any notes will be password protected on a computer hard-drive. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton University. Research data will only be accessible by the researcher and the research supervisor.

All research data be securely destroyed post-publication of the research findings, once the project is complete. (Electronic data will be erased and hard copies will be shredded.)

If you would like a copy a poster summarizing the findings of the research, you are invited to contact the researcher to request an electronic copy, which will be provided to you.
The ethics protocol for this project was reviewed by the Carleton University Research Ethics Board, which provided clearance to carry out the research. Should you have questions or concerns related to your involvement in this research, please contact:

CUREB contact information:
Professor Shelley Brown, Chair of CUREB-B
Carleton University Research Office
511 Tory
1125 Colonel By Drive
Ottawa, ON K1S 5B6
Tel: 613-520-2600 ext 1505
ethics@carleton.ca

Researcher contact information:
Alyssa Wongkee
School of Industrial Design
Carleton University
Alyssa.Wongkee@carleton.ca

Supervisor contact information:
Lois Frankel
School Of Industrial design
Carleton University
Lois.Frankel@Carleton.ca

Do you agree to be photographed: ___Yes ___ No
Do you agree to be video-recorded: ___Yes ___ No

________________________ ______________
Signature of participant Date

________________________ ______________
Signature of researcher Date

Sample Interview Questions

The interviews are semi-structured based on the results of the first phase of research

- *What were your general impressions of the music making devices? Of the music?*
- *How would you describe the classes' reaction to music making?*
- *What did you think of the exercises done while making music?*
    - *Were the participants able to exercise effectively?*
- *Why is the purpose or goal of coming to classes for most of the clients?*
- *Did you feel like creating music was productive?*
- *What would your impressions be of putting on a performance?*

APPENDIX C – Design Workshop

Participant Consent

This image cannot currently be displayed.

Consent Form

Title: Fitness through Music: Designing Objects to Create Electronic Music using Movements in a Senior's Exercise Class

Date of ethics clearance: 01/29/2016

Ethics Clearance for the Collection of Data Expires: 08/31/2016

I ____, choose to participate in a study on creating music using body movements in an exercise class. This study aims understand how creating music will change the experience of the class and help inform how future objects could be designed.

The researcher for this study is Alyssa Wongkee in the Industrial Design Department at Carleton University.

She is working under the supervision of Prof. Lois Frankel, School of Industrial Design, and Prof. Jesse Stewart, Faculty of Music.

This study involves helping to develop ideas and designs for an object or product to make music during an exercise class at Churchill Senior's Centre. It involves participating in a design workshop and a completing a questionnaire. With your consent, the session will be video-recorded for research purposes only and will not be available to anyone other than the researcher and the research supervisors. With your consent, photographs will be taken and your identity will be protected in any reports.

While the risk is expected to be low, precautions will be taken to ensure you do not over exert yourself, you are able to rest at any point and are encouraged to drink water. Measures will be taken to protect your identity, your name will not be associated with any data. In any pictures used in publications, faces will be blurred using computer software.

You have the right to end your participation in the study at any time, for any reason, up until January 30th 2016. You can withdraw by phoning or emailing the researcher or the research supervisor. If you withdraw from the study, all information you have provided will be immediately destroyed.

As a token of appreciation, refreshments are provided. This is available to your even if you withdraw from the study.

All research data, including video-recordings and any notes will be password protected on a computer hard-drive. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton University. Research data will only be accessible by the researcher and the research supervisor.

All research data be securely destroyed post-publication of the research findings, once the project is complete. (Electronic data will be erased and hard copies will be shredded.)
If you would like a copy a poster summarizing the findings, you are invited to contact the researcher to request an electronic copy, which will be provided to you.

The ethics protocol for this project was reviewed by the Carleton University Research Ethics Board, which provided clearance to carry out the research. Should you have questions or concerns related to your involvement in this research, please contact:

CUREB contact information:
Professor Shelley Brown, Chair of CUREB-B
Carleton University Research Office
511 Tory
1125 Colonel By Drive
Ottawa, ON K1S 5B6
Tel: 613-520-2600 ext 1505
ethics@carleton.ca

Researcher contact information:
Alyssa Wongkee
School of Industrial Design
Carleton University
Alyssa.Wongkee@carleton.ca

Supervisor contact information:
Lois Frankel
School Of Industrial design
Carleton University
Lois.Frankel@Carleton.ca

Do you agree to be photographed: ___Yes ___ No
Do you agree to be video-recorded: ___Yes ___ No

_________________________ _______________
Signature of participant Date

_________________________ _______________
Signature of researcher Date

Facilitator Consent

This image cannot currently be displayed.

Consent Form

Title: Fitness through Music: Designing Objects to Create Electronic Music using Movements in a Senior's Exercise Class

Date of ethics clearance: 01/29/2016

Ethics Clearance for the Collection of Data Expires: 08/31/2016

I ______________________________________, choose to participate in a study on creating music using body movements in an exercise class. This study aims understand how creating music will change the experience of the class and help inform how future objects could be designed.
The researcher for this study is Alyssa Wongkee in the Industrial Design Department at Carleton University.
She is working under the supervision of Prof. Lois Frankel, School of Industrial Design, and Prof. Jesse Stewart, Faculty of Music.

This study involves helping to develop ideas and designs for an object or product to make music during an exercise class at Churchill Senior's Centre. It involves helping to facilitate a co-design workshop with seniors, by helping to get them to share their ideas and helping to visualize them. It will also involve participating in a pilot test of the workshop and debriefing in preparation for the co-design workshop With your consent, the session will be video-recorded for research purposes only and will not be available to anyone other than the researcher and the research supervisors. With your consent, photographs will be taken and your identity will be protected in any reports.

While the risk is expected to be low, precautions will be taken to ensure you do not over exert yourself, you are able to rest at any point and are encouraged to drink water. Measures will be taken to protect your identity, your name will not be associated with any data. In any pictures used in publications, faces will be blurred using computer software.

You have the right to end your participation in the study at any time, for any reason, up until January 30th 2016. You can withdraw by phoning or emailing the researcher or the research supervisor. If you withdraw from the study, all information you have provided will be immediately destroyed.

As a token of appreciation, a 10 dollar Starbucks or Tim Hortons gift card will be provided.

All research data, including video-recordings and any notes will be password protected on a computer hard-drive. Any hard copies of data (including any handwritten notes or USB keys) will be kept in a locked cabinet at Carleton

University. Research data will only be accessible by the researcher and the research supervisor.

All research data be securely destroyed post-publication of the research findings, once the project is complete. (Electronic data will be erased and hard copies will be shredded.)
If you would like a copy a poster summarizing the findings, you are invited to contact the researcher to request an electronic copy, which will be provided to you.

The ethics protocol for this project was reviewed by the Carleton University Research Ethics Board, which provided clearance to carry out the research. Should you have questions or concerns related to your involvement in this research, please contact:

CUREB contact information:
Professor Shelley Brown, Chair of CUREB-B
Carleton University Research Office
511 Tory
1125 Colonel By Drive
Ottawa, ON K1S 5B6
Tel: 613-520-2600 ext 1505
ethics@carleton.ca

Researcher contact information:
Alyssa Wongkee
School of Industrial Design
Carleton University
Alyssa.Wongkee@carleton.ca

Supervisor contact information:
Lois Frankel
School Of Industrial design
Carleton University
Lois.Frankel@Carleton.ca

Do you agree to be photographed: ___Yes ___ No
Do you agree to be video-recorded: ___Yes ___ No

_________________________ _______________
Signature of participant Date

_________________________ _______________
Signature of researcher Date

Questionnaire

Participant Workshop Questionnaire Participant:___________

1. What general impression did you have of making music while exercising?

(example: it was distracting, too loud, nice to listen to, was fun, boring, I didn't notice it)

____

2. How difficult was it to make music in the class?

1	*2*	*3*	*4*	*5*
Very Easy				*Very Difficult*

3. In the workshop, did you feel like you were able to contribute to the designs?

1	*2*	*3*	*4*	*5*
Not at all				*Yes, A lot*

4. Which was your favourite design idea from the workshop? Could you see yourself using any of the design in the class or by yourself?

5. Do you have any other comments about the workshop, or making music in the exercise classes?