Sensory Insights for Design:

A Sensory Anthropology Approach to Industrial Design Research

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ABSTRACT

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This study explores how sensory anthropology perspectives can provide empathic and sensory knowledge for designing wearable technologies with and for impaired older people. The investigation draws from the fields of gerontology, design, anthropology of the senses, and wearable computing. It is driven by the main question: How can designer researchers gain insights for designing wearable technologies for an older population?

The participants included students enrolled in an Industrial Design course at Carleton University in Ottawa and older people attending special fitness classes at the Churchill Senior's Recreation Centre in Ottawa. Data was gathered in-situ over six months. The methods for data collection included ethnographic Participant Observation, Co-design exercises, and Exploratory Technology Probe activities. Data analysis took an open-coding approach leading to thematic categories following Ackoff's Data, Information, Knowledge, and Wisdom (DIKW) Model.

The themes that emerged include: the Setting, the nature of fitness instruction, Participant's Worldviews, Bodily Ways of Gathering Information, Interaction between the Senses to achieve fitness goals, and the Sensory Roles of Artifacts. These sociocultural themes about the sensory practices of the older exercisers are described in narratives that can stand alone as a contribution to the field.

Additionally, the findings from the Co-design workshop provide insights into the nature of the design process. They highlight an unanticipated empathic finding about the use of gestural language in Co-design activities. The gestures are organized into three categories. The discussion also tracks the influence of participants' gestures on the artifacts developed during and after the Co-design workshop.

The insights arising from this study are presented as two major contributions to the field of participatory design research. The first is a set of Guidelines for exploring Sensory Contexts for generating Design Insights with five categories: Participants' Worldviews, Sensory Practices, Sensory Interactions, Sensory Role of Artifacts, and Gestural Language. The guidelines are relevant for a wide variety of user-centered design investigations and not specific to designing wearable technologies for older people. The second contribution is specific to the issue at hand and provides seven insights for designers to consider when developing assistive technologies for fitness for older adults.

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1 Introduction

Have you ever had your foot catch on a curb, and had to correct your balance to avoid falling? For many older adults this sort of quick correction is challenging. In fact, the likelihood of experiencing a fall increases with the diminishing sensory capabilities of ageing bodies. This is one, but not the only, type of physical trial that affects an ageing person's quality of life. After a fall, the frail elderly in Canada often end up in hospital with a broken hip and of those, many never completely recover. While the particular fall would have been unexpected, it is likely that prior to it the older person may already have begun adapting her everyday patterns in response to changes in sensory experiences. She may have modified a fitness regime, consulted a doctor, had rehabilitative surgery, or worked with a physiotherapist. She may have adopted assistive devices such as canes, rollators (walkers), handrails, or wearable call buttons designed to support her declining physical abilities.

Professional designers and engineers, working in collaboration with or advised by medical professionals, design these (and other) supportive artifacts for ageing people's physical and cognitive needs. These devices are often tested on end users and certified by regulatory bodies. However, older people frequently view them with ambivalence, sometimes avoiding them, regardless of the expertise involved in design development. Why are the elderly reluctant to embrace many products or aids designed for their independent living? Perhaps such artifacts are simply foreign to their self-image, confirming their status as an old person, an outsider. This design research study explores how sensory anthropology perspectives can provide empathic and sensory knowledge about designing wearable technologies with and for the impaired older people who will use them.

For this research, I spent six months attending fitness classes for older adults; most had recently graduated from health care rehabilitation programs, or recovered from a stroke, heart attack, knee or hip surgery. Twelve design students joined me in a class project for the first four months, and three continued on for the remaining two months. We worked closely with small groups of older adults in and outside of their post-rehabilitation fitness classes. Our objective was first to understand if assistive devices could help them in their fitness regimes and second how these devices could provide that assistance. We wanted to find out if simple sensor-enabled devices would be useful to monitor or offset some of the multi-sensory fluctuations of ageing. For example, in fitness exercises, older people may practice stepping onto curb-height surfaces to simulate and prepare for common daily experiences. Would they want to wear a sensory enhanced device to help them gauge their bending limits or measure their progress? We learned about the seniors' sensory experiences and whether technology could play a part assisting with their fitness aspirations. This dissertation describes the exploration.

1.1 Research Focus

My research focused on gaining a first-hand understanding of the re-ordering of sensory modalities as one's strength, endurance, balance, and cardiovascular capabilities change due to age-related impairments. It was intended to gather multi-layered (and possibly idiosyncratic) insights to inform and inspire the design of wearable assistive sensory technology products. Wearable technologies for fitness are growing in popularity. However, the one-size-fits-all products that are currently on the market do not address the unique requirements of many older users, as we discovered during this investigation. Design research has demonstrated that products can be more appropriately integrated into a person's everyday life by incorporating perceptions gained in the field. As a result, it was important to participate in activities, in-situ, with the potential future users of wearable fitness products to learn about their distinctive sensory design needs.

For this investigation we worked with a group of older people attending fitness classes at the Churchill Senior's Recreation Centre in Ottawa. We focused specifically on the sensory practices and bodily experiences in their "golden-age" fitness exercises because fitness is directly related to quality of life and independent living, particularly for older people. Since the effects of being unfit can be, and in some instances had already been, devastating for an older person, we hoped to make a useful contribution to design research in this area.

The emphasis was on understanding whether or what type of technological product would fit appropriately into an older person's everyday fitness experiences. The research concentrated on issues related to designing wearable technologies for monitoring and augmenting their current sensory and physical experiences during exercise.

Currently, especially when designing for the ageing population, technology experts take the dominant role in the development of such artifacts. In contrast, this study took a human-centered and collaborative approach to the design process. This exploration is situated in the area of participatory design research. In addition, it draws from the fields of gerontology, anthropology of the senses, and wearable computing.

Each area contributes a different and valuable perspective about sensory experiences: sensory transitions from the first two and sensory augmentation from the last one. These differing perspectives led to potential links between older people's sensory ways of being fit and the potential for wearable technologies to support them.

We gathered this knowledge by including older participants in some of the research activities. Through co-creative collaboration between the elderly participants and student design researchers, participants explored how wearing sensor enabled multi-modal devices or systems could add to their bodily awareness in fitness activities. To come to an understanding of the sensory-design related issues, the study also included a qualitative ethnographic study of sensory experiences in improving and maintaining reasonable levels of fitness. Another objective of this research has been to generate meaningful and inspirational narratives that could provide compelling reasons for participating with older users in the early design stages (fuzzy front end) of the design process.

1.2 Research Question

The objective of this investigation is to add to existing industrial design research knowledge about working with and for an ageing population, given advances in technology that could improve their quality of life. The research was initially driven by the main question: *How can designer researchers gain insights for designing wearable technologies for an older population*? It intends to address both the process for gaining insights and the insights revealed. This knowledge fits into the context of existing scholarly design research as discussed here.

1.3 Inspiration

For over a decade my industrial design students and I were involved in a number of projects, in which we would design product concepts to monitor, assist with, or collect data related to health and well being. We often consulted with systems and computer engineers since several of the tangible technology-oriented solutions to people's needs involved systems of networked products, such as individualized patient information management devices for teams of health care professionals. This led us to initiate a joint project with systems and computing engineers focusing on everyday navigation devices for the visually impaired. Shortly after embarking on the project we discovered that while the engineers were keen to begin by making prototypes, we designers had no idea what this user population needed or, for that matter, what people already used to help them navigate. We knew we had to do this research before we were ready to generate any viable design concepts that would fit into their everyday lives. Due to our different interests, we decided to run parallel projects, where we could follow our own user-oriented design development processes and the engineering team could pursue prototype development. There was never a point where we were able to integrate the parallel streams.

While the separate projects approach helped each team meet its objectives, it also exposed some of the human-oriented challenges with potential new technologies. In particular, we learned that with miniaturization, it is possible to monitor, process, and collect large amounts of data, which require interpretation. Furthermore, it was unclear who determines what and how much the end user needs, sees, hears, feels, (or even smells and tastes) and how this becomes resolved in the design of the features of tangible devices. Does the designer or the engineer decide how much information is too much (hence overwhelming) and how much information is just right (hence informative)? For example, in one design project for monitoring independent seniors in the early stages of Alzheimer's disease we wondered how much information would a remote family member need to know that their father is okay? Did they really need to measure his anxiety levels and comfort him over Internet video immediately? In the end, through usability design research with caregivers, we determined that having real-time remote access to their father's vital signs might overwhelm family members. Instead, it made more sense to provide pre-recorded messages and task reminder alarms for their father. In addition a 'moments of frustration' tracking feature would enable caregivers to review his everyday problem areas and suggest changes to assist with his independent living.

Given that technical advances will continue, the human-related design issues have become substantially more important; how many features and how much technology would be appropriate. Moreover, as the size of the devices becomes smaller they can also be used in closer contact with the human body. However, engineers are not particularly well prepared to understand the human-centered design nuances that make some products better suited for close contact with the human body in everyday activities than others. While engineers are skilled at making things work, they are rarely trained in understanding user-centered design requirements. Industrial designers, on the other hand, are trained to understand and incorporate user needs into the products they design, making them essential for the human-centred design process.

While human-centered design has long been an essential component of most industrial design processes for determining product characteristics, the inclusion of sensory aspects of design is a relatively recent development. The idea for this exploration arose from the challenges of weaving these opportunities together. Consequently, one motivation for this research was the desire to connect the technological potential to a greater knowledge of people's sensory practices relevant to product design. Another motivation was the desire to understand the design potential for the explosion of miniaturized sensor capabilities. I was excited by the possibilities for integrating the two.

Several of our projects involved older adults, especially those related to the TAFETA (Technology Assisted Friendly Environments for the Third Age) project at the Sisters of Charity's Elizabeth Bruyere Hospital in Ottawa. Since we knew that older adults experience sensory changes, often gradually and sometimes abruptly, there was a possibility that they would be aware and able to articulate those changes. This was significant because design research has appropriated ethnographic fieldwork practices in which researchers immerse themselves in a "different" culture to study people's practices, in the case of design, for applied design purposes. So here was a culture that was not only "different" to the young researchers, but also to its members, who were coming to terms with their own bodily changes.

In view of this combination of challenges and opportunities, I became interested in learning more about the field of anthropology, a field that design researchers have mined for design methods for more than thirty years. In particular, the emerging area of anthropology of the senses seemed well suited for this design research. It might provide sharper insights into the sensory modalities that are key to designing useful products for older people's exercise regimes. The outcomes of such a sensory-oriented and technology-focused study could be valuable for both designers and engineers. As a result, I began this investigation.

1.4 Theoretical Approach

I adopted a qualitative research perspective, which seemed to be best suited for exploring and discovering how the participants, young and old, would perceive and experience the relationship between sensory awareness and design development. Qualitative research focuses more on the detailed or 'thick' description and interpretation of people's meaningful experiences though the eyes of the people involved and less on how many people are included in the sample (Geertz 2002; Ladner 2007). This kind of research is associated with discovery, description, understanding, and shared interpretation in which the researcher-personal biases and values- is part of the process (Sanghera 2007). The alternative would have been to take a quantitative approach in which reality would be captured by measuring "quantity, amount, intensity, or frequency" of an objective external reality (Denzin and Lincoln 2005: 10; Sleeswijk Visser 2009). While the quantitative approach is well used by technology-driven experts in the field of technology-assisted product design, it does not provide the desired sensitivity to the participants' subjective sensory experiences.

Anthropologists and design researchers use qualitative research approaches, in part, because "qualitative researchers study things in their natural settings" (Denzin and Lincoln 2005: 3). In this case, the natural setting was primarily the Churchill Seniors' Centre (CSC) where the older participants attended fitness classes. Our ongoing participation in fitness classes provided a foundation for understanding. Since this study was conducted in this situated "field", it provided a context "for understanding what the participants [were] saying" (Creswell 2013: 20). The importance of what this small group of older individuals was saying, perceiving, and doing was integral to discovering insights about their sensory challenges in fitness activities.

A qualitative research approach also uses a variety of "interpretive practices" because "each practice makes the world visible in a different way", according to Denzin and Lincoln (2005 :4). In order to experience the setting and relevant events, my students and I adopted different qualitative research strategies that would enable us to "get to know the participants"(Creswell 2013: 20). The data collection methods were varied and can be organized under three headings: participant observation techniques, co-design events, and exploratory technology probe activities. They are described in Chapter three, along with the approach to analysis and synthesis of the data. The point of using multiple methods was to provide different and mutually related information (data triangulation) that would support the kind of inductive data analysis associated with qualitative research (Bloomberg and Volpe 2008: 12).

1.4.1 Constructivist Framework

A constructivist model is appropriate for generating a new approach to sensory design research with older people. According to Bloomberg and Volpe (2008), a constructivist paradigm looks at the subjective meanings that individuals ascribe to their personal experiences. These personal values and meanings can be organized using a constructivist or interpretivist framework. This provides the opportunity for exploring, reflecting on, and responding to participants' experiences in stages and over time. As Charmaz (2005: 509) notes:

> *A constructivist approach emphasizes the studied phenomenon rather than the methods of studying it…That means giving close attention to empirical realities… and locating oneself in these realities… What observers see and hear*

> *depends upon … the research context, their relationships with research participants, concrete field experiences, and modes of generating and recording empirical materials.*

As design researchers we engaged in this way with the older participants' sensory design issues related to their fitness practices. As a result we were exposed to and attempted to understand the meanings or realities from the perspective of their experience.

The research participants in this study included the design students, the older exercisers, their exercise instructor, their program coordinator, and myself as the main researcher. As design researchers and participants, the students and I tried to stand back and look at these experiences from a fresh or unfamiliar perspective (Bell, Blythe and Sengers 2005). Consequently, it was appropriate to take Erickson's advice for seeing the familiar through different eyes. He recommends that researchers continually ask, "Why is this_______(act, person, status, concept) the way it is and not different" (1984: 62)? This interpretive approach involved "empathetic understanding of the participants' day-to-day experiences [as well as] an increased awareness of the multiple meanings given to the routine and problematic events by those in the setting" (Bailey 2007: 53).

1.5 Design Research Approach

A qualitative approach to research is common today in the field of design research, which was initially touted as a scientific discipline with a positivist approach to design enquiry (Archer 1995; Bonsiepe 2007). Now research activity related to design is exploratory, and is both a way of inquiring and a way of producing new knowledge (Cross 2007: 52; Downton 2003: 1). Eminent design professor, Richard Buchanan, says, "What I believe has changed in our understanding of the problem of design knowledge is greater recognition of the extent to which products are situated in the lives of individuals and in society and culture" (2001 : 14). According to Buchanan, a significant challenge for design research is "to understand how designers may move into other fields [such as the social sciences] for productive work and then return with results that bear on the problems of design practice" (2001:17). This study responds to his challenge: integrating a sensory anthropology enquiry into the design research process related to technology-enabled artifacts for an aging population.

In this investigation, the emphasis is on the research objective of creating design knowledge, not on gathering requirements for one specific project solution. That means the goal of my research is not to understand how to design a better heart-rate monitor, although the design of that specific device may also benefit from the outcomes of this exploration. It is to understand the sensory practices that older people with cognitive and bodily limitations experience; practices that would enrich the design of technology-augmented devices for their fitness activities.

1.6 Sensory Anthropology

Anthropology of the senses is a relatively recent approach within anthropology that studies the patterns of sensory practices within different cultures in order to learn more about sociocultural meanings and values (Classen1997: 401; Howes 1991: 3). Sensory anthropologists engage in ethnographic research, with a strong focus on "attending to the sensory dimensions of other people's experience, with the same order of preferences and intensity that they do" (Howes 1991: 172). It can be valuable for examining subcultures within one's society. Therefore it is appropriate for the study of older people, whose evolving sensory modes often isolate them from everyday customs and from others. Another reason is that through developing a sensory profile of the relationship between the senses and the meaning of the different senses within the culture, it is possible to come to deeper understanding of how people relate to their world (Classen 1993; 1997: 402; Geertz 2002; Howes 1991: 3) and, in this case, to the assistive technologies they use.

Sensory anthropology also places value on the inter-related fashion in which the senses work, sometimes augmenting and sometimes opposing/contradicting each other, instead of isolating and studying sensory experiences individually (Classen 1993, 1997; Howes & Classen 1991; Paterson 2007; Stoller 1989). It studies "how the senses are used in practice" as part of the cultural context of people's daily lives (Howes 1991: 170). Since some older people's ability to experience their activities is affected by their limited sensory modalities, this approach makes sense for examining older peoples' 'sensorium of experience'. The term 'sensorium of experience' refers to the holistic experience that enables an individual within a culture to gain knowledge about his or her world through all of the bodily senses (Geertz 2002: 253). This field is discussed in more detail in the second chapter as it contributes significantly to this investigation.

1.6.1 Sensory Anthropology and Design

Anthropology of the senses provides a perspective for exploring the sensory worlds of the elderly and it can also contribute a different way of looking at design issues (Abram1997; Bull 2006; Macpherson 2009; Malnar & Vodvarka 2004). For example, technology could affect a person's sensorium, by reconfiguring or extending it (as discussed by McLuhan and Merleau-Ponty in Classen 1993; Parisi 2008: 310; Paterson, 2007:21). In his discussion of the iPod, Michael Bull provides an example of reconfiguring the auditory bubble that defines an individual's personal sphere relative to the outside world (2006). The iPod enables its wearer to control his or her "largely private and mobile" auditory space, almost completely cut off from the external soundscape (Ibid: 107).

In another case sociologist John Hockey delves deeply into the multiple sensory interactions that enable runners to "corporeally know and cognitively categorize" their progress and the nature of their training routes (2006: 198). Not only do they listen to and monitor their own and surrounding sounds along the way, they actively see, smell, and feel their "training space". For example, as runners rhythmically advance, their feet, even with running shoes, are continually adjusting to the haptic touch of the ground, "its shape, size, texture, and temperature" (Ibid: 197).

Cultural ecologist David Abram praises the remarkable capabilities of his sensory system to respond to continuous changes in the environment when hiking on uneven terrain without his conscious involvement (1997: 49). Moreover, he questions the practice of designing standardized features into products that make it difficult for people's senses to learn from unanticipated sensory feedback. These examples illustrate the idea that through investigating sensory practices it may also be possible to understand how our designed solutions fit into an impaired older person's changing sensorium.

1.7 Assumptions and Scope

Initially, as a researcher, one dives into a space that seems to make sense from a place of inner knowing or even perhaps, inner wishing. This exploratory space is gradually furnished through the literature and the inspiration provided by examples set by PhD supervisory committee members. This case study was seeded by my previous experience; designing and making jewellery on one hand and working on applied design projects for the elderly on the other. It seemed evident to me that there would be an opportunity to marry wearable sensory technologies to the wavering sensory capabilities associated with ageing. I thought that by becoming more tuned into the sensory aspects of people's experiences it would be possible to see familiar situations in a new light. In this case, the new light or knowledge would come from the impaired older person's point of view.

I believe that this knowledge is important for the engineers designing wearable computing technologies as those professionals do not really seem to take humans into consideration. In his book, *The Inmates Are Running the Asylum: Why High-Tech Products Drive Us Crazy and How to Restore the Sanity* (1999), Alan Cooper argues that the engineers are leading the design of technologies, which is resulting in too many features that overwhelm users, leading to frustration and rejection of potentially useful products. According to Bill Buxton (2007: 9),

> *Hardly a day goes by that we don't see an announcement for some new product or technology that is going to make our lives easier, solve some or all of our problems, or simply make the world a better place. However, the reality is that few of these products survive, much less deliver on their typically over-hyped promise. But are we learning from these expensive mistakes? Very little, in my opinion.*

Buxton goes on to add that, "without informed design, technology is more likely to be bad than good" (ibid: 38). Buxton and other experts believe that user-oriented design processes are essential for user acceptance of products with embedded technologies (Greenfield 2006; McEwen and Cassimally 2014).

This study aims to contribute to the field of design research by demonstrating how a sensory anthropology point of view can be applied to study the experiences, practices, and perceptions of a special population. The intention is to assist design researchers and members of design teams to recognize that the people they are studying have different "ways of sensing" than they do (Howes and Classen 2014). Hopefully this will affect how and what they design. While the objective is to contribute design research guidelines and principles for designing sensory-augmented technologies for older people, it does not intend to specify technical features for these products. With these assumptions and scope, the study that is described in this document came to be.

1.8 The Chapters

There are eight chapters in this dissertation. In this chapter the focus and inspiration for the study were introduced. This chapter presented the background, general context, and areas of influence for this research, as well as explaining the research approaches that could lead to an integration of design research and sensory anthropology perspectives.

In Chapter two the relevant literature in four different fields is explored. These fields include: Ageing, with respect to sensory changes and everyday life; Wearable technologies and interaction design challenges in the areas of health and well-being; Industrial Design research strategies, including Participatory design research for designing product experiences; and Anthropology of the Senses, explaining the concepts of different sensory models and customs, inter-relatedness and ordering of the senses and sensory studies in design. This chapter provides the foundations for this study, introducing the theoretical discourse and identifying challenges and opportunities for design research. It also explains the relationship between the investigative framework and the research methods.

Chapter three describes the step-by-step progress through the study, the three methods of participant observation, co-design, and technology probes and the rationale for those methods. It is divided into two main phases. Phase one discusses preparing for and facilitating the co-design workshop with design students and seniors. Phase two describes the ongoing ethnographic fieldwork, including the prototype probes in which participants explored implementing technology into fitness activities. In addition, it discusses the approach to analyzing and synthesizing the data.

Chapter four presents the findings from this case study as narratives. The stories provide detailed description in the hopes of engaging readers more fully in the fitness experiences of the older exercisers. The narratives describe the sociocultural and sensory discoveries from the following points of view: the Seniors Centre, the nature of fitness instruction, participant's worldviews, their bodily ways of gathering information, how their senses interact to achieve fitness goals, and the sensory roles of artifacts.

Chapter five focuses specifically on the findings that emerged during the Co-design workshop, with an emphasis on the relationship between co-design and empathy in user-centered design research. It highlights an unanticipated empathic finding about the use of gestural language in co-design activities and reviews more literature to understand the value of this knowledge. It also presents an analysis of the artifacts that were produced in the three stages of the co-design activity with the students in relation to the use of gestural language as a design process.

Chapter six discusses the answers to the main question of this study, breaking them into two contributions to the field. One contribution is the Sensory Contexts for Design Research Guidelines. The other is a set of Insights for designers to consider when developing assistive technologies for fitness for impaired older adults. This chapter also addresses limitations to this investigation and suggests future research directions.

Chapter seven is a short reflective chapter. It touches upon aspects outside the scope of this case study that I experienced due to this research. It addresses the value of ethnographic writing in the field of design. It acknowledges the tensions between intuitive and systematic approaches that influenced this research, such as the richness of empathy instead of prescriptive paradigms for design research. It also describes how a sensory approach has changed how I teach form and colour principles to industrial design students.

Chapter eight is the conclusion where the three main contributions of this research are summarized: the Narratives, the Sensory Contexts for Design Research Guidelines, and the Insights for designing appropriate sensory augmented assistive technologies for an impaired older population.

Chapter nine offers a brief afterword. It explains how this experience has transformed my practice as a design educator. It also discusses the impact this perspective should have on design education.

2 Foundations in the Literature

One day in 1977 in Düsseldorf, I was visiting the Gallery of my professor, Friedrich Becker; the sunlit room was filled with his metal sculptures. Herr Becker flicked a switch on the wall and the gleaming geometric forms began to move — precisely and silently — with light bouncing off the rotating surfaces. Afterwards, as I walked home, I could hardly contain myself. I experienced an epiphany that has lasted to this day; my personal definition of "success" had been enlarged in ways that would only gradually become apparent.

The experience started earlier that week when I was completing a piece of jewellery at my workbench in the Düsseldorf Fachhochschule (University of Applied Sciences). I had just finished riveting an 18k gold gunman action figure onto a perspex and ivory Italian flag brooch. Silver letters around the border said, in Italian, "Why not spend an exciting week in Rome?" My Herr Professor walked by, looked at it, and asked me if I understood anything about beauty. And, after muttering something about unsophisticated Canadians, he invited me for a visit.

The tour at his home started in the basement, where his apprentices were working away on precious jewellery and sculptural pieces. On the main floor he showed me his Jugendstil (Art Nouveau) collection of glass vases. Placed in a row along a floor-to-ceiling glass wall in the living room, ranging from very short to taller than both of us, the coloured glass was illuminated by sunlight. A collection of modern American paintings lined the stairwells on the way to the Gallery. He clearly appreciated the aesthetics of different historical periods of art. Then, on the top floor, came the Gallery, where everything moved silently. I was awestruck by the silence, the precision, and the beauty.

How did this contribute to expanding my understanding of success? I pieced together Professor Becker's history. He was a trained mechanic before World War Two, a trained aviation engineer during the war, and a trained silversmith after the war. He had kept all the doors of his past open and all those experiences accumulatively informed his work with meticulousness, perfection, and aesthetic harmony. At that moment I understood that the nature of success is to infuse whatever a person undertakes with the essence of what he or she has already done.

This chapter presents a number of themes that arise from a bricolage of my creative, intellectual, and personal experiences, past and present. The first theme introduces issues relevant to design for older adults, an area my students and I have worked in for over a decade. It describes older peoples' bodily experiences, capabilities, and attitudes that influence the design of appropriate things, processes, and surroundings for them. The second theme, wearable technology as the object of design, evolved from many years of designing and teaching others how to make beautiful, useful, and meaningful things, ranging from jewellery to assistive products. The third theme deals with design research, an area of interest developed late in my career, which has taken on more importance in the field of design and design education. The final, most recent, and most important theme explores the sensory aspects of experience. Hopefully the sensory perspective will enrich the other themes and provide design researchers with a stepping-stone into the future. The discussion draws from the literature in each of these areas to describe the current context influencing the question at hand: *How can designer researchers gain insights for designing wearable technologies for an older population?*

2.1 Understanding the Ageing Experience

Social science literature about ageing and disability provides valuable insights into the cognitive and bodily changes that contribute to the subjective perceptions of the elder population (Cunningham-Burley, Nettleton and Watson 1998; Goffman 1959; Goffman 1963; Sherman 1991; Strickler and Neafsey 2002; Stuart-Hamilton 1991; Williams, Nettleton and Watson 1998). The design literature primarily supports the notion that the perceived quality of an older person's life corresponds directly to his or her altered mental and physical capabilities, in particular ways that design might be able to accommodate (Bennett 2007; Blessing and Elsner 2002; Bowling et al. 2007; Hirsch et al. 2000; Huppert 2003; Ostlund 2007; Rose and Vinay 2007). These concepts are discussed in this section, beginning with background information about older people relevant to this design exploration.

2.1.1 Demographics

There is a growing demographic of older people living on their own. In 2000 [in the U.S.], approximately thirty percent of all non-institutionalized elders lived alone — forty percent of older women and seventeen percent of older men (Mann 2005). By the year 2030 one in four American women will be over the age of sixty-five (Yarnal 2006: 51). While women outnumber their male counterparts in late adulthood, they have higher rates of disability (Mann 2005; Quadagno 2011). In addition, the number of elderly persons is increasing globally. There is a worldwide opportunity for design innovation aimed at older people in ways not yet considered, based on the increasing life expectancy for the world population over the age of sixty (Coughlin 2007; Johnson 2005; Mueller 2003; Quadagno 2011; Rose and Vinay 2007). There is a need for a design strategy that spans the longer lifetime of older adults.

Frailty in older age is a concern. One out of three Americans over age sixty-five and one out of two Canadians over eighty fall each year, often leading to a loss of independence (McCredie 2007: 6; Scott, Pearce and Pengelly 2005). Designers have been developing physical mobility aids for walking stability for several decades (Clarkson, Langdon and Robinson 2006; Fisk and Rogers 1997; Katz 2001; Pirkl 1994). There is statistical evidence that "assistive technology (AT) has been shown to be effective in reducing functional decline and reducing health-related costs" for older adults (Mann 2003:185). Advances in wearable technologies could support older people's health-oriented activities, and possibly improve overall quality of life.

2.1.2 Quality of Life

The word 'life-course' is used to describe flexible biographically related stages of life (Featherstone and Hepworth 1989 and 1991). This term replaced the 'life-cycle' concept when experts agreed that stages in life were not fixed but varied according to the individual and his or her circumstances. Furthermore, chronological age is considered the least valuable indicator of biological old age (Biggs 2004; Bytheway 1990; Fairhurst 1998; Featherstone and Hepworth 1989; Quadagno 2011). Functional age is a better measure of age for this study, where an older person fits into one of the following categories: well elderly (healthy and active), somewhat impaired elderly (need some assistance due to transitional limitations), or frail elderly (highly dependent due to mental or cognitive deterioration) (Quadagno 2011: 7).

This "de-differentiation of the life-course," places less emphasis on "age-specific role transitions" and more value on optimal health contributing to a positive experience of old age (Featherstone and Hepworth 1991: 374). This approach is consistent with the concept of "successful ageing", a term used by Social Gerontologists. To them successful ageing "depends not just on the prevention of disease and disability, but also on the attainment of peak physical and psychological functioning and participation in rewarding social and productive activities" (Quadagno 2011: 4). This approach to one's state of health is contested by others who hold that "successful ageing" is more about "accepting the limitations and losses that accompany ageing without becoming grumpy and bitter" (von Faber and van der Geest 2010: 27). Regardless of the approach, bodily health is clearly a critical factor that contributes to ageing well (Bowling et al. 2007; Migliore and Dorazio-Migliore 2010). The popular literature is full of information about the importance of making healthy lifestyle choices, for example:

> *Some 70 percent of premature death and aging is lifestyle-related. Heart attacks, strokes, the common cancers, diabetes, brittle bones, most falls, fractures and serious injuries, and many more illnesses are primarily caused by the way we live. If we had the will to do it, we could eliminate more than half of all disease in women and men over fifty. Not delay it, eliminate it. That is a radically attainable goal, but we are not moving toward it. Instead we have made these problems invisible by making them part of the "normal" landscape of aging. As in "Oh, that's a normal part of growing older"(Crowley and Lodge 2007: 31).*

The argument that is widely accepted today is that doing aerobic exercise, weight training, and "avoiding the worst foods being thrust upon you in our national diet and eating less of everything" are the keys to ageing well (Crowley and Lodge 2007:244). Older people in all three functional age groups could benefit from this advice. Those who are beginning to experience some impairments may still be in a position to slow them down. Thus, there is a role for research that investigates a group of 'somewhat impaired' older people who are pursuing fitness goals to maintain their independence.

2.1.3 Independence

Independence is defined as "the ability to complete basic daily tasks without personal assistance" (Mann 2005; Stuart-Hamilton 1991). The degree of independence is a measure of a person's ability to do things and the extent of his or her disability. The lack of independence is the hallmark of the frail elderly. Marion Bieber, an eighty-one year old woman, and leader of a study group on "Design for all Ages' at the University of the Third Age in London, England says, "older people… want, above all, to maintain their independence." She goes on to assert,

> *They do not want to become a burden to their family and friends. They want to be physically and mentally active and appropriate design is one of the vital requirements for the satisfaction of their needs (Sherwood, Mintz and Vomela 2005).*

To this Keates and Clarkson, authors of *Countering Design Exclusion: An Introduction to Inclusive Design*, add, "Older adults today enjoy many years of comparatively healthy and active lifestyles and they would like products and services that help them to maximize those years before the inevitable terminal decline"(2003: 23). However, ageist attitudes may present an obstacle to designers, as explained in the following section.

2.1.4 Ageism

The dominant discourse on ageing, ageism, constructs the old as inferior to the young and attributes this inferiority to biological grounds (Wearing 1995:265). Losing control of one's bodily functions, with declining cognitive and emotional skills, leads to losing both social acceptability and a sense of personal power (Biggs 2004:55; Featherstone and Hepworth 1991:376). This separation between old and young has permeated the view of ageing, even in the gerontological professions, where ageing continues to be treated as a disease, as opposed to being part of the natural course of life (Nelson 2005:211; Quadagno 2011). This attitude influences even the people who are ageing (Biggs 2004: 46; Wearing 1995: 264). An indicator of this attitude is that "approximately 90 million Americans each year purchase products or undergo procedures that hide physical signs of ageing" (Nelson 2005: 208).

Design researcher Patricia Moore experienced ageism firsthand. As a young woman, she spent three years traveling throughout North America while disguised as an old woman to learn about ageing-related design issues (Clarkson et al. 2003; Featherstone and Hepworth 1991; Moore 1985; Worcester Consortium 1985). She confirmed sociologist Irving Goffman's observations, that the older person is seen as THE OTHER whom we do not want to become or be associated with (1963). This is a key issue for design researchers, who benefit from understanding the users' subjective attitudes as well as their physical and cognitive needs to establish design requirements. A frequent finding in the literature is the seemingly paradoxical information that many elders will not use assistive devices even if they need to. They do not want to rely on a device that "makes them feel embarrassed or incapable" and "they will do this even at the expense of independence or social interaction" (Hirsch et al. 2000).

Moreover, design researchers may also hold ageist stereotypes of older people. Social Gerontologist, Jill Quadagno lists several stereotypical views, such as, "most older people are disabled and most retirees are lonely and depressed", which she dispels as incorrect (2011). This study could be considered as a case of 'designing for our future selves', which was the title of an annual design competition for inclusive design at the Royal College of Art in London, sponsored by the Helen Hamlyn Centre for Design (Cassim and Dong 2007: 74). In North America, where there is an emphasis on youthfulness, activity, and independence, disruptions to everyday life from accident, chronic illness, and ageing present a profound challenge to the sense of self-identity (Turner 2001:261). A common refrain in disability studies is that disability is the one identity category that, if we live long enough, everyone will inhabit. White people will not become black, and men will not become women, but most people will become disabled (Davidson 2001:118). The nature of some of the disabilities associated with the changes of age is discussed next.

2.1.5 Physical and Sensory Changes

While wrinkles are an obvious sign of ageing, it is not just the exterior physical body that changes with the years (Quadagno 2011). Sensory organs also age, resulting in deficiencies in processing incoming sensory information (Glass 2007; Huppert 2003). For example, seventy-five per cent of older people need eyeglasses, which may provide limited improvements to vision (Stuart-Hamilton 1991). The ability to hear in noisy environments, to interpret what is being said, and to differentiate among complex auditory information also occurs (Pattison and Stedmon 2006). Every day the average person makes hundreds of judgments in which the sense of touch casts the deciding vote, whether or not the decision arises consciously (Sheldon and Arens 2005: 426). Sensory changes such as less tactile sensitivity to shapes, textures, temperatures, and high frequency vibrations impair these judgments (Huppert 2003).

Balance is a multi-modal sensory process that incorporates inputs from the visual, vestibular, and proprioceptive sensor systems, and can be affected by changes to any one of those systems. According to McCredie, the brain has an "extraordinary ability… to compensate for weakness or dysfunction in any one input by increasing its reliance on the other two" (2007: 91). An example of this occurs when an older person with vision impairment depends on his or her senses of hearing and touch to locate him-/herself to determine when and where to walk across a busy intersection. Furthermore, cognitive changes also come into play; they are discussed next.

2.1.6 Cognition and Memory

The elderly are traditionally seen as people who retain their wisdom (crystallized intelligence) while losing their wits (fluid intelligence) (Stuart-Hamilton 1991:58). Fluid intelligence refers to functions that require processing novel information and concurrently dealing with other complexities, which require the rapid assimilation of new information (Huppert 2003: 44-46). The decline in fluid intelligence can present problems with speed related or complex information processing, such as in computer games. On the other hand, crystallized intelligence remains relatively stable and data collected over a long time such as knowledge of facts and strategies remains easily accessible to the older person.

The literature confirms that the oft-used expression, "My memory is not what it used to be" is true (Huppert 2003: 44; Stuart-Hamilton 1991: 99). While it is easier to remember things that require less processing load, there are certain tasks "with which older individuals have particular difficulty — remembering context and remembering to carry out an intended action" (Huppert 2003: 45). In this research fluid intelligence and memory could come into play, as new technologies often demand speedy responses and routines or sequential behaviours. It is important to note that while this discussion refers to sensory and cognitive factors separately, people tend to experience them as interwoven or "multi-modal".

2.1.7 Multi-modality

From a biological perspective, the senses and cognitive functions do not operate solely and independently, as noted below:

> *Homo Sapiens does not experience the world through just seeing, hearing, or speaking. The body with its total sensing apparatus assesses the environmental conditions on a cathectic basis (that is, intuitive, emotional, uninformed judgment) feel good or feel bad, adumbration, making benefit or loss assessments, adjusting and readjusting… What is clear is that for the sake of survival what one sense cannot apprehend another must, even if the brain has to abstract the experience and translate it through another sense's memories (Winkler 2002).*

Quadagno explains that it is relatively easy for middle-aged adults to adjust to incremental sensory losses, through sensory rebalancing, but more pronounced losses may interfere with daily activities and communication (2011:131). Nonetheless, the concept of multi-modal experience, whether compensating for deficits or operating within the body, is also a consideration for sensory anthropologists, as noted later in this chapter. There is thus a need for design research to accommodate the complexity of multi-sensory functioning for older adults. It may lead to facilitating their ability to use the multi-modalities of interactive products, which leads to the following considerations about older adult and computer use.

2.1.8 Computing/Technology Competence and Old Age

Much of the available information about the elderly and technology is related to computer use, primarily web site use but secondarily to the use of technology-enabled products for medical and work applications (Huppert 2003). Studies indicate that older adults are using technology, however their adoption rates are far less than those of younger people (Czaja et al. 2006). There are a number of factors negatively affecting the adoption of technology. Frequent 'improvements' in technology (Bohn et al. 2004; Hirsch et al. 2000; Ostlund 2007), and the escalating technical complexities of everyday life (Dourish 2004; Hirsch et al. 2000; Tenner 1996; Varela, Thompson and Rosch 1993) are challenging for older people (Coleman 2003; Coughlin 2007). In the western world, research indicates that this may especially be the case for the very old, where sensory decline and increasing physical and cognitive limitations make it demanding to keep up with advances in technologies (Czaja et al. 2006; Forchhammer 2006).

Older users are, nonetheless, highly receptive to new technology if it fulfills a perceived need (Bauer, Streefkerk and Varick 2005). For example, the need to maintain contact with others to combat loneliness comes up in the geriatric psychology literature as a motivation for using technology (Caprani et al. 2005; Mann 2005; Sherwood, Mintz and Vomela 2005). In this case technology responds to "a need for products and services that provide comfort, communication, and companionship for seniors" (Bauer, Streefkerk and Varick 2005). While design specifications for older computer users traditionally focus on addressing human-factors considerations like enabling better visual acuity, longer cognitive processing times, efficient steps for sequencing tasks, and ergonomic design of devices, there is a need to gather requirements that address the variable bodily changes of older users. According to Hardy and Baird of the Florida

State University Institute on Aging and Public Policy, "Only when we stop assigning the root cause of performance failures to the user, and instead view them as challenges for better designs, will we be able to overcome the tendency of 'new' technology to exclude older people" (2003:39).

2.1.9 Design for the Older Person

The design literature that documents academic research related to making homes, computers, vehicles, and public spaces more accessible for the older and/or disabled user[1] is extensive and informative (Benktzon 1993; Coleman, Bendixen and Tahkokallio 2003; Connell et al. 1997; Keates and Clarkson 2003; Pirkl 1994; Vanderheiden 2007). In particular, most of the industrial design literature focuses on human factors requirements for physical mobility and computer use, and much less on "subjective" experience requirements (Bauer, Streefkerk and Varick 2005; Bennett 2007; Clarkson et al. 2003; Clarkson, Langdon and Robinson 2006; Coughlin 2007; Czaja et al. 2006; Dorsey 1997; Fisk and Rogers 1997; Forchhammer 2006; Forlizzi 2005; Hirsch et al. 2000; Mann 2005; McCarthy 2005; Norman 2002; Pirkl 1994; Wright 2004). Industrial design literature primarily concentrates on low technology aids for daily living rather than on high technology interactive systems such as wearable computing devices.

2.2 Describing Wearable Technology Issues

The literature claims that we are nearing the time when computers will be seamlessly integrated into our everyday lives, whether in intelligent coffee cups or "smart" assistive "wearware" (wearable computers) (Ashok and Agrawal 2003; Barfield

[1] Unfortunately the literature on disability often includes ageing, assuming that ageing is a disability!

and Caudell 2000; Baurley 2004: 275; Hallnas and Redström 2002: 106; Tenner 2003; Weiser 1991). According to Barfield and Caudell (2001: 24), in the future we will be wearing computers that look like clothing and contain all the computing capabilities of high-end workstations. McCann et al (2005) point to smart clothing for sport and fitness, health and wellness, and ageing currently on the market as evidence that this vision is a possibility. Many of the wearable technology examples discussed in the literature, however, fall short of being capable of seamlessly integrating into people's daily activities. According to Dunne et al, "the challenge of monitoring the human user of technology unobtrusively in an everyday setting is one of the most significant remaining obstacles to realizing the vast potential of ubiquitous computing and pervasive healthcare " (2011: 11).

Currently there is a wide range of interdisciplinary activity involved in wearable computing investigations. Researchers, designers, scientists, engineers, and artists are exploring a diversity of ways to augment natural human capabilities (Berzowska 2005; Berzowska and Coelho 2005; Clark 2013; Doppler et al. 2009; Hodson 2012; International 2013; O'Mahoney 2005).

> *Specialists of different fields may envision smart clothes [and other wearables] with divergent focuses and priorities, for example, everyday comfort and functionality in clothing, personal and social image in fashion, dignity and efficacy in medicine, growth and dependence in psychology, reliability and security in electronics, or awareness and empowerment in wearable computing (Duval, Horeau and Hashizume 2010).*

Extensive experimentation is propelling the design of wearable and other ubiquitous technology solutions to augment or improve health and well-being (Consolvo et al. 2008; Doppler et al. 2009; Forlizzi, DiSalvo and Gemperle 2004; Kim et al. 2007; McCann 2009; Park and Jayaraman 2007; Yeh et al. 2007). Though much of the work is exploratory, the range of applications demonstrate the potential for enhancing older people's sensory experiences in ways that could provide emotional, cognitive, and physical support, as well as providing more health-oriented information for medical providers, care givers and family. The following discussion introduces the background and context of wearable technologies for this investigation.

Background and Context

Due to the requirement of technological components, computer scientists and electrical engineers are driving the advances in the area of wearable computing (Barfield and Caudell 2001; Knight et al. 2007; Ross and Blasch 2002; Zhai and Bellotti 2005). Early applications of wearable technologies arose in academia. In the early 1960s the first wearable computer shoe system, devised at M.I.T. by Claude Shannon and Edward Thorpe, was used to predict the outcomes of roulette (Thorp 1998). Decades later M.I.T. graduate and University of Toronto Electrical and Computer Engineering Professor, Steve Mann (2002) continues to make advances in the field with his evolving Wearcomp system that includes a head-mounted display (see Figure 2.1: Wearcomp).

FIGURE 2.1: EVOLUTION OF STEVE MANN'S 'WEARABLE COMPUTER' INVENTION (MANN, S. 2014)

The Wearcam enables him to augment his vision with replays, freeze frames, and other better-than-human features, now commonly associated with security cameras. Georgia Institute of Technology Professor, Thad Starner, who has been wearing a computer continuously since 1993, is also currently the technical lead on the Google project "Glass", a fashionable head-mounted data-capture display that takes pictures, communicates, and delivers data (Hodson 2012) (see Figure 2.2: Google Glass).

FIGURE 2.2: GOOGLE GLASS (WILSON, T. 2013)

Initially these M.I.T. researchers were their own and only test subjects, but as evidenced by the Google project (Google 2013), the interest in wearable devices is rapidly spreading beyond the academy.

On another front, the U.S. Army wearable computing research programs, initiated in 1994, are now amalgamated under the "Future Force Warrior" initiative. For example,

> *… the Warfighter Physiological Status Monitor Subsystem (a subsystem that consists of an on-board physiological and medical sensor suit was designed in*

> *order to monitor and collate the detailed information regarding all vital signs of the soldier such as his body temperature, his heart rate, his blood pressure, his accurate hydration and stress levels, his sleep status, his body positioning and even his workload capacity as a warrior (Ashok and Agrawal 2003; International 2013; Media 2013).*

Many of these features have been integrated into the field of wearable devices for healthcare monitoring.

By 2007 the largest growth sectors for biophysical monitoring wearable systems were the military, medical, and health/fitness (Berzowska 2005: 3; Hurford 2009:39; McCann 2009: 357). According to Duval et al, smart wearables in the health care sector, "monitoring wearers' cardiac and bodily activities are probably the most publicized, and may save the lives of patients suffering from physical conditions by advising them about impending problems, alerting emergency crews after dramatic events, and informing doctors or families about long-term trends" (2010: 162). Wearable monitors are readily accepted in the medical and general health sector, even when they are uncomfortable to wear due to health needs (Bryson 2009: 341; Duval, Horeau and Hashizume 2010: 163; Park and Jayaraman 2007: 140). Wearables are also currently integrated into popular sporting equipment and clothing markets as seen in product offerings from Garmin, Fitbit, Nike, and Polar, (see Figure 2.3) to name a few (Consolvo et al. 2008: 1798; Hurford 2009; Malmivaara 2009: 10-11; Papadopoulos 2007). According to a wearable technology survey of four thousand people, seventy-one per cent of Americans and sixty-three per cent of British respondents said that wearable tech has "improved their health and fitness" (Nusca, 2013).

Figure 2.3: Clockwise from top left: Nike+ Fuelband, Jawbone, Fitbit, Garmin Vivofit, Olar Electric Loop, Withings Pulse (Shop Your World.com 2014)

In addition, in recent decades, artists, designers, companies, and research institutes, such as Apple, Joanna Berzowska's XSLabs, Hussein Chalayan, CuteCircuit, Kate Hartman, International Fashion Machines, Microsoft, Joo Youn Paek, and Philips Research have been exploring the fashionable and conceptual side of wearable computing (Consolvo et al. 2008; Popadopoulos 2007). Even the local news believes that wearable computers are "set to take off" and CTV reports that the "wearable computing device market will grow to 485 million annual device shipments by 2018" (LaSalle 2013). Wearable computing research about exercise monitoring for older people fits into this expanding field.

2.2.1 Advances in Technologies

Wearable technologies can be divided into three categories: wearable computer systems, wearable electronics, and intelligent clothing (Knight et al. 2006: 1; Malmivaara 2009: 5).

The first category is *wearable computer systems* that incorporate CPUs (central processing units), power supplies, input, and output devices that can perform a variety of complex tasks (Barfield and Caudell 2001: 6, 13-14). They provide hands-free access to and interaction with information anywhere and at anytime. The system should be situated in such a manner that the wearer considers it a part of him or herself (Knight et al. 2006:1). An example of this is the sign language translator (see Figure 2.4: Sign Language Translator) developed at Georgia Institute of Technology that translates gestures into English phrases for face-to-face communications between deaf and hearing individuals (McGuire et al. 2004).

FIGURE 2.4: SIGN LANGUGE TRANSLATION SYSTEM FOR DEAF PEOPLE, SHOWN WITH PROFESSOR THAD STARNER AND PHD STUDENT HELENE BRASHEAR (GEROGIA TECH RESEARCH NEWS 2003)

The second category, *wearable electronics* only work when worn on the body. They are far less complex than wearable systems and are usually function specific, incorporating electronics and possibly a power supply (Malmivaara 2009: 5; O'Mahoney 2005). In the literature, several researchers reported on short-term experiments with wearable electronics incorporating sensors, such as accelerometers, which are useful for measuring posture, gait, and movement and provide feedback to the wearers (Consolvo et al. 2008; Iso-Ketola 2009; Knight et al. 2007; Yeh et al. 2007). An example of this is Bodymedia's Sensewear (see Figure 2.5) weight management solution with an armband monitor and a wrist-mounted display that networks to a website to calculate intensity of exercise and calories burned (Bodymedia).

Figure 2 The SenseWear® Pro$_2$ armband (2003 – current).

FIGURE 2.5: BODYMEDIA SENSEWEAR PRO2 ARMBAND (ANDRE, PELLETIER ET AL, 2006)

The third category is *intelligent clothing*. Here technology-enabled enhancements are integrated into washable garments and have all the features of ordinary clothing, according to Malmivaara (2009: 5). Electronic textiles belong in this category. Joanna Berzowska, Professor and Director of XS Labs, explains that, "an electronic textile refers to a textile substrate that incorporates capabilities for sensing (biometric or external), communication (usually wireless), power transmission, and interconnection technology to allow sensors or things such as information processing devices to be networked together within a fabric (Berzowska 2005: 4)". For example they may include emotive interfaces that "react to the wearer's visceral experiences" by changing colour or shape, glowing, or opening like a flower (Berzowska and Coelho 2005; Quinn 2010:22-28;

Randell and Muller 2002). Most importantly, they can include diagnostic textiles that can capture and transmit a wearer's vital signs (Hurford 2009:337; Hurford 2009b: 39; Quinn 2010: 97). The Vivometrics Lifeshirt (see Figure 2.6) is an example of intelligent clothing that, in this case, provides remote wearer monitoring (Duval, Horeau and Hashizume 2010: 163; Mattila, Korhonen and Saranummi 2007: 122).

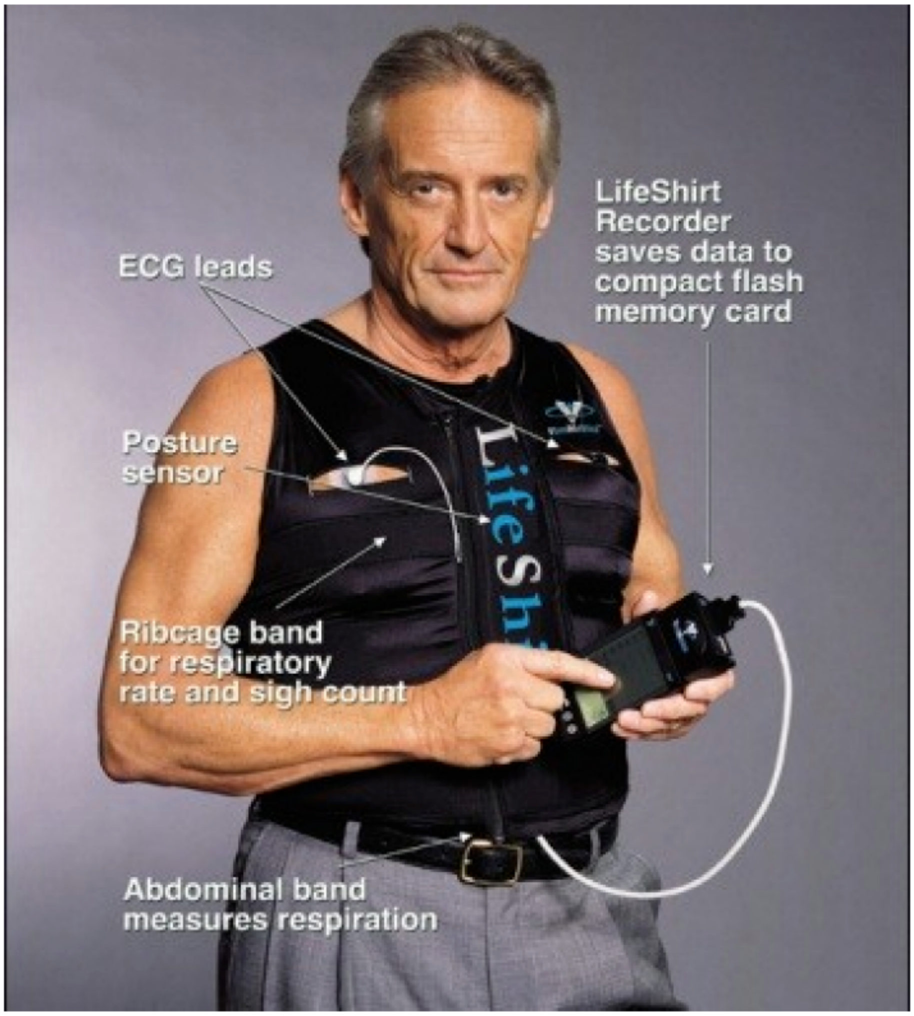


FIGURE 2.6:VIVOMETRICS LIFESHIRT (MANDEL, R. 2014)

This thesis investigation of wearable electronics and intelligent clothing uses sensor technologies for input and output. Given the possibility of increased sense impairment with age, sensors can provide opportunities for a wide range of sensory responses in many wearable technologies (Barfield and Caudell 2001: 15) as follows:

- *Mechanical sensors respond to stimuli of position, acceleration, force, and displacement to detect people's/object's position, weight, and movements.*

- *Biological sensors respond to stimuli of heart rate, body temperature, neural activity, and respiration rate to measure people's moods, mental and physical states.*

- *Acoustic sensors respond to stimuli of volume, pitch, frequency, and phase changes to detect sounds and interpret speech.*

- *Optical sensors respond to stimuli of emissivity, refraction, brightness, luminance, light wave frequency to provide computer vision detection, infra red motion, and presence detection.*

- *Environmental sensors respond to stimuli of temperature and humidity to monitor the conditions of the environment people are in.*

While this list of sensors is not complete, it provides an idea of the range of opportunities. However, there are still some challenges in this emerging field, which are addressed in the next section.

2.2.2 Challenges

According to Hurford (2009:26), earlier technologies for smart clothes and wearable electronics were not fully functional. The biggest hurdles have been bulkiness, rigidity, and the weight of the power supply necessary to allow the device to operate an acceptable length of time (Min 2009: 217-218). However, technology is maturing and the products that are being introduced are beginning to live up to consumer expectations (Hurford 2009).

Driving much of the wearable technology research has been a "we can make it work" philosophy that fuels the function-oriented technical fields, as noted in the introduction (section 1.3). Berzowska (2005:3) attributes this orientation to the influence of policy makers who fund electronic textile research in the fields of consumer electronics, military, and health. Cooper attributes it to the professional skill set that follows "rigorous engineering methods that ensure the feasibility and quality of the technology" and leaves out "a repeatable and analytical process for transforming an understanding of users into products that both meet their needs and excite their imaginations"(Cooper 2003: 8). Jane McCann, Director, Smart Clothes and Wearable Technology, at the Newport School of Art, Media & Design, (2009: 46) notes that such a technology-driven approach can result in poorly designed and unattractive user interfaces that are hard to interact with or understand. For example, a person may find it difficult to remember how to switch her polar heart rate monitor from showing time of day to showing heart rate if she has not worn it for a few weeks.

McCann explains that the emerging technologies are confusing to clothing design teams since they have little technology knowledge, while the design aspect is equally confusing to electronics and medical experts since they have little understanding of aesthetics and criteria for user adoption. As a result she calls for a design tool that identifies the key considerations that could guide the designer or product development team, new to this hybrid area of design (2009: 46).

Thus on one hand the challenges are related to smaller, faster, more flexible, and more powerful electronics, while on the other hand a guiding tool like a set of guidelines is needed for cross-disciplinary design teams. This research study focuses on gathering sensory information to contribute to design research guidelines, which will help build bridges of understanding that connect people's sensory needs and practices with technological possibilities for wearable computing. The next section addresses the issues that are important in designing technologies with users in mind from a Human Computer Interaction perspective.

2.2.3 Interaction Design

The field of Interaction Design emerged from the field of Human Computer Interaction (HCI) design, also referred to as Computer Human Interaction (CHI) (Dourish 2004 and 2006). The main objective of HCI is to design useful and usable computer systems to "enable humans to effectively interact with devices to perform tasks and to support activities (Hewett et al. updated 1996; Poslad 2009:135)". Researchers test the usability of design concepts at stages in the development process. Swedish Interaction Design Professors, Lars Hallnäs and Johan Redström (2006: 53) describe a human factors approach to human-computer interaction, that allows for measurement:

> *Usability refers to properties of a design that characterize the ways in which we do something specific with a given thing, system, tool, etc. – those properties that characterize use for something. It usually refers to qualities of use such as easy to learn, efficient in use, robust in use, different sorts of use experience, etc.*

In her Masters and PhD research, University of Minnesota Professor and Director of the Wearable Technology Lab, Lucy Dunne describes additional "soft" or human-centered considerations for designing wearable technologies, "such as social acceptability, physical comfort, ease of interaction" (Dunne 2004: 2). From her perspective wearability depends on comfort, which, in turn depends on the degree to which sensory stimuli do not "intrude into the wearer's conscious attention" (Dunne and Smyth 2007: 302). Some of her research builds on the work of Francine Gemperle and others at Carnegie Mellon University (1998) who studied suitable positions for wearable computing devices on the body. Berzowksa also adds personal considerations about the user experience, including "the intimacy of textiles, their close proximity to the body, and their potential for personal expression and playful experimentation" (Berzowska 2005: 3).

Other interaction researchers and social scientists have extended a human-centered approach to technologies that includes meaningful integration of technology into people's lives (Hallnas and Redström 2002; Larssen, T. and J. 2007). They note that people's subjective interpretations give meaning to the things in their lives. They call this the value of expressiveness. Using a mobile phone as an example, it may serve as a "talking-loudly-to-yourself"-device for one person; a "flirting"-device for another; and a "check-that-nothing-has-happened"-device for someone else (Hallnas and Redström 2002: 119). This fine line between usability and expressiveness is important when designing for older people, who, according to Heidrun Mollenkopf (2003: 211), sometimes reject useful assistive devices because they attach a negative meaning to them.

2.2.4 Older People and Wearable Technologies

The dilemma this research addresses arises from the following issues: the stigma associated with assistive technologies, the inability of a single solution to meet the wide variety of older people's physical and cognitive needs, the necessity for staged technology assistance, and the need for user involvement.

Some older people reject technical aids since "they are an unmistakable reference to increasing weakness and failing strength" (Mollenkopf 2003: 211; Pullin 2011). Becoming older is not the same as having had a lifetime to adjust to a disability; it is a gradual and frustrating process that might best be addressed through the design of multiple interim solutions for the different stages of severity of impairments

(Mollenkopf 2003:211). McCann also suggests that there is less market demand for smart clothing for older people since they do not want more stuff, especially stuff that has not been tried and proven its worth (2009: 366).

Still there are others who recognize the usefulness of technical assistance. McCann predicts that the baby boomers will demand active-living "clothing that is enhanced with unobtrusive assistive technology and appropriately designed for older users" (McCann 2009: 347). She highlights the areas of sports and daily activities such as walking and gardening as trends in the older population for which clothing that can be enhanced through "smart wearable textile products to help make self-monitoring more accessible and positive for those who wish to keep fit" (2009: 357).

McCann and Dunne caution, however, that a one-size-fits-all approach to wearable computing does not take the physical or cognitive limitations of older people into consideration (Dunne 2004:42; McCann 2009:347). Staged assistance could allow people of all ages to resort to technical aids at the proper time and without fear of discrimination, as has long been the case for visual aids (Mollenkopf 2003: 212).

McCann (2009:366) also believes that collaborative engagement with older users will enable design researchers to match "individual needs, desires, and expectations with a set of non-restrictive, supportive, and wearable lifestyle-enhancing and monitoring devices and associated services". She argues for sensitivity to the "aspirations, desires, and everyday needs of the end user" when developing innovations in smart wearables for older users. She (2009:348) draws on her personal communications with Gerontology Nursing Professor Dr. Julia Ryan of Salford University and Biomedical Engineering Professor Christopher Nugent of the University of Ulster to support her ideas about understanding older users' needs in this field of design:

> *A* ***collaborative design approach*** *involves users in requirements capture, understanding and specifying the context of use, design specification, and design and prototype development and evaluation. The* ***psycho-social, lifestyle, health criteria and motivational issues*** *that influence personal choice in clothing, connectivity and daily life* ***must be established in consultation with an identified individual or target group****.*

This advice is highly relevant to the research path taken in this investigation. In this study older people are involved in different design research stages throughout the technical design process to create and assess the prototypes being developed.

2.3 Situating Design Research

The nature of research in the field of product design is a matter of considerable debate (Buchanan 2007:15; Frankel and Racine 2010; Roth 1999; Sanders 2008). Some participants believe that the main purpose of design research is to gather information for a prescriptive solution to specific design problems. At the other extreme, participants believe the main purpose of design research is to inquire into the nature of design activity (Buchanan 2007; Dorst 2008; Findeli 1995: 2; Friedman 2000). Sir Christopher Frayling, Rector of the Royal College of Art identified three distinct categories of design research, apparently derived from deceased Art Professor Herbert Read. They are Research for Design; Research through Design; and Research about Design (Archer 1995; Cross 2007; Downton 2003; Findeli 1995; Frayling 1993; Friedman 2003; Jonas 2007).

The three categories of design research are briefly discussed in this section. They can be mapped onto the three categories of clinical, applied, and basic research that align with university and funding agency guidelines for research (see Figure 2.8) (Buchanan 2001: 17; Friedman 2000:18).

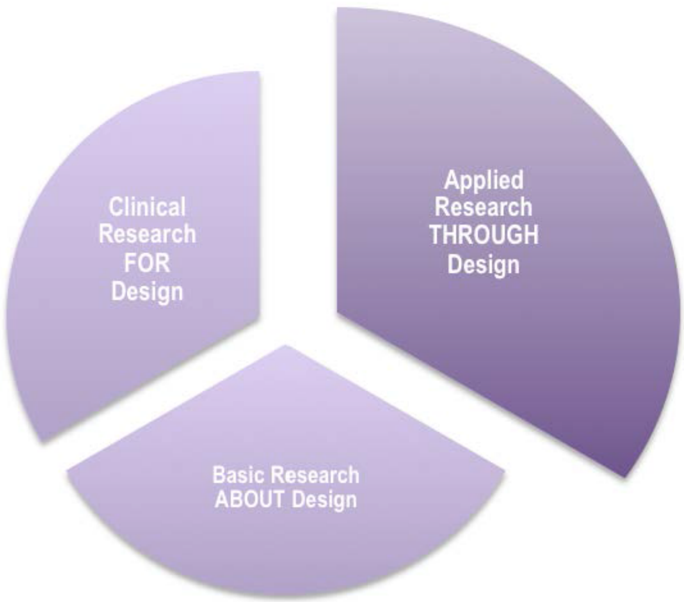


FIGURE 2.7: THREE TYPES OF DESIGN RESEARCH WITH AN EMPHASIS ON THE CATEGORY FOR THIS INVESTIGATION

2.3.1 Clinical (Research for Design)

Research for Design focuses on design problems that are specific to individual cases; in other words, Research for Design requires information for one unique or "clinical" situation. For example, the design of a particular walking aid would require project-specific research that involves gathering wide-ranging information about users, environments, materials, and competitive products. This is data that designers can apply to achieve an end result in their design projects (Downton 2003; Forlizzi, Stolterman and Zimmerman 2009).

According to Design Research Professor, Peter Downton, at RMIT University in Australia, Research for Design is mostly prescriptive research for specific and feasible design solutions (2003: 20). The kind of data that could apply to clinical design research includes, "establishing pertinent regulations & standards, finding the appropriate formulae, finding meterological data, finding performance specs of materials or equipment, obtaining data on human physical characteristics & understanding human behaviour" (2003: 22-28). Notably, Research for Design is the category of research that most practitioners and many academics associate with the term "Design Research". There are two reasons for this interpretation: it has the most potential to contribute to successful design outcomes and it is the most relevant data for design practice (Dorst 2008; Friedman 2003; Roth 1999).

In undertaking Research for Design one might ask, "What do I need to know to solve this problem?" or "What is this problem that needs to be solved?" or "How can I apply my skills to solve this problem?" These kinds of questions would be too specific for a broad inquiry dealing with the sensory changes of an older population and sensory technologies to address. They are focused on finding research outcomes applicable to only one viable solution. This category is only relevant to position this study in the continuum of design research categories. Research for Design is outside the scope of this investigation.

2.3.2 Basic (Research about Design)

Basic Research about Design focuses on empirical examination of fundamental principles leading to developing theories about design with far-reaching implications for the design discipline (Downton 2003; Lawson 2003; Stappers 2007). Bruce Archer, past Professor and Director of the Department of Design Research at the Royal College of Art in London, developed a series of design topics that fit primarily into the category of basic research investigations:

> *Design taxonomy, for example, was to focus on the classification of phenomena (observable activities) in the design area; design praxiology referred to the nature of design activity, its organization and its apparatus; while design epistemology was to be concerned with identifying special designerly ways of knowing, believing, and feeling (Buchanan 2001).*

Archer's student, Nigel Cross, Emeritus Professor of Design Studies at the Open University in the United Kingdom, added another category to Archer's list: design phenomenology which is "the study of the form and configuration of artifacts" (in Margolin 2002: 247).

In undertaking Research about Design, one might ask, " What is the nature of design activity?" or "How are design activities organized?" or "How can we identify an epistemology for design?" These questions, which illustrate the nature of Basic Research for Design, are too theoretical for the purpose of this study. Since this study is not focused on understanding theoretical design knowledge, this category of research is also outside the scope of this dissertation.

2.3.3 Applied (or Research Through Design)

Applied Research through Design focuses on investigating general categories of design problems or products to create new knowledge in an area. In the literature, this category is considered by some to be the only genuine design research approach because it includes "reflection and inquiry" not just knowledge for practical application (Friedman 2000: 18- 20; Jonas 2007: 189- 192; Schneider 2007). The common trait of applied research is the [systematic] attempt to gather from many individual cases a hypothesis or several hypotheses that may explain how a class of products takes place, and the kind of reasoning that is effective in design for that class (Buchanan 2001: 18). Research through Design seeks to contribute new knowledge that explains or contributes to design knowledge generally, rather than to a specific project solution (Buchanan 2007: 57; Downton 2003: 77; Findeli 1995: 2; Jonas 2007: 192).

Research through Design, in the area of inclusive design, focuses on classes of design problems that may exclude users of different abilities (Keates and Clarkson 2003). For example, researchers may investigate whether there is an opportunity to address how people with dexterity problems prepare their meals (Benktzon 1993). They may discover aspects of the ritual around food preparation that can become important criteria for designing for disability and not just for designing a better kitchen knife. This sort of research, developed through long-term academic investigation, often generates the kind of knowledge that designers can apply later in their clinical Research for Design (Keates and Clarkson 2003).

In undertaking Applied Research through Design, one might ask, "How can we learn about design problems through constructive activities and embodiments?" or "How can we develop principles to specify design problems efficiently?" or "Is there an effective approach to designing in this class of design problems/products? (Buchanan 2007; Cross 2007; Dubberly 2005) " These kinds of questions are most relevant to this investigation, which is primarily situated in Applied Research through Design.

The category is important for several reasons: it is derived from and valuable for practice; it is growing rapidly; both practitioners and researchers are contributing significantly to the literature and online discussions; the discussion is extensive, addressing hundreds of research methods; and it incorporates insights derived from the social sciences, business, and marketing. Systematic design methodologies form much of the literature in the Research through Design category (Buchanan 2007; Cross 2007; Laurel 2003).

This category of research is most relevant to the main subject area of this study, an exploration about older adults' sensory changes in relation to the design of sensory-augmented wearable technologies. It promises new knowledge: for designing a class of products, for gaining insight about sensory changes in ageing, and for understanding how sensory anthropology can inform industrial design research.

2.3.3.1 Technology-Driven versus User-Centred Design Research

In the areas of clinical Research for Design and applied Research through Design, there are two approaches that guide product design research. The first can be termed technology driven, which was previously addressed in sections 2.2.1 and 2.2.3. It is practiced in technical professions such as engineering and computer science. In this approach it is most important to make the technology work correctly, and less important to make the technology fit with the user's needs, experiences, or aspirations. Nevertheless, according to Interaction designer Alan Cooper,

> *The high-tech industry has inadvertently put programmers and engineers in charge, so their hard-to-use engineering culture dominates… In our rush to accept the many benefits of the silicon chip, we have abdicated our responsibilities. We have let the inmates run the asylum… They see how rich the product is in features and functions. They ignore how excruciatingly difficult it is to use, how many mind-numbing hours it takes to learn, or how it diminishes and degrades the people who must use it in their everyday lives (1999).*

Even though this approach leads to a rapid development of technology, it generates products that alienate many users. That is why there are only a few senior-friendly cell phones on the market; most have too many features (Cummings, 2014).

The second approach addresses this shortcoming to some degree. It is the User-Centred Design (UCD) or Human-Centred Design (HCD) paradigm, in which researchers study the user to acquire design research insights, as previously noted in section 2.2.4 (Courage and Baxter 2005; Vredenburg, Isensee and Rughi 2002). Human factors studies emerged in the 1940s when the design of airplane cockpits was improved. By the 1970s human-factors research began to be implemented into clinical Research for Design, and by the 1990s it was a widespread part of product design development (Sanders and Stappers 2008: 10; Sleeswijk Visser 2009: 12).

Within a clinical Research for Design approach human-oriented research methods are applied at different points in iterative phases of design development, from initial user-needs analysis to prototype usability testing (Hanington 2003; Roth 1999; Rothstein 2000; Sanders 2008; Squires and Byrne 2002). Human Factors/Ergonomics design research experts use a range of methods to gather anthropometric and cognitive data for designing within known human capabilities (Loewy 2007 (1951); Petroski 1994; Pheasant and Haselgrave 2005; Sanders and McCormack 1993; Tilley 2001).

Recently, human-factors specialists have begun to study more elusive factors such as people's emotional responses and their desire for pleasure and delight in products (Jordan 2000; Jordan and Green 2002; Norman 2004). This area of investigation has migrated into a domain called User Experience, originally coined by Don Norman, when he was Vice President of Research and Head of the Advanced Technology Group at Apple in 1993 (Gabriel-Petit 2005). The importance of this approach is that it focuses on the interactions a user has with a product:

> *…the way in which people interact with a product is clearly product-dependent, they always use their senses to perceive it, they use their motor system and their knowledge to operate or communicate with it, and during the interaction they process the information they perceive, they may experience one or more emotions, and they are likely to form an affective evaluation of the product. Thus, although the interaction may be product-specific, the processes that are activated during the interaction are similar over products (Hekkert and Schifferstein 2009: 1).*

Traditional User-Centred Design approaches involve research activities in which professional experts "observe and/or interview largely passive users, whose contribution is to perform instructed tasks and/or to give their opinions about product concepts that were generated by others"(Sanders and Stappers 2008: 5). Sanders and Stappers call this an 'expert-led' approach, in which design researchers see themselves as experts and the people they are researching (and designing for) as "subjects," "users," "consumers," etc. for whom they make decisions (Sanders and Stappers 2008; Sanders and Stappers 2012; Sleeswijk Visser 2009). They see (2012: 23) the researcher as the translator between the users and designer: "The designer then passively receives this knowledge in the form of a report and adds an understanding of technology and the creative thinking needed to generate ideas, concepts, etc.". To some, such objectification of the user falls short of actively involving him or her in the design process since the user is ultimately the expert with the deepest knowledge of his or her experiences and requirements. This calls for more active involvement on the part of the user, the design researcher, and the designer, such as a participatory design approach, which is discussed in the next section.

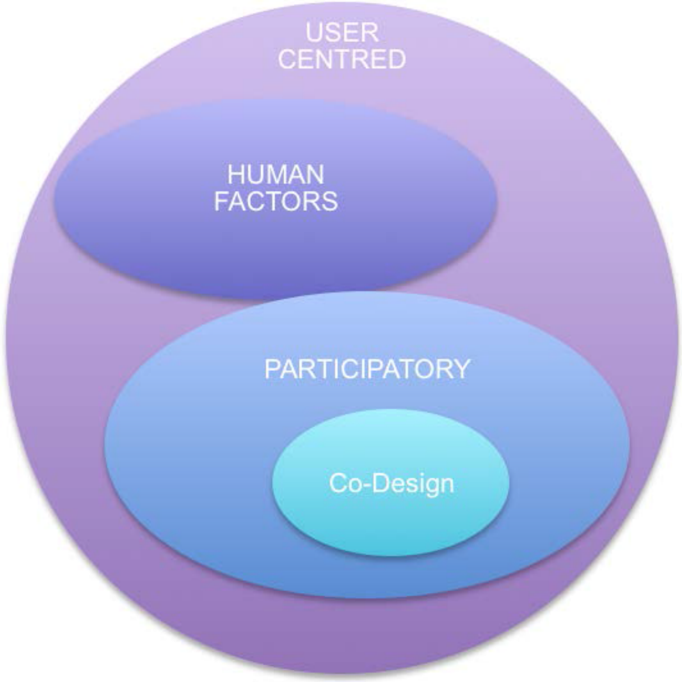


FIGURE 2.8: USER-CENTRED DESIGN MAP

2.3.3.2 Participatory & Co-Design Research

As early as 1940, participatory design had its roots in social action research in which groups of people in communities collaborated with researchers to effect social transformation (Kemmis and McTaggart 2005). By the 1970s the idea that researching *with* people — who know their own experiences — rather than *on* people — as an outsider — made its way into the field of design, through the fields of architecture, planning, and human computer interaction (Lee 2008; Luck 2007; Sanoff 2007). An early example of participatory engagement in design was the early 1980s Swedish UTOPIA project. It brought researchers and graphic workers in a trade union together to develop computer supported work practices. It was widely believed that people experiencing the challenges and benefits of working with computers would be reliable, current, and engaged enough to provide designers with the information necessary to improving the design of the computer human interface (Westerlund: 38). These users were, in fact, experts in working with computers and their knowledge exceeded and informed that of the designers.

Co-design is a participatory approach, inspired by similar Scandinavian participatory research practices. In the Co-design or Co-creation model, design researchers collaborate with the people who are being served by design as co-creators or co-participants in the design process (Sanders and Stappers 2008). In this approach the people who would be affected by the designed solutions are considered to be the experts whose experiential knowledge provides information for design. Collaborative activities take place primarily during the early stages of the design process where the nature of the product(s) is not very well defined (also referred to as the fuzzy front end). The practical significance of this approach is that everyday (non-design trained) people, according to Sanders and Stappers (2012: 25), make, generate, or create artifacts together with the design researchers or facilitators, to shed light on the design issues. This radically different role for design researchers promises to deliver User-Centred benefits:

> *There is a compelling reason for involving designers in the research process. One of the most powerful tools designers bring to the table is empathy: the ability to feel what others are feeling. The direct and extensive exposure to users that proper user research entails immerses designers in the users' world, and gets them thinking about users long before they propose solutions. One of the most dangerous practices in product development is isolating designers from the users because doing so eliminates empathic knowledge (Cooper 2003: 14).*

It is important to note that Co-creation moves beyond traditional participatory approaches of looking at what people do and use, and even beyond approaches of listening to what people say and think, and focuses on what people make or create using generative design toolkits (Sanders 1999: 4). It provides additional insights into people's experiences, "one can look at what people do, what they say, and what they make", and the data gathered from these techniques "complement and reinforce each other" (Sanders and Stappers 2012: 66). Sanders and Stappers describe how this approach aligns with the traditional techniques of observing what people do and listening to what people say (2012: 66):

> *For example, if you're conducting a generative study on future kitchen experiences of people, you can visit their homes and observe what they do: how do they use the kitchen? You can ask them questions and listen to what they say: interview them about what they do in the kitchen, with how many people, for how long, and when. You can get them to recall earlier kitchen experiences and reflect on those. And you can study what they make when given an 'ideal kitchen experience construction kit'; what ideas do they have, and what reasons do they give for these.*

The implicit assumption is that knowledge revealed during hands-on 'making' or 'doing' activities is deeper or more reliable than that revealed through talking.

This study engages participants in making, exploring, and discussing artifacts that address their fitness concerns primarily from a sensory perspective. It incorporates the Co-design approach in which the designer researchers, at the table with the participants, act as facilitators in probing activities that engage people when talking about or making artifacts that illuminate their unique stories (Sanders 2002; Sanders and William 2003; Sanders 2008; Sleeswijk Visser 2009). In this 'generative design research' the facilitators prepare and provide the tools for making or generating ideas, as in the previous 'ideal kitchen experience construction kit' example. Together with the participants they produce tangible concepts that represent the participants' personal insights about the design issue (Sanders and Stappers 2008: 13-15).

While being made or afterwards, the artifacts become props or stimuli for narratives about the design-related issues. The narratives often illustrate the multi-layered, sometimes fragmented, individual and even ephemeral aspects of people's experiences (context of use and state of mind) that can contribute to design innovation (Sleeswijk Visser: 21). Nonetheless, the stories of people's experiences can inspire new design thinking because they are, ideally, developed with design researchers and/or designers present and bring up deep and rich understandings of the needs, emotions, and possible future opportunities (Sanders and Stappers 2008).

Since Co-design or Co-creation is a newly evolving approach it crosses the boundaries of mindsets, methods, and tools. Sanders and Stappers (2012: 30) explain that as a mindset, co-creation can refer to a set of attitudes or a worldview "that changes how the entire design development process is seen and takes place". It is presented in this section as a mindset. However, as a method, it employs a collection of tools and techniques that are still emerging. This investigation incorporates some of the existing methods used for co-design, which are discussed in the Methods Chapter following this one. This study builds on current co-design methods, while exploring the engagement of older users in a generative design research process. It could address a gap in the field of designing technologies for ageing, as discussed in the following section.

2.3.4 Design Research Opportunity

The literature indicates that expert-led approaches to design research are considerably more prevalent than co-design approaches, especially concerning older people (Sanders 2008: 13-15). It shows that generally there is minimal consulting to gather older adults' opinions on consumer products, although sometimes older adults are interested and participate actively in research (Stephens 2001; Walker 2007). It seems obvious that increased involvement by older people in the design research process would result in products that fit their needs, capabilities, and desires more closely. The experts often overlook older people's subjective interpretations of their experiences, implying that there is a need for more intimate design research into ageing and design development (Walker 2007: 482). In his article *Why involve Older People in Research,* Alan Walker (2007: 482) makes a case for the latter:

> *If researchers want to produce findings that might contribute to the quality of life of older people or the quality of the services or products they use, then it is essential to involve them so that they can contribute their own understandings about ageing and service use which can often be far removed from those of scientists and service professionals. The well-documented partial and precarious take-up of assistive technologies is just one example of the inadequacy of attempts to involve older people in identifying needs and appropriate solutions.*

This can be taken as a call for engaging older people in a co-design exploration that may provide insights into sensory changes in ageing when designing appropriate sensory-augmented technologies for an older population.

2.4 Sensory Anthropology

Sensory anthropologists hold the premise that, in addition to mediating with the physical world, the senses reveal information about a culture through the values placed upon sensory perception and practices, the ordering of the senses, and the nature of relationships between the senses (Classen 1997: 402; Howes 2003:xi; Howes 1991: 3; Howes and Classen 2014; Paterson 2007: 156). They examine patterns of sense experiences within and across different cultures to learn more about socio-cultural meanings and values (1997: 401; Howes 1991: 3). As Classen (1997: 402) notes:

> *The senses, in fact, are as regulated by society as most other aspects of bodily existence, from eating to aging. Social codes determine what constitutes acceptable sensory behaviour at any time for anyone, and indicate what different sensory experiences mean. To stare at someone may signify rudeness, flattery or domination depending on the circumstances and the culture.*

She explains that an anthropologist comes to understand the meanings and values that contribute to a society's sensory model, "according to which members of that society 'make sense' of the world, or translate sensory perceptions and concepts into a particular 'worldview' (Ibid)." Since sensory anthropology applies to studying sensory patterns in sub-cultures within the researcher's society, it could provide a meaningful framework for empathic learning about older people whose shifting sensory behaviours may be changing their 'worldview'.

Sensory patterns involve a range of sensory experiences and their inter-relationships, especially, but not limited to, those involving the commonly acknowledged senses of sight, sound, touch, smell, and taste. While the senses are addressed in more detail in Section 2.4.1, it is important to note here that the study of sensory anthropology goes beyond the dominant audio-visual orientation of the west (Classen 1997: 405).

According to Howes, this field of study arose partially in reaction to the hierarchical approach of western anthropologists whose prevailing visual cultural bias limited their interpretations of sensory interactions within other cultures (2003: 5). For example, as early as Aristotle, men were associated with the superior senses of vision and hearing, thought to be connected to intellect and analysis (Classen 1997:404; Howes 2013; Paterson 2007: 1). Women were associated with the senses of taste, touch, and smell, which were considered to be lesser senses. In contrast, some societies may privilege smell over sight, taste over hearing, or combinations of touch and sight, depending on their cultural, environmental, and spiritual influences (Classen 1997: 402; Howes 2005: 10; Howes 2003: 5). In view of the relationship between social situation and the senses, sensory anthropology may also contribute to an understanding of how older people fit into our prevailing cultural model, given their evolving sensory abilities.

According to Classen (1997), when we study cultures from within the perspective of a sensory framework it is possible to learn about sensory models, sensory symbolism, and culturally transmitted meanings. Howes and Classen use the term "ways of sensing" to describe the variety of ways the senses are practiced (Howes and Classen 2014: 5). They explain that the researcher's personal experience is not enough "for understanding how people everywhere perceive the world" since people's sensory capabilities "are developed and understood in different ways" (Ibid: 9).

The concept of studying sensory models and praxes as part of a design research approach is relatively new in the field of design, albeit designers have instinctively addressed these issues in designing products for a long time. Therefore the study of the senses deserves further consideration.

2.4.1 Sensorium

Anthropology of the senses is interested in the sensorium of experience: how an individual within a culture gains knowledge about his or her world through all of his or her bodily senses (Classen 1997; Classen 1993; Geurts 2002: 253; Howes and Classen 1991; Paterson 2007; Stoller 1989). Sensory anthropologists assert that it is possible to come to a deeper understanding of how people relate to their world through describing the 'sensory profile' of the interactions between senses and the meaning of the different senses within the culture (Classen 1993; Howes 2005).

> *The idea of 'sensory profile' or 'sense ratio'… is the idea of function, and of sensory functions in particular, with which the anthropology of the senses is*

> *most centrally concerned. In approaching other cultures, what we want to find out is: What is the relative importance and meaning of the different senses to the members of that culture? How does their culture's map of the senses differ from ours (Howes, 1991: 168)?*

Malmar and Vodvarka extend Howe's perspective into the field of design. They say (2004: 55) that, "not only is sensory response critical to any cultural outcome (like design), but the specific social context (the sensory ratio of that culture) will need to be addressed if it is to resonate with its users". While it is clear that studying the senses provides valuable information for design researchers and anthropologists, there is no common agreement about how many senses there are to study.

Anthropologists such as Geurts (2002), Howes (1991, 2003), Classen (1993, 1997), and Stoller (1989) question the commonly held belief that our sensorium consists of only five senses — sight, hearing, taste, smell, and touch. They acknowledge that there are additional sensory classifications, extending the count from five to nine or even twenty-one types of sensory perception.

> *Sensory scientists at the end of the twentieth century would probably agree on a taxonomy of approximately nine sensory systems: (1) **visual apparatus**, responding to luminous and chromatic impressions; (2) **auditory apparatus,** responding to tonal impressions; (3) olfactory apparatus; (4) gustatory apparatus; (5) **tactile apparatus**, responding to mechanical impressions; (6) **tactile apparatus**, responding to thermal impressions; (7) **tactile apparatus**, responding to kinesthetic impressions; (8) **labyrinth apparatus**, governing balance; and (9) **affective apparatus** (pleasant and painful), responding to impressions of tickling, itching, voluptuousness, desiccation, burning, distension, pinching, pressure, and so forth*
>
> *…A second (and complementary) taxonomic scheme divides the sensations into three subcategories: extero-receptors, intero-receptors, and proprio-receptors. The **exteroceptive sensations** include the classic five [eye, ear, nose, tongue, skin], which provide a person with information about external objects. The interoceptive sensations exert action on internal surfaces: esophagus, stomach, and the intestines. Finally, **proprioceptive sensations** provide a person with information about three conditions: the state of her deep tissue, her own movements and activity, and the effects of her displacement in*

> *space… Neither the ninefold nor the threefold taxonomy is accepted by all (Geurts, 2002: 8-9).*

The senses highlighted in bold font above indicate the ones most relevant to this investigation.

The sensory anthropology literature argues against the idea of isolating sensory experiences and studying them separately. For example, focusing on hearing might reveal the range of cultural experiences associated with sound or auditory senses such as singing, talking, and/or chanting, from the perspective of making sounds as well as hearing them. Moreover, the literature points out that the senses operate in an inter-related fashion, sometimes augmenting and sometimes opposing/contradicting each other (Classen, 1997, Geurts, 2002, Howes 2003, 2006, Howes and Classen, 1991, Paterson, 2007).

> *Indeed, if I attend closely to my nonverbal experience of the shifting landscape that surrounds me, I must acknowledge that the so-called separate senses are thoroughly blended with one another, and it is only after the fact that I am able to step back and isolate the specific contributions of my eyes, my ears, and my skin. As soon as I attempt to distinguish the share of any one sense from that of the others, I inevitably sever the full participation of my sensing body with the sensuous terrain (Abram 1997: 60).*

This interdependence between the senses may be key to developing an organized understanding of how the senses come into play in different fitness exercise situations. Howes and Classen developed an initial framework that can support this kind of research, as discussed in the next section.

2.4.2 Sensory Framework

Howes and Classen provided a framework of ten areas for probing into the importance and position of the senses within a culture, some of which include: the role artifacts and aesthetics play in relation to the senses; the exceptions to the dominant sensory model within the community in cases such as sensory handicaps; the inter-relation between the environment and built surroundings and the senses; and the use of language relating to the senses (1991: 257- 285).

The use of language often reveals sensory symbolism that may lead to understanding meanings attributed to, or the importance of, sensory faculties. For example, cultural studies lecturer Mark Paterson refers to the often-used phrase, "seeing is believing," noting that in our visually-oriented culture the other half of that phrase, "but feeling's the truth" is not used (2007: 2). Yet in a store we might ask the sales person, "Can I see that please?" when we really want to touch the object to feel what it is like. In this case, the language of seeing, our culturally dominant sense, overrides our innate need to learn about the material object through inter-sensory perception. Attention to language may also reveal older people's perceptions about their exercise-related experiences.

Moreover, Howes and Classen propose that the senses a culture values and bases their 'lifeworld' or 'worldview' on can be ordered, however this ordering is not static and evolves as the society does (Howes and Classen, 1991: 258-259). For example, the Tzotzils of Mexico use thermal symbolism to describe interpersonal relations. Here men are associated with heat and women with cold. Older people with extensive life experience and importance in the community gain heat as they age, whereas those who become ill are considered colder (Classen 1993: 136-137). By comparison, older people in this society tend to hide their visible signs of ageing to continue to fit into the youth-oriented culture (Featherstone and Hepworth 1991; Grimstad and Storm-Mathisen 2005). There is a notable difference between how the Tzotzils perceive the world through a cultural order that relates to sensory perception than how we, of the visually dominated west, do (Classen 1993: 123). As a result, a framework derived from sensory anthropology looking at the ordering of senses in relation to a sense of self may contribute an understanding of how the changing sensory worlds of older people affect their relationships to artifacts and environments.

2.4.2.1 Bodily Ways of Gathering Information

According to Howes (1991:182) and Downey (as cited in 2005: 32-33), "Marcel Mauss (1973) long ago pointed out that the 'techniques of the body' vary across cultures, even for such basic tasks as walking, spitting, eating, sleeping, swimming, climbing or having sex". The transmission and operations of such body techniques could be key to understanding unique user needs for design. Kathryn Geurts used the term, "bodily ways of gathering information" to describe a similar focus in her research into balance among the Anlo-Ewe-speaking people in southeastern Ghana (2002: 3). She went on to explain her concept: "A sensibility is a field where habituated bodily sensations link to individual feelings, attitudes, orientations, and perceptions and finally to cultural themes, motifs, and ethos" (2002: 17). For example, she learned that, to Anlo speakers, sensory disabilities were simply considered as culturally acceptable alterations that did not detract from living a fruitful life:

> *When I asked what it was like to be without sight, people often pointed out that a blind person could still hear, speak, and walk. When I asked what it was like to be without sound, they often insisted that the person was still able to see. As for being lame, their logic was that one still had the ability to see, hear, speak, see, and use one's mind (2002: 212).*

Bodily ways of gathering information would be components of a sensory framework for older people whose sensory ways of being are shifting. The nature of people's relationships to objects that may extend their bodily capabilities are discussed in the next section.

2.4.2.2 Bodily Extensions and Responses

The concept of bodily extensions can be traced back to Marshall McLuhan who believed that new technologies (the medium) have the potential to become "extensions of ourselves" (1964, reprint 2001: 7). Howes quotes McLuhan, "It would seem that the extension of one or another of our senses by mechanical means, such as [the wheel as an extension of the foot, the book of the eye, the telephone of the ear], can act as a sort of twist for the kaleidoscope of the entire sensorium" (1962 from McLuhan's The Gutenberg Galaxy: 55 in Howes 2003: xix). However, Howes argues that this is not necessarily the case given that "the body is humanity's first instrument or tool" and different cultural sensory practices "need not have any exterior or extracorporeal form" (Ibid).

Communications Professor, David Parisi adds, "It is the reforming of the perceptual act brought about by technological extension that is significant, not the extension itself" (2008: 309). In this study the focus is on understanding the relationship between older people's sensory experiences and the objects or environments in their sensory landscape rather than identifying prosthetics that could extend their sensory capabilities.

In addition, an interpretive sensory framework for bodily ways of knowing could also consider a person's "active response" to the things in his or her environment. Anthropologist Greg Downey (2005: 32-33) describes objects as being imbued with a potential for action, where a person may take an active role in accepting or rejecting them. For example, one person may accept a rollator (walker) as a functional assistive device that is useful for getting around and gives him or her some freedom, whereas another person may reject the same rollator because he or she perceives it as a stigma that identifies a handicap and isolates him or her from other more mobile people. Thus, a sensory framework for this study would include people's attitudes toward objects, as well as sensory ways of adapting to them.

2.5 Sensory Studies in Design

The sensory anthropology framework described in the previous section could be more relevant to discovering empathic and sensory insights than the well-documented prescriptive and experimental approaches to sensory design in the literature. It may contribute to deeper understandings for developing a range of products for an older population, rather than specific features for single products. An overview of the sensory design literature indicates that it can be organized into the following categories, of which the first two are the most relevant to this investigation:

i) *Sensory aesthetics* for product design that provide pleasurable experiences for users. This approach, which uses quantitative research methods based primarily in the field of psychology, focuses on creating an overall context for the user, "in which he may enjoy a film, a dinner, cleaning, playing, working, with all his senses" (Desmet and Hekkert 2007; Jordan 2000; Norman 2004; Overbeeke et al. 2003: 9; Schifferstein and Hekkert 2008). This research approach is complementary to this study, but differs methodically.

ii) *Sensitizing designers* so that they will understand the multi-sensory nature of a user's interaction with a product. Such a multi-sensory approach is important, not only to avoid unwanted conflicting messages, but most of all because an integrated and coherent approach of the senses is a powerful approach to enrich the overall experience one is designing for (Schifferstein 2011; Schifferstein and Desmet 2006; Sonnenveld, Ludden and Schifferstein 2008: 2).

iii) *Sensory design detailing* information for designers so they can optimize sensory features of products to enhance user experience. This realm of sensory design includes: visual choices, such as color palettes and typography; sound elements, such as the background music in a shopping mall or the beep of a microwave oven; and tactile qualities, such as the textured handle of a power drill or the click of a button on a remote control (Garrett 2006: 39; Karana, Hekkert and Kandachar 2010; Kim and Boradkhar 2002).

iv) *User requirements* that specify the quality and kind of sensory feedback users need to operate a product. For example, for a computer mouse, the tactual characteristics were reported to be most important, for a vacuum cleaner the sound it made, for a cleaning product its smell and for a soft drink its taste (Dore et al. 2007; Gibson 1966; Salvendy 2006; Schifferstein and Desmet 2007: 2027).

2.6 Overall Summary

The topics discussed in this chapter provide the context for exploring older people's variable sensory experiences to discover possible insights when designing wearable technologies for older adults. The literature review begins by introducing the needs of the older population that inform this design research. It establishes reasons for focusing on design research for and with older adults, whose lifespan and numbers are increasing. It confirms a need for a design strategy that spans their longer lifetimes, supporting the ability to remain independent. For example, changing fluid intelligence and other cognitive factors can affect their ability to grasp the complexity and speed of technology interactions. These limitations could negatively affect an older person's disposition toward assistive technologies. Nonetheless, they are interested in adopting products that meet their needs, especially related to fitness, health, and well-being, and contribute to 'successful ageing'. It confirms that technology-enhanced products can be designed to better support multi-sensory and quality-of-life experiences. Therefore it makes sense to study the sensory practices of somewhat impaired older people who are attending exercise classes that target their unique needs.

The literature goes on to present the advances in wearable technologies as a design research opportunity with some challenges, especially when designing for older adults. This section describes the ongoing and technology-dominated evolution of the domain, capturing the excitement and conflict between the disciplines involved. It provides examples of current work, categorizing different types of wearable technologies and the advances in sensor technology that make some of them possible. It explains the technology challenges as well as the need for applications that accommodate seniors' requirements.

It also looks at issues related to the opportunity for design research targeting older users, especially in the area of fitness, health, and well-being. For example, a one-size-fits-all solution does not "fit all" since it does not address the ongoing physical and cognitive changes associated with ageing and may be rejected due to stigmatization. It proposes collaboration with older adults throughout the stages of design research and development. It calls for a clear profile of the requirements of future wearers of technologies and for a design tool that provides insight into the design criteria. As a result it provides a rationale for a human-centered exploration of the needs, experiences, desires, and subjective meanings that older people would want in smart wearable technologies designed for them.

The next section situates this investigation in the field of design research. It is an Applied Research through Design study within a Human-Centered Paradigm, taking a Participatory Co-design approach. It explains the principles of co-design that guide researchers and users when collaborating to create objects that tell an intimate story about the design issues at hand. This section further identifies the need for engaging older adults in the design process. This approach may generate new knowledge: for designing a class of products, for gaining insight about sensory changes in ageing, and for understanding how sensory anthropology can inform industrial design research.

Finally the field of sensory anthropology is introduced as a new perspective that can contribute sensory insights and perspectives to the field of design research. It focuses on aspects of studying the senses that could expand or deepen design research knowledge. It provides a completely different perspective for design researchers to understand the importance and meaning of the senses as a subject for exploration, especially in relation to defining cultures and cultural differences. It introduces the concepts of different sensory models and praxes, the range of senses within the sensorium of experience, the inter-relatedness of the senses, and the ordering of the senses. Moreover it provides a sensory framework for analysis that includes investigating: language as a source of understanding sensory experiences; the sensory roles of artifacts and sensory aesthetics; the roles of sensory handicaps as possible exceptions to dominant sensory models; the inter-relation between the built environment, artifacts, and the senses; the bodily ways of gathering information as well as learning new information; and the sensory relationships with and attitudes towards new technologies.

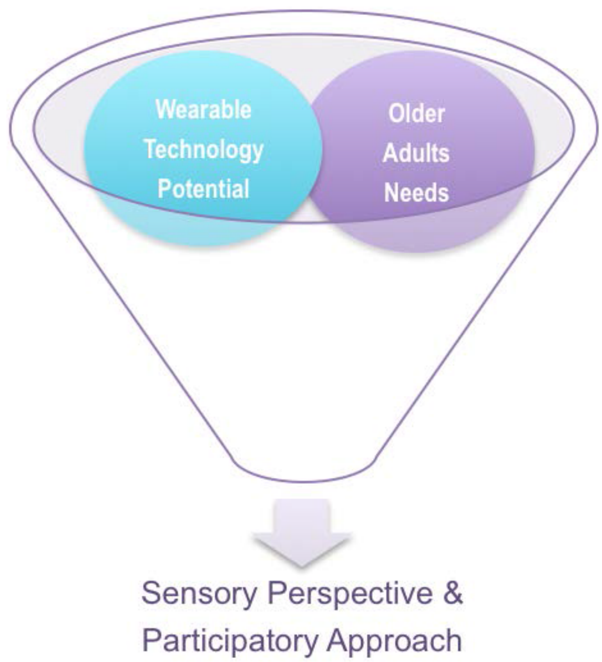


FIGURE 2.9: REPRESENTATION OF THE CONTEXT OF THIS INVESTIGATION

The context of this investigation is represented in the diagram above (Figure 2.9) where the design research takes place within a participatory approach, where users are considered the experts of their experiential knowledge. It addresses the following:

1) OLDER ADULTS who are well or somewhat impaired and living longer with variable physical, sensory, and cognitive states.

2) WEARABLE TECHNOLOGIES that are advancing quickly in a one-size-fits-all technology-dominated approach, where there is a call for human-centred

sensibilities of older adults' needs, experiences, desires, and subjective meanings.

3) SENSORY PERSPECTIVES that provide guidelines for investigation into people's sensory worldviews, their bodily ways of knowing, interactions between the senses, and the sensory roles of new or existing artifacts during fitness activities.

2.7 Discussion

The selection of literature in this chapter was guided by the following main question:

How can designer researchers gain insights for designing wearable technologies for an older population?

When initially asking this question my assumption was simple: if older people's senses change we should be able to augment them with sensor technologies. This led to a study of the literature about sensory changes in ageing, wearable technologies and design research. It became apparent that the aspect of gaining insights required its own question, which follows:

How can a sensory anthropology perspective inform industrial design research?

This new question led to a study of the literature related to anthropology of the senses, which revealed the importance of sensory knowledge for design research activities. It added more complexity to my initial assumption: if we apply sensory-oriented perspectives in participatory processes we should be able to generate sensorial insights to augment variable changes with technologies. Since co-design methods were already one step closer to the user than other user-centred methods the following question emerged:

How can generative co-design methods help provide empathic and sensory knowledge about designing with and for older people?

At the end of this literature review there is a new sub-question, that does not, in any way eliminate the others:

At what point and in what form do sensory perspectives fit into the design research process?

After reading the literature, sensory factors seem obvious enough to make me wonder what I have been paying attention to all of these years. Forty-one years ago I started to design and make precious things for the body, which required an understanding of the relationship between the body and a piece of jewellery. Seventeen years later I turned away from making elitist artifacts that were more likely destined for safety deposit boxes than bodies. I decided to design things people really needed in their everyday lives. Up until five years ago I had never considered that I was designing, or teaching others to design, for the whole sensorium of bodily experience. Now I am beginning to believe that the anthropologists' sensory approach may:

- Add new levels of rich holistic knowledge about people;
- Act like a filter for sensory practices to be aware of;
- Provide clues for interpreting the bodily information that is gathered; and
- Become a tool for framing and analyzing design research.

3 Research Design and Methods

The previous chapter maintains that an increasing number of older people may benefit from the potential for wearable technologies to assist in their fitness exercises. The variety and range of their bodily challenges is wide; physical and sensory problems are often interconnected and experienced simultaneously. In addition, major advances in miniaturization, functional capabilities, and power supplies for wearable technologies have the potential to address these needs. However, blanket design solutions will not leverage the potential of the technology or respond to older people's multifaceted cognitive and bodily issues. Designing technological assistance for fitness activities, for example, is complex, requiring empathy and sensitivity. As a result, the main objective of this study is to explore how sensory anthropology perspectives can contribute to empathic and sensory knowledge when designing wearable technologies with and for the older people.

Methods of inquiry in the field — at the Churchill Seniors Recreation Centre — included ethnographic Participant Observation, Co-design exercises, and Exploratory Technology Probes for methodological and analytical data triangulation. These methods are described in this chapter.

3.1 Research Design

The research phases progressed iteratively. First in parallel and interwoven with a Carleton University School of Industrial Design course project and subsequently, with two research assistants who helped with the exploratory technology in the background, while another assisted in the field. The opportunity to involve the students in the study was mutually beneficial. The students learned about design research with and for older adults, while I learned how sensory and perceptual information could contribute to the students' collaborative activities and design knowledge.

The study took a constructivist approach to understanding the sensory framework of the older participants in relation to each other, the things in their environment, and, in some cases, the environment. This approach uncovers patterns of meaning through qualitatively observing and analyzing the participants' in-situ sensory and perceptual experiences. Since the class of products and the sensory variables of the older adults were rather broad it was important to embark on a qualitative exploration rather than a quantitative evaluation. As noted earlier, such user-centered approaches contrast, for the most part, with current practice in the technology-led field of wearable computing.

John Creswell, Professor of Educational Psychology at the University of Nebraska-Lincoln, describes the assumptions underlying a Constructivist approach that make it appropriate for this investigation. He says that, "Individuals develop subjective [and varied] meanings of their experiences– meanings directed toward certain objects or things" (2014:8). Researchers "generate or inductively develop a theory or pattern of meaning" based on diverse participants' meanings, instead of applying a theoretical approach, such as postpositivism (Ibid). Since the participants' views differ from those of the researcher it is important to study people in their specific settings to "make sense of (or interpret)" their perspectives.

Accordingly, the research methods I used allowed for engagement with older adults in their Recreation Centre and fitness classes, giving me the opportunity to position myself in their world. This contributed to an evolved understanding about them and my future self. My approach to gathering data about the participants in this exploratory investigation is described in chronological order, as much as possible, in the following sections of this chapter. Where methods are introduced, they are also explained and contextualized with references to the literature.

3.2 Contextual Background

Prior to this exploratory investigation, I undertook a short ethnographic pilot study to discover the multi-sensory changes older people experience in relation to their balance (Frankel 2009). The goal was to understand how applied sensory anthropology methods could contribute to design research knowledge. The study revealed that people, ranging from age seventy to eighty-four, experience kinesthetic, proprioceptive, and painful feedback in relation to their sense of balance. They responded to their sensory divergences with fear, intentional behavioral changes, and ingenuity. They improvised a bricolage — a patchwork solution — of contact within their own "sensorium". For example, instead of simply having one walker (rollator), a person might have a different one on each floor of his house, and another in the car, with wall handholds to provide support in the gaps between walkers. This was new design knowledge because designers typically work to provide one best walker and not a stable of walkers for a person to use during a range of daily activities. The pilot project provided some insight into where expert-designed products do not fully optimize the sensory challenges people are facing, opening the door for further design research.

Rather than focusing on balance issues I began this study with an open-ended exploration in the spirit of constructivism, to determine the key sensory issues from an older exerciser's perspective. Since a group of industrial design students also took part in this investigation, the discussion turns to how their course was integrated into this study.

3.3 The role of IDES4305: Co-design Explorations for Wearable Computing for Ageing

My initial application to the Special Individualized PhD program at Concordia University was entitled "Designing for Sensory Decline: Sensible Technology for the Independent Elderly". As part of that proposed research direction I stated that, "A key aspect of this research will be the collaboration between elderly participants and design students in exploring how sensor enabled multi-modal devices or systems could be integrated into seniors' lives to provide a sense of wellbeing". Although I had not taught such a course, nor did I yet have permission to do so, I added, hopefully, "There will be an opportunity to engage design students in a studio course in interaction design in the design of prototypes and usability studies of sensor-based products for special populations".

The concept of involving design students remained core to the research plan for two reasons. On one hand it provided a unique learning opportunity for engaging with older users. On the other hand, it provided me with an opportunity to conduct research into an area of longtime interest, while working full time as a design educator. I was granted permission to teach the course in the School of Industrial Design at Carleton in the winter semester of 2011.

Twelve students of mixed ethnic backgrounds enrolled in my course: four females and eight males. The students had selected the course based on their interest in the subject matter; I did not recruit them. Eleven of them were in their fourth and final undergraduate year of industrial design studies and all, but one, were under twenty-five years old. The one older undergraduate student was an experienced technology professional taking a mid-career degree in industrial design. The twelfth student, also over twenty-five, was a Master of Design candidate and Interior Design Professor at Algonquin College.

I had no intention of studying the students as subjects of the research during the course, but they were asked to take part in the Co-design workshop sessions. The students who enrolled in the class received an email prior to the first day of classes describing the experimental nature of the course and my research. They were also informed that they would be "observing older people exercising and documenting what they wear and what they do; designing and making simple paper-based and electronic resources for engaging the older people in design activities; and interacting with older people to design together through play." Their documentation and our discussions were valuable in providing more eyes and more perspectives in the analysis of the data.

In accordance with Carleton University's Ethics Committee request the design students were also informed that:

- The course "learning objectives are clearly defined and subject to grading" and
- Some aspects of interacting with older participants will be documented for research purposes and each student will be asked to sign a consent form

acknowledging this and agreeing to participate. It is possible to pass this course without consenting and interacting with the older participants.

All of the students signed consent forms (see Appendix A: Student Consent Form) and contributed to the Co-design session, which was the highlight of the semester for everyone.

The course was to be an experimental learning experience, with a "focus on the co-design process at the front end of a design project to generate ideas and concepts for wearable computing devices and/or clothing for elderly people during exercise." The course outline in Appendix B: IDES4305 Course Outline provides the course objectives, information about the deliverables and evaluation, and a weekly schedule. From the first class I encouraged students to take on the role of designer-researchers, beginning with an exercise listing all of their assumptions "about what you expect to see or learn about elderly people exercising in a fitness class". Through this exercise the students identified their biases and how they might influence their perceptions in the field.

The next significant activity was to create a framework that set up the parameters for the students' research, taking their short preparation time frame into account. They received two resource documents to help them understand a designer's perspective about sensory issues in a specific design project (Schiphorst 2009) and to identify sensor technologies that could be used in wearable computing devices (Network 2004). In class two weeks later we posted an amalgamated list of criteria to pay attention to while observing exercise classes (see Appendix C: Observation Criteria) on the class blog. The assumptions exercise and the observation criteria guideline development activity were new to the students, as neither was a part of their designer skill set. They used them as guidelines for their visits to and reports about observing the fitness classes. By the end of January the class had condensed their initial reflections into a table identifying physical and technical parameters for their research and design explorations and posted it on the blog (see Table 3.1: Opportunity Chart).

Opportunities	Applications	Input	Output	Components
Physical	flexibility	bend sensor	vibration/buzz	socks
self-monitoring	balance	pressure sensor	lights/LED	gloves
correction	cardiovascular	accelerometer	colour change	T-shirts
feedback	strength	Heart rate monitor	sound	Shoes
		proximity		buttons
Communication		heat sensor		velcro
instruction				ribbons
guidance				

Table 3.1. Opportunity Chart developed after initial observation analysis.

The table identified the students' observations about initial physical and communication conditions where technology might be helpful: how people monitor their own progress, how they know to correct form or movements, how they get feedback about their progress, and how they receive instruction or guidance. It also noted the types of exercises that were most common: flexibility, balance, cardiovascular, and strength. Since there was a hands-on component to the students' class it also identified sensor inputs, technology outputs, and types of clothing that they could begin to work with.

The students also spent time each week building circuits with the input and output elements from the table above. Meanwhile, I introduced them to the concept of Co-design through lectures and examples. By the end of January the students were wrapping up their observation sessions at the Churchill Seniors Centre, reporting on their findings, and beginning to prepare for facilitating Co-design workshop sessions with the older adults.

They divided into two teams: the People & Logistics team and the Technology team. The People & Logistics team planned and scripted the Co-design pre-session and workshop session activities, producing fifteen "homework" kits (see Figure 3.1: Homework Kit below) for distribution to registrants before the workshop, and preparing for a pilot run of the workshop session in early February.

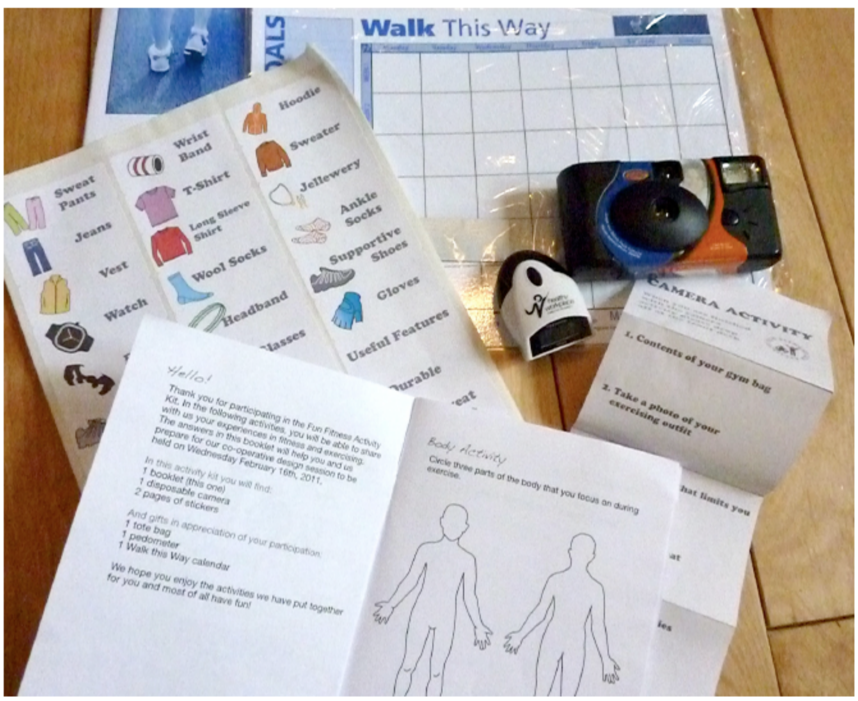


FIGURE 3.1. HOMEWORK KIT CONSISTING OF JOURNAL & STICKERS FOR ADDING TO JOURNAL,CAMERA & INSTRUCTIONS FOR WHAT TO PHOTOGRAPH, PEDOMETER AND CALENDAR. ITEMS WERE PACKED IN A CLOTH BAG THAT WAS GIVEN TO PARTICIPANTS.

The Technology team prepared demos for the workshop to show the capabilities of working sensors to the participants. They assembled components supply kits for making simulations of sensor-activated wearables in the workshop, put together toolkits for making the components, and planned video and photo coverage of the workshop. I prepared and posted the recruiting notice (see Appendix D: Recruiting

Notice). We delivered the pre-workshop “homework” kits to the front desk at the Centre, where registrants received them from the receptionist when they signed up. A student picked up the completed kits the day before the workshop and had the participants’ photos developed in time for the workshop.

On Thursday February 10 the whole class met to perform a dry run of their scripted Co-design workshop activities with three industrial design students recruited from second and third year studios. We ran through the script, demonstrated the working sensors, videotaped and photographed the session, and debriefed at the end. We learned enough to warrant revising the sensor demos and the planned activities for a second rehearsal on Monday February 14. We were ready for the big day. On Wednesday February 16 we met at the Churchill Seniors Centre at 10:00 am. The older participants arrived by 11:30 and left before 2:00 pm. In between their arrival and departure the students facilitated two Co-design activities, one with everyone together and one with three parallel groups of participants. The activities are described in more detail later in this section. I was involved every step from critiquing their dry runs, suggesting changes, welcoming participants, buying lunch ingredients, setting up, and tearing down.

At the end of the session, we invited the older participants to a follow up session on March 14 and returned to school, where the design students spent the next weeks advancing the ideas from the Co-design sessions into scenarios for product concepts. Each student or student team was required to create scenarios that illustrated how an older adult would wear and use the sensor-enabled garment or device they had chosen to develop further. Each student could also choose between making a working circuit demonstrating the proposed input and output cycles or making a short video simulation of how the design would work.

On March 14, they presented their evolved ideas to a group of over twenty older adults at the Churchill Seniors Centre, including the fitness instructor. Eight members of the audience had participated in the February 16 workshop, and the others were curious about the excitement. At that event, students presented their scenarios and engaged in discussions with the audience members. We also held a draw for the older participants who had attended the Co-design workshop sessions for a one hundred dollar gift certificate to a fitness equipment store. The industrial design course ended at that point, and two of the students continued on as my assistants to the end of June, along with the student who had worked as a teaching assistant in the electronics lab throughout the course.

3.4 Participants and Setting

The proposal for this study was titled "Feeling Fit: Sensory Co-design Research to inspire wearable technologies for ageing well" when it was submitted for ethics approval. The plan was to attend seniors' fitness classes offered at the Churchill Seniors Recreation Centre in Ottawa, a facility "dedicated to the recreational needs of participants aged 50 and over" (Ottawa 2013). In December 2010 I learned that the clients were used to having researchers observe them in classes, as the Centre was known for its innovative fitness approaches for seniors. Moreover, my students and I would be welcome to observe classes in small groups.

In January 2011 pairs of students began to observe a range of "senior friendly" classes offered by the Centre, including: Integrated Fitness, Tone and Stretch with

Weights, and Total Fitness. In addition, over the next six months I became a regular, observing and attending classes most weeks until the end of June 2011. Initially I attended two or three fitness classes, one after the other, one day a week, until I settled into two back-to-back sessions of the Integrated Fitness class on Tuesday or Thursday mornings. The classes are advertised as:

> *Integrated Fitness: Low ratio instruction in a group setting using senior friendly fitness equipment. Suitable for post stroke, post physio and post surgery. Participants must be able to work in a 1-8 staff client staff ratio (Ottawa 2013).*

On most days there were fewer than the eight registered participants in the classes; there were always more women and sometimes a volunteer. Most had graduated from rehabilitation or physiotherapy and were long-time Integrated Fitness students. These adults were on either side of age seventy, except in cases where they had experienced an early stroke or another mobility impairment and were recovering. This was a convenience sampling because it was dependent on who came to class. In all, eighteen of the older adults – sixteen women and two men – who took part in the weekly classes agreed to participate in the ethnographic component of my study. One of the women also joined the Co-design workshop session.

Twelve older adults participated in the Co-design session on February 16, 2011. This convenience sample was a self-selected group of volunteers from within the target community. They were all exercise fitness students at the Churchill Seniors Centre. They were recruited during the two weeks prior through the notices I had placed on the bulletin board (see Appendix D: Recruiting Notice) and at the encouragement of the fitness instructor and the Program Coordinator. I had initially hoped to recruit adults over seventy years of age, however some of the older adults who had free time on that day were younger. As a result, the more suitable research sample criteria was a lifespan status of "well" or "somewhat impaired". Eight people signed up at the reception desk where they received their pre-workshop "homework" kit. Four more people decided to attend in the day or two prior to the workshop and did not receive a pre-workshop kit. They all signed consent forms at the workshop (see Appendix E: Older Participant's Consent Form). In total twenty-six older adults participated in this research study.

3.5 Rationale for Data Gathering Methods

This section positions the research methods in relation to my research questions introduced earlier. The two sub-questions guided the investigation, which led to a comprehensive answer to my main question: *How can designer researchers gain insights for designing wearable technologies for an older population?*

The first sub-question asked: *How can a sensory anthropology perspective inform industrial design research?* Here I wanted to learn about the participants' sensory ways of interacting with people, activities, and things. This query would include the range, inter-relatedness, and ordering of the senses. I wanted to understand the aspects of sensory anthropology that contributed to the participants' sensory frameworks: sensory related language and behaviours, the sensory roles of artifacts, the effects, if any, of sensory handicaps, and the bodily ways of gathering information and engaging in activities. I also wanted to learn about sensory and perceptual interactions with existing and new technologies (low and high tech).

The ethnographic method of Participant Observation (described in section 3.6) allowed me to be involved with older adults in their fitness environment and experience these aspects while being part of the action. In addition, Co-design (described in section 3.7) activities, especially talking, gesturing, and creating models, provided sensory and perceptual insights in the present moment that were not premeditated and possibly not adjusted to please the researchers. This provided methodological triangulation and a different approach to understanding sensory interactions with existing and new technologies. A third method, Exploratory Technology Probes (described in section 3.8), was also used as a tool for discovering older participants' perceptions, sensory interactions, and bodily ways of gathering information.

My second sub-question asked: *How can generative co-design methods help provide empathic and sensory knowledge about designing with and for older people?* Here I wanted to focus on how the process of co-design could contribute to the designer-researchers' empathic knowledge. What activities would produce sensory knowledge for design or about designing? I wanted to know how participants would interact with each other and with artifacts to illustrate or represent their needs, experiences, desires, and subjective meanings. I wanted to learn about the kinds of ideas, concepts, or information that would communicate the participants' tacit bodily knowledge. As the study progressed, I wanted to understand how participants responded to the iterative concepts using models to probe for responsive behaviours and reflections. To answer this question, the two methods of Co-design and Exploratory Technology Probes were useful for enabling interaction between participants and artifacts, and for providing exploratory activities to engage in.

Overall these data collection methods were selected because they would support an "empathetic understanding of participants' day-to-day experiences and an increased awareness of the multiple meanings given to the routine and problematic events by those in the setting" (Bailey 2007: 53).

3.6 Participant Observation/Ethnography

As an industrial design researcher I was familiar with ethnographic fieldwork or participant observation, which was originally taken from the social sciences. In her article, *Ethnography in the Field of Design*, Christine Wasson explains that in the 1980s at Xerox Paolo Alto Research Center (Xerox PARC), anthropologist Lucy Suchman and her colleagues were among the first to introduce ethnographic fieldwork techniques into design research (Reese 2002; Wasson 2000). As similar "ethnographically informed design practices" spread into design firms such as IDEO, Fitch, and E-Lab (Blomberg and Burrell 2002: 966) designers realized that:

> *Ethnography…investigates, not just what consumers say they do, but what they actually do. From the beginning, ethnographic studies showed major discrepancies between designers' intended uses of their products and consumers' everyday behaviors. Such discoveries …[highlighted] the importance of learning about product use "in the wild [in the field]"(Wasson 2000: 378).*

However, participant observation is usually a quick affair for a design researcher. In contrast to academic ethnography where social scientists conduct years of participant observation, in a business context, ethnographies (read: participant observation) can last half a day or even less (Plowman 2003: 34). Nonetheless, designers, like social scientists, are interested in gaining deeper insights "into the desires, beliefs, habits, motivations and understandings of behavior in a given context"(Plowman 2003: 34). Immersion in the setting permits the researcher to hear, see, and to begin to experience reality as the participants do (Marshall and Rossman 2006: 100). That is why it was important to be immersed in weekly classes at the Churchill Seniors Centre. Over the six months, the

Ethnographic fieldwork in this investigation included both brief design research ethnography on the part of the students and more immersive academic ethnography on my part.

In Phase One of this investigation, during the first three months that I attended classes at the Churchill Seniors Recreation Centre, I assumed the role of Observer as Participant (Bailey 2007: 80). In other words, while I was not a full participant in the exercise classes, I was fully engaged in ethnographic fieldwork. In that role, I observed what people were doing, helped when asked, shared my chocolate chip cookies and fruit, sat in on opening and closing sessions of exercise classes, talked with most of the people there, and spent some of my time taking notes, photos, or videos. During class time I engaged in semi-structured conversations with the older adults, sometimes guided by questions that were prepared ahead of time (see Appendix G: Questions for Semi-Structured Interviews). In general, the older adults were very happy to talk and often after one question the conversation would fly by until the instructor summoned one of us to another task. Since the class structure and the older adult student attendance varied, I relied on unstructured observations, "concentrating instead on what seemed relevant as events unfolded" (Bailey 2007: 83).

Over the first five weeks, my twelve industrial design students participated significantly less than I, attending only two classes each, guided as much as possible by the structured observation criteria we had developed in class, as noted earlier (see Appendix C: Observation Criteria). These brief fieldwork visits have been referred to in some of the ethnography in design literature as "diluted ethnography" or "ethnography-lite" (Dourish 2006; Reese 2004). Nonetheless, six pairs of observers gathered many insights into the activities, abilities, sensory interactions, environment, attitudes, and other aspects about the older adults' exercise experiences. They posted them on the class blog and in individual reports. Our different approaches to participant observation provided an unexpected opportunity to compare academic ethnography and design research fieldwork.

In Phase Two of this investigation, from April to the end of June, I alternated between the roles of Observer as Participant and Observer as Influencer. I invented the latter term to capture the nature of my intervention in the setting. While the technology probes method will be explained in section 3.8, it is important to note that in my role as Observer as Participant I was actively involved in the routine events of the everyday setting (Bailey 2007). In addition, in my role as Observer as Influencer, I was responsible for shaping some not-so-routine events by bringing experimental technologies to class with me, thereby changing the nature of the older adults' everyday experiences. In both Observer roles I was immersed in understanding the bodily experiences of the older participants, several of whom I had come to know. These experiences led to the insights described later in this document.

3.6.1 Ethnographic Representations

Anthropologists and design researchers communicate their research insights in different ways. Academic ethnographers represent their interpretive understandings through a primarily textual "thick description" of a literary nature (Anderson 1994; Dourish 2006; Geertz 1973: 5; Marcus 1998; Van Maanen 1988). While the objectives of anthropology are to understand, and to record understanding, designers seek understanding only as a first step toward the creation of solutions to problems, and often show little interest in documenting preliminary research (Frankel 2009).

Innovative forms of visually representing design research findings provide a compromise between ethnographic objectives of descriptive interpretation and design objectives for prescriptive solutions (Moggridge 2007: 671). Scenarios, which the students used in their work, thus provided a visually informative story for presentation purposes. Scenarios often take the form of sequential illustrations offering a semi-abstract representation of original field observations and/or potential design interventions (Blomberg and Burrell 2002: 980). To illustrate this approach one of the student's scenarios appears in figure 3.2: Mat Mate Scenario below

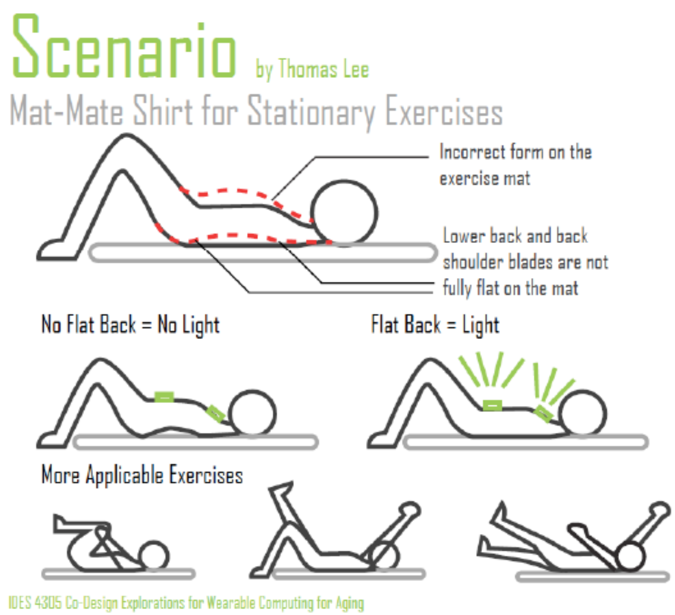


FIGURE 3.2. MAT MATE SCENARIO ILLUSTRATING A POSTURE PROBLEM DURING MAT EXERCISES THAT CAN BE ADDRESSED THROUGH A DESIGN SOLUTION DESIGNED BY T. LEE.

While scenarios serve an immediate purpose in design projects, they are less effective for preserving design research insights over time. As a result, interpretive ethnographic texts can play a part in illustrating design research insights into sensory information. Therefore, this research considers the full intention of academic ethnography, which:

> *is, after all, ethno-graphy; a form of writing and a way in which cultural understanding is inscribed as a literary form. Writing then, is central, and the ethnography is not, itself, the project, but the written form that is its final outcome (Dourish 2006: 543).*

Therefore insights from this study are presented through "thick description" in literary format in Chapter 4. In this case "thick description" refers to the illustrative textual passages that "make the scenes easy for the reader to visualize" (Bailey 2007: 137). The narratives should enable the reader to 'see' the participants and the setting (Ibid). The insights that contribute to the narratives were gathered through all of the methods described in this chapter.

3.7 Co-design

During the students' in-situ observation activities they developed a contextual understanding about designing technology-enabled fitness wear for older adults. Following that, they proceeded to prepare for the co-design sessions. There are four stages in generative design development with participants (Frankel 2011). These stages are represented in Figure 3.3: Stages of Co-design Development. They are: preparing **a contextual framework** for the design researchers as explained in the class description, **sensitizing** design research facilitators as well as potential co-design participants through ethnographic fieldwork, preparing for and facilitating **co-design workshops**, and developing **scenarios** of use based on the analysis of the data gathered in the previous three phases.

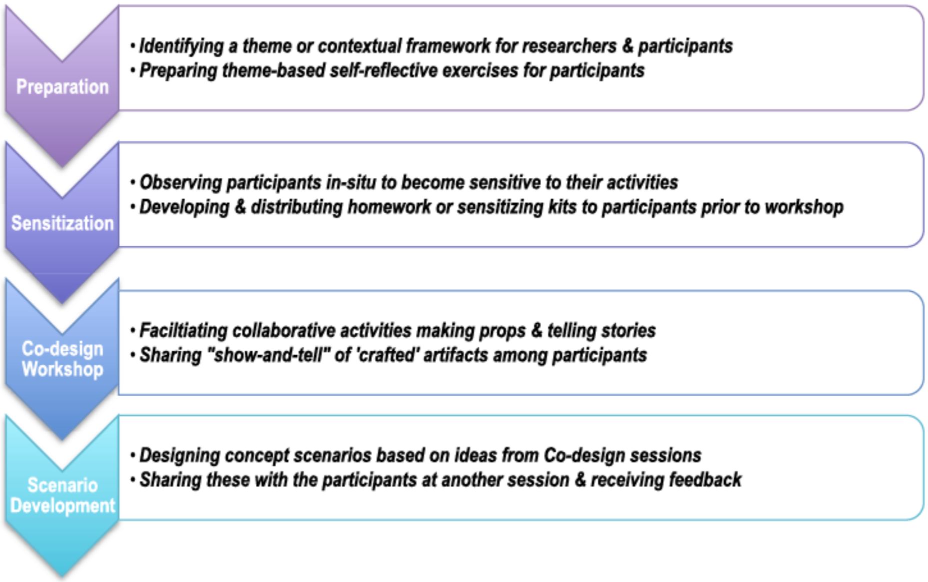


FIGURE 3.3. STAGES OF CO-DESIGN DEVELOPMENT

Preparation: Sanders and Stappers, professors and experts in the field of generative design research, say it is best to acquaint participants with a broad theme ahead of time, to stimulate their "memories, and to provoke their observation and reflection of the current situation before asking them to take a leap into [design for] the future"(Sanders and Stappers 2012: 161). The students chose the theme 'experiences in fitness and exercising' for introducing the older participants to the theme of the study. Based on their understanding from their observations, the students incorporated this theme into the "homework" kits given to the participants when they registered for the Co-design workshops (Mattelmaki 2006: 66). The kits included simple self-reflective exercises to complete before the workshop, such as journaling and picture taking. They served to acquaint the senior participants with our general area of interest and are explained in more detail in the cultural probes discussion in this chapter.

Sensitization: During field observations the students met several of the older participants who volunteered to attend the workshops. The older participants still needed to be primed for the activities that would take place in the co-design session (Martin and Hannington 2012: 94). That was the purpose of the "homework-sensitizing" kits. Eight participants filled in the journals in the kit and returned the kits before or at the workshop. They provided information about the parts of their body they focus on during exercise; the kinds of clothes they wear for fitness and the kinds of exercises they have enjoyed; what they did over two days described in a journaling section; and their fitness experiences over two days, also described in a journaling section (see Figure 3.4: Journal Entries: Body Activity & Exercise Clothing Activity). They also returned photos taken with the disposable camera from the kit, showing their exercising outfits, exercise machines they use at home, and their home environment (see Appendix H: Photos taken by participants). We pinned their photos on the wall during the workshop.

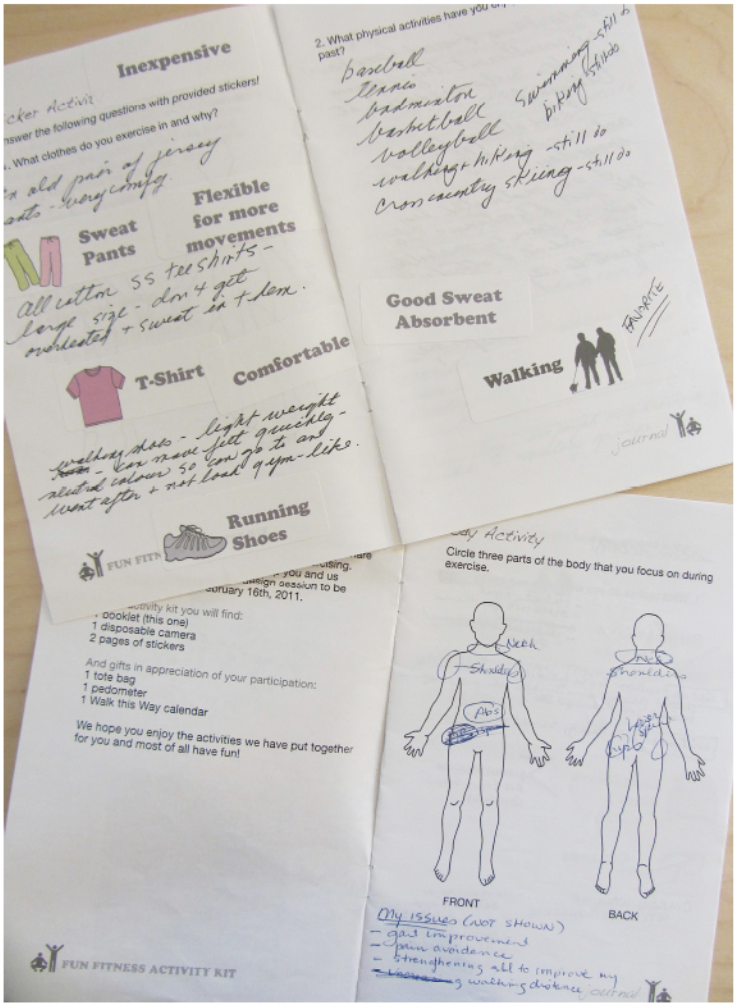


FIGURE 3.4. JOURNAL ENTRIES: BODY ACTIVITY (BELOW) AND EXERCISE CLOTHING ACTIVITY (ABOVE)

Co-design Workshop: The objective of a generative design session is to facilitate collaborative activities in which participants make various props with the facilitators and use them to tell stories about their experiences. According to Martin and Hanington, authors of *Universal Methods of Design*, the kind of expressive exercises that researchers use should enable,

> *…participants to articulate thoughts, feelings, and desires that are difficult to communicate through more conventional verbal means. Furthermore, the creation of an artifact around which a participant may talk will act as a trigger for engaged and comfortable conversation (2012: 94).*

The theme for the workshop was 'to craft something wearable to monitor or measure activity during exercise'. It consisted of carefully scripted activities, beginning with introductions and consent form signatures, followed by a large group warm-up activity as an icebreaker and bridge from their previous homework. In the first activity the older adults were invited to identify the body parts that they focus on when exercising, which was one of the activities that they had already done in their "homework-sensitizing" journal at home (see previous figure 3.4: Journal Entries-Body Activity). This activity was adapted from a model Bo Westerlund used for his PhD workshops,

> *First the participants tell stories about recent situations or incidents that have been meaningful for them. We encourage actual descriptions of real situations that make sense to the participants, instead of general descriptions that are reduced and without detail… We do not get complete descriptions of problems or lists of features they would want in an artifact. Instead we will hear the situations described as intentions and activities. This reduction and selected articulation makes the described situation more available to design activity than say a list of requirements that are abstract (Westerlund 2006: 3).*

Everyone was given a chance to talk and student scribes posted their concerns on a large body poster as seen in Figure 3.5: Body Mapping Activity.

FIGURE 3.5. BODY MAPPING ACTIVITY. PHOTO BY J. MARUSAIK

After this ice-breaking activity, participants were encouraged to have the lunch we set out. This was an opportunity for casual conversation between older adults and the students. Over lunch one student volunteer modeled the sensor prototypes showing how sensor inputs can provide simple sensory outputs (see figure 3.6: Sensor Behaviour Kit).

FIGURE 3.6. SENSOR BEHAVIOUR KIT MODELED FOR PARTICIPANTS. PHOTO BY J. MARUSAIK

Participants then chose to sit at one of three tables — balance, strength, or flexibility — for the wearable crafting activity. There were four older participants and two students at each worktable. This activity was also partially influenced by Westerlund's research experiences:

> *The work proceeds by the participants locating opportunities and possibilities in the explained situations as well as generating ideas that seem desirable. The ideas that are considered meaningful are developed into new scenarios [or prototypes]. The scenarios are constructed where these ideas for improvements are used to change the initial situation into a desired one (2006:4).*

In each of the parallel groups facilitators began with prepared examples of how to indicate sensor placement on various types of clothing. The participants talked among themselves and made rough models of sensor-enabled exercise wear as in the example in figure 3.7: Rough Model of shirt.

FIGURE 3.7. ROUGH MODEL OF SHIRT WITH TAPE INDICATING WHERE SENSORS ARE NEEDED. PHOTO BY J. MARUSAIK

The activity ended with an all-group show-and-tell, where an older participant from each table shared the issues they had targeted and described the prototypes that they had made. All of the parallel sessions were recorded on video.

Scenario Development: In the fourth stage of the research activity the student design participants reviewed the workshop videos, focusing on the ideas generated in the co-design sessions. Then they developed concept scenarios (slides – see an example in Appendix F, videos, or renderings) for wearable sensor-enabled gear to augment mature exercise experiences. We presented the scenarios to an audience of the older participants at CSRC, which according to Sanders and Stappers, "is the traditional mode of communication for research findings and the one that is most commonly used today" (2012: 236). The audience members asked questions, made comments, and engaged in discussion, giving us feedback about the concepts. Follow-up semi-structured interviews (see Appendix G: Questions for Semi-Structured Interviews) were conducted with three of the older participants to learn about their reflections after the co-design sessions. The students also submitted "learning reports" describing their reflections on the experience.

3.8 Exploratory Probes

Probes were used for gathering data. The first probes used were the "homework" kits, introduced in the previous section. Adapted from Gaver, Dunne and Pacenti's experimental cultural probes and subsequent applications by others, they were used to sensitize the older participants to the theme of our research and probe for relevant data (Boehner et al. 2007; Gaver, Dunne and Pacenti 1999; Graham et al. 2007; Sanders and Stappers 2012; Vetting Wolf et al. 2006). Cultural probes,

> *…are based on user participation by means of self-documentation… Probes are a collection of assignments through which or inspired by which the users can record their experiences as well as express their thoughts and ideas… The assignments focus the users' attention and record their daily lives including social, aesthetic and cultural environment, needs, feelings, values, and attitudes (Mattelmaki 2006: 40).*

In the kits we used traditional design research probes where people record the moment through journaling in specially created diaries and document aspects of everyday life with supplied cameras. This is considered to be a more genuine way of gathering personal data than interviews that take place after and away from the situation (Mattelmaki 2006). The probes were appropriate for cultivating the participants' awareness of their experiences, or "making the invisible visible" through introducing a new artifact (journal, camera) into daily life that gives the participants an opportunity to record their point of view (Graham et al. 2007: 31).

In the last three months of the study, additional artifacts were introduced into the fitness environment. These artifacts were exploratory technology probes, which differ from cultural probes. They were in-situ vehicles for discovering sensory experiences that could inform or inspire design development with and for the older participants. As a result, they evolved in response to people's feedback and interactions. They were influenced by the work of Hutchinson, Mackay, Westerlund et al (2003: 18):

> *Our technology probes involve installing a technology into a real use context, watching how it is used over a period of time, and then reflecting on this use to gather information about the users and inspire ideas for new technologies. A well-designed technology probe is technically simple and flexible with respect to possible use. It is not a prototype, but a tool to determine which kinds of technologies would be interesting to design in the future… we expect the users to adapt to the new technology but also adapt it in creative new ways, for their own purposes.*

Technology probes are used to learn about how people act with, orient toward, or attend to them, especially if they have qualities that are unexpected, new, or different (Larssen, Robertson and Edwards 2007; Sundström et al. 2009; Westerlund 2007).

In all, my research team used four technology probes, and only one of them had a wearable component, which will be explained later. The first was a mat with pressure sensors arranged in a grid under its surface as shown in figure 3.8: Older Participant standing on sensor mat. The Dean of the Faculty of Engineering and Design, Rafik Goubran, provided this mat, used for research by his Computing Systems group at Carleton University. It is instrumental in his biomedical research and seemed to be open ended enough to provide opportunities for understanding how aware exercisers are of their balance. It was used for stationary balance exercises due to its small size.

FIGURE 3.8. OLDER PARTICIPANT STANDING ON SENSOR MAT AND LOOKING AT IMAGE OF HIS FEET ON LAPTOP SCREEN IN FRONT OF HIM. PHOTO BY J. MARUSAIK

The second probe was a mat that we made in our lab (see Figure 3.9: Mat 2). It was modeled after a balance exercise the students were familiar with in their fitness classes. They would shift their weight onto different quadrants in a clockwise or counterclockwise direction, while maintaining their balance. This probe also had a panel with lights on it that changed to indicate which square to step on, in response to the participant's previous step.

FIGURE 3.9. MAT 2 SET UP IN FITNESS ROOM WITH ONE LIGHT ON IN DIRECTIONAL PANEL. PHOTO BY J. MARUSAIK

The third technology probe was a Wii Fit video game. Participants tried out two activities: the Wii Fit balance body test and the balance bubble as shown in figure 3.10: Participant on Wii Fit board and her view.

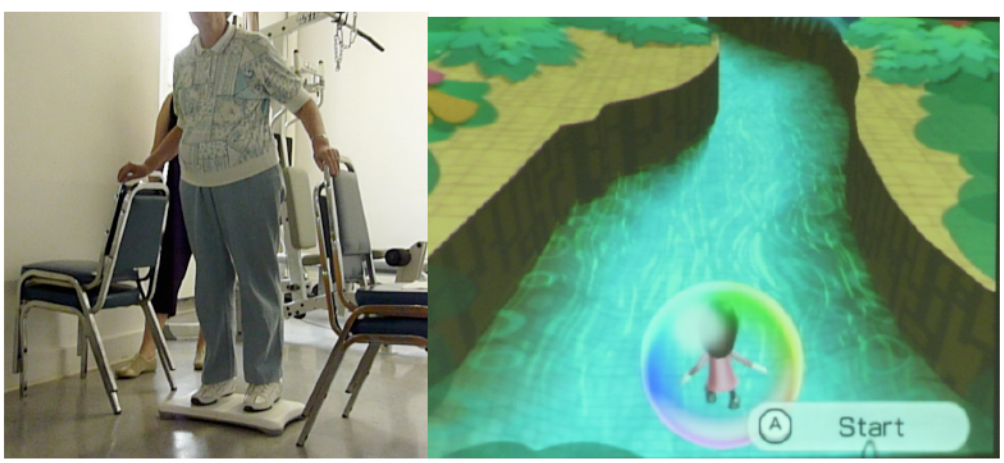


FIGURE 3.10. PARTICIPANT ON WII FIT BOARD & VIEW OF WHAT SHE SAW ON SCREEN. PHOTOS BY T. PHILLIPS

The fourth technology probe, the terrain mat (see Figure 3.11: Terrain Mat and Foot Component), was also made in our lab and consisted of separate modules with a variety of heights and textures. It had a component to attach to the participant's shoe to provide haptic and visual directions. The participants were told that the foot component had sensors in it, so they could imagine that it was working.

FIGURE 3.11. TERRAIN MAT SET UP IN FITNESS ROOM WITH DIRECTIONAL PANEL & PARTICIPANT TYING ON FOOT COMPONENT

3.9 Phase two

There were two phases in this study. Phase one included the methods of Participant Observation and Co-design with students in IDES4305 and older participants from January to March. Phase two included the methods of Participant Observation and Exploratory Technology Probes with the smaller team of researchers and older adult participants from April to June. Phase two arose in response to an initial analysis of the data gathered in phase one. While the findings will be discussed in a later chapter, early insights led to a refocusing of the research, as can be expected in an exploratory methods approach. One insight gained was that the older adults, who were clearly interested in assistive technologies, preferred to have them available at the recreation center, not at home. Another insight was that the older adults were particularly interested in solutions that addressed the position and use of their spine, knees, joints, legs and feet.

During this time of refocusing I organized a brainstorming session with two of the students who had participated in the project, the technical support student, and the fitness instructor, who provided an expert opinion and had been a key figure in the fitness classes. The idea was to have expert consultation at this point to understand if and what kind of opportunity might bring technology probes into the fitness classes. No older participants were invited to this session.

As a result of the brainstorming session I decided to focus on balance again, which had been the subject of the pilot study prior to this one. Since the older adults were concerned with the parts of their body that contributed to stabilizing their balance, it made sense to narrow down to this issue. In addition, out of a worry that wearable technologies for use at the center might limit their transferability, it made sense to explore technologies that could be more easily accessed or shared among exercisers. Another decision at this point was to explore how comfortable participants would be with technologies, so we added technology probes.

3.10 Data Analysis and Synthesis

While attending classes I kept my own notebooks and took photos, videos, and audio recordings, depending on which was appropriate or feasible. I used NVIVO software to organize the written and audio-visual data, which made it possible to have an overview of the codes emerging from the data, while transcribing and studying the material. However, using the software proved to be very time consuming and not very intuitive, so I switched to manually creating post-it-note fields of information on cartridge paper (Figure 3.12: Analysis post-it notes).

FIGURE 3.12. ANALYSIS POST-IT NOTES

They could be laid out or pinned up to provide access to all the information at once. All of the artifacts — my journals, participants' journals, participants' photos, workshop models, student notebooks and reports, the class blog, student scenarios and presentations, and the technology probes —were also systematically reviewed and incorporated into the coding process.

Over two years, in fits and starts, I analyzed the data, beginning with an open coding technique where major categories emerged from the data as noted by Creswell (2013: 86). Since I had not entered the field with a specific hypothesis to prove, it was, at times, not easy to see where the data was leading. As Charmaz notes:

> *The interaction between the researcher and the data result in 'discovering', i.e. creating categories. In short, the 'discovery' process consists of the researcher creating discoveries about the data and constructing the analysis. How the analyst uses the method and which questions he or she brings to the data shapes the results (Charmaz 1990: 1165).*

For example, the two sub-questions I started with changed over time. Initially they were:

> *How can insights into the experience of sensory changes in ageing contribute to design guidelines for innovative wearable technologies to enhance quality of life?*
>
> and
>
> *How can generative methods for co-creation contribute to providing empathic knowledge about the senses for applied industrial design research?*

They evolved iteratively into the questions in this document, in part because my initial approach to the data was focused on looking for information about older adults' sensory experiences. However the data began to lead to questions about the kinds of sensory information that were arising and the appropriateness of Co-design as the only method for gathering empathic sensory knowledge. As a result, I modified the questions and added more. These changes were inspired by sociologist Kathy Charmaz who says, "from a social constructionist view, the researcher takes those questions a step further. Whether addressing definitions, awareness, feeling, control, or any experience, the social constructionist attempts to find out how each develops, changes and gives rise to consequences" (1990: 1165).

Furthermore, while sorting the data into larger thematic groupings, those groupings became more focused. Bailey notes that, "like Emeril Lagasse, a master chef and television personality, who "kicks" his dishes "up a notch" by adding additional garlic or other seasonings, the goal of moving from open to focused coding involves kicking the raw materials in the field notes and transcriptions up a level that facilitates your ability to make analytical insights into the setting" (2007: 130). For example, in this study while regrouping and adding data, I first named one of the categories "What is your sense of it (experience based)", which became "Having a sense of it (experiences)", which turned into "Sensory Contexts" (see Appendix I: Analysis Iterations Coding).

This process for analysis and interpretation is influenced by Ackoff's DIKW model, representing different levels of Data, Information, Knowledge, and Wisdom in successive steps going from the practical to the abstract (Ackoff 1989). Sanders and Stappers' (2012: 200-202) version of the DIKW model makes the most sense to me (see figure 3.13: DIKW Model). At each stage of analysis, the data is transformed into more meaningful insights.

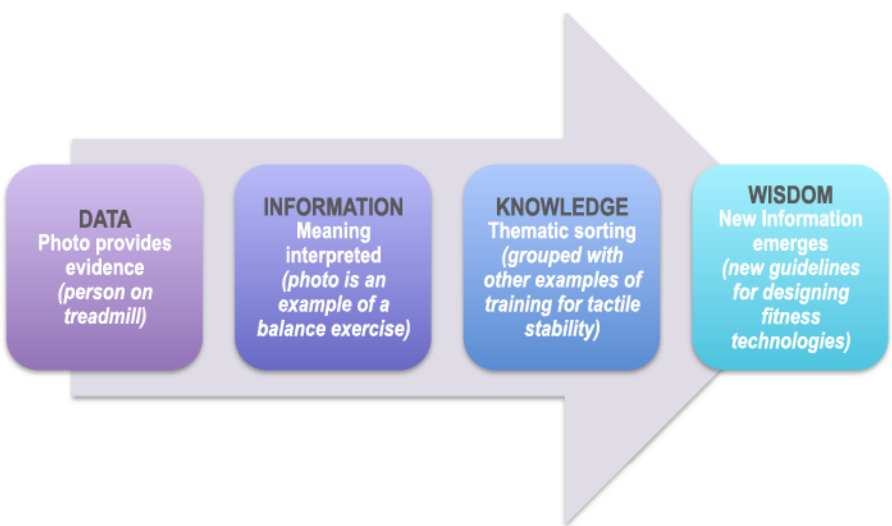


FIGURE 3.13. DIKW MODEL WITH EXAMPLE (ADAPTED FROM ACKOFF 1989 AND SANDERS AND STAPPERS 2012)

At level one, the Data level, Sanders and Stappers explain that when a phenomenon occurs the researcher captures that evidence as Data, for example by taking a photo of an older person on the treadmill. Since the researcher has selected what to record, according to his or her criteria of importance, the data has been singled out from the phenomenon. At this point it has no meaning; it is simply a photo of a person on a treadmill.

It becomes more significant at the next level, the Information level, when the researcher interprets it and ascribes meanings to the photo. For example, instead of simply being a snapshot of an older person on a treadmill, the photo is interpreted within the context of the research study. It could be categorized as a "photo of a balance exercise" or as "photo of balance training position on treadmill" or alternately as "photo of most popular piece of balance equipment in the gym". Clearly, each of these meanings can be valid, and the one chosen by the researcher reflects his or her interpretation of the main categories emerging from studying the data. At this level, several photos may fit into the same category of balance exercises, making it possible to analyze and organize the observations into a range of balance exercises or popular pieces of equipment.

At this point the researcher moves from analysis to synthesis, into the Knowledge level, where insights begin to emerge. All the information from the previous level is further sorted into patterns, or groupings that belong together thematically. In the case of the photo of the person on the treadmill, it may now be grouped with other information in a theme called "training for trust". The knowledge extracted from the "training for trust" category could be as simple as, "older adults depend on their tactile senses in their hands as well as their feet to keep their balance while exercising".

Sanders and Stappers say that, "Knowledge is generalized, abstracted from the individual data and information bits about which it is made and, if we succeed in making a successful theory, it can predict further events, and further data can be extracted from the evidence" (Ibid: 201). That describes the highest level, the Wisdom level. Here, the researcher synthesizes the thematic insights and may propose new theories or applications arising from studying the material. In this case, the emerging wisdom could contribute new empathic and sensory knowledge about designing technologies for fitness for older adults.

3.11 Limitations and Validity

> *Researchers never really know how projects will work out in the end, how much work will be entailed, or when their projects might be considered completed. This sense of "open-endedness" is further complicated by a realization that beyond the efforts one might be willing or able to devote to a project, one is inevitably dependent on the schedules and willingness of others to participate in this endeavor (Prus 1994: 25).*

There are limitations to these methods. In this study, it would have been desirable to hold another co-design session with the older participants who had been involved with the technology probes for comparison. It would also have been preferable to conduct expert interviews with physiotherapists and other trainers. In addition, this sort of qualitative research will not generate quantifiable measures of success for new products, environments, or services, although some measures may come out of such practices. However, the three methods described in this section yielded an enormous amount of data that is applicable to design processes as well as potential applied design research insights for wearable technologies for older adults.

Data triangulation, a key feature of qualitative research, contributes to the credibility of this investigation, in which data sources as well as data-collection methods were triangulated. According to Bloomberg and Volpe, "Gathering data from multiple sources and by multiple methods yields a fuller and richer picture of the phenomenon under review" (2008: 86). However, other criteria assuring validity such as inter-rater reliability were not employed in this study, since the data was not standardized. The insights from the triangulated data sources and methods "will be useful to others in similar situations, with similar research questions or questions of practice", which contributes to the transferability of the knowledge arising from this research (Marshall and Rossman 2006: 201).

3.12 Ethical Considerations

This study received ethics clearance from two university research ethics boards: Concordia University where I am a Doctoral candidate and Carleton University, where I am an Associate Professor. As it involved two groups of participants — students and older adults — it was important to ensure that there would not be any risk for either population. Out of the thirty-nine signed consent forms, only one person asked not to have their photo or video included in the documentation of this project. No one withdrew from the study, although they were given that opportunity. Nonetheless, participants' names have been changed in part two.

4 Narratives

Many years ago, as a jeweler, my relationship with metals like silver and gold was intuitive. When soldering two pieces of silver together while constructing a ring or a coffeepot, I could sense when both pieces were hot enough for the solder to flow yet not so hot as to cause the metal to melt. This could be the difference of a split second. When the red glow of the metal and the sound and colour of the flame were just right, I would gently run the flame along the path of the joint to guide the flow of the solder. It was a meditative process that required a clear mind, a steady hand, and good contact between pieces. Sometimes I could perform miracles, by soldering pieces that had no physical contact, through heating, hammering, and forming metal in ways that challenged my common sense. I relied on some sort of bodily knowing about just how hot, just what colour, just what kind of flame sweep, just how much time, and so on.

That inner knowing changed in 1994, when I began teaching in the School of Industrial Design at Carleton University, which was well known for its engineering approach to materials and processes. We taught students to iteratively sketch their ideas, and then to translate the final sketches into technical drawings, with exacting specifications for materials and tolerances, especially at connection points. We taught them to make illustrative models from materials other than those specified. These were later painted to represent the plastic or metal of the proposed end product. This industrial design approach to visual representation ensured that multiples of the same products would be identical and exact. Over time I became indoctrinated by the idea that precision and technical knowledge were essential in the design of a good product concept. Without realizing what had happened, I had morphed into an outsider; a technical approach had replaced my intuitive relationship with the materiality of my designs.

One summer after several years of immersion in this new frame of mind, I spent a week working with a Canadian silversmith I had long known and admired. I had an idea for a piece that would have been difficult for me to render in a technical drawing, given its curves and constantly changing diameters and directions. In fact, given my current industrial design mindset, I was convinced that it wasn't even possible to make and was about to discard the idea when she encouraged me to pursue it. So there I was, no longer a believer, back at the jeweller's bench, intuitively performing miracles by heating, shaping and soldering a flat sheet of copper into an undulating tube with varying diameters and orientations along its length. It took four and a half days of intense concentration to complete the piece.

I still have that wonky artifact, but I didn't keep it to remind me of my high level of craftsmanship. I kept it to remind me of how easy it is to get stuck in a limiting point of view, especially when my body had previously experienced a deeper knowing. This dissertation acts like a similar reminder for me. It presents my ethnographic findings first as descriptive narratives, not as prescriptive suggestions for product solutions. It is meant to guide an intuitive appreciation for the sensory aspects of ageing from an anthropology perspective. These narratives set up the foundation for generating principles for designers to consider when developing wearable technologies for impaired older people.

In the long run, however, the principles are less important than the deeper knowledge about how a sensory anthropology perspective can inform industrial design research. These chapters present my learning, avoiding the third person narrative style typical of design research, because the insights arose through my immersion in the field and my particular frame of reference. It presents what I found in answer to the questions in the following order:

Chapter 4 presents findings relevant to the question: How can a sensory anthropology perspective inform industrial design research?

Chapter 5 presents findings relevant to the question: How can generative Co-design methods help provide empathic and sensory knowledge about designing with and for older people?

Lastly, in Chapter 6 this information comes together to answer the main question: How can designer researchers gain insights for designing wearable technologies for an older population?

4.1 People and Place

This section begins with contextual information that describes the place and the key expert influence, with supporting examples. The interpretive narratives that follow address four of the sensory anthropology themes that arose in this investigation: participants' worldviews, bodily ways of gathering information, interaction between senses, and the sensory roles of artifacts. It begins by describing the setting.

4.1.1 The Seniors Centre: A Safe Place for Successful Ageing

There are nine of us in the Integrated Fitness exercise room: Debbie, in the corner is raising and lowering her heels; seven others are in a circle tossing beanbags to one another. George is sitting on top of the two chairs that I had stacked, one on top of the other, so that he too can participate in the circle. I am watching the others, mostly standing stiffly in place, carefully tossing or catching the beanbags. Over time, some people loosen up, giggle a little and toss further: leaning to receive the beanbag, or stretching to throw it to someone across the circle. As the bags crisscross the circle, I see arms moving, hands reaching, and heads turning to the sound of gentle laughter. Only Sandra, the instructor, is using her whole body with each throw, dipping, bending, leaning over, and laughing out loud. Her positive attitude, firm instructions, and willingness to exaggerate her body movements provide a role model for the older exercisers. She can do it and she doesn't fall over. Is anyone else ready to take that risk?

I think back to Kindergarten, when it would have been hard to stay in one spot in a game such as this. Here I could be looking at my future self; stiff and unable to loosen up to do the simplest of things, like tossing a ball. Now, however, we are in a non-risk environment; when someone is ready to push beyond his or her limits Sandra will be there to assist.

Earlier in the morning, the exercisers gradually ambled in for the start of class and sat in a circle for warm up and discussion. Sandra greeted them like a bird chirping sweet songs their way. How could they not be encouraged? The two men and five women followed her lead in alternate knee raising and lowering; toe raising and lowering; heel raising and lowering. While demonstrating in her chair, she said, "if you're comfortable, come to the front of the chair with your hands behind your back." One person did. To my design student Philipe it seemed like, "no pain is basically the rule that is followed. At any sense of discomfort, exercisers are to stop their activity and rest".

After the warm-up circle, the exercisers headed to their first exercise spot — one of the two senior-friendly treadmills, one of the two elliptical bicycles, the recumbent bicycle, the weight-stack machine, the balance station, a chair, or a floor mat placed on a raised table top for easy accessibility. Each person may have adjusted the machine to his or her capacity, or not, then slowly, while chatting away, everyone worked on his or her exercise routines. Maybe that's why Philipe added, "the class is not a rehab class, but more of a social fitness gathering where people stretch, move and train muscles they may not necessarily train with other daily activities." Confirming the social aspect, Anne arrived late with her tin of homemade cookies: a reward for the end of class. Steve greeted her across the room, interrupting his non-stop talking to a fellow doing back exercises on a raised table, happy to see Anne and the cookies. Since this room is rather small, it is easy to talk to the person across the room or tell jokes that everyone can share a chuckle over. One of the older exercisers told Philipe, "We exercise our tongues more than our muscles!" Sarah, another design student added, "they have a joke file" in their exercise room — imagine that!

After machine training, Sandra invited anyone interested to join in the beanbag circle exercise in the center of the main room. This room is part of a sunny cluster, including four smaller rooms. It is at the street front of a converted 1896 gray stone town hall building next to a matching gray stone church. The glazed street door entrance is no longer used; it is now a small equipment anteroom beyond the balance exercise station where Debbie was doing her heel raises. I place my backpack in another slightly larger equipment room off to the other side when I am there.

The other room in the cluster has a multi-weight machine that the more independent exercisers use. It also has bins of smaller equipment, a cupboard and a kitchenette at one end. In the last few months of my visits we set up the technology probes in this sunny space. The machines are similar to those at a regular gym, but appear much less complicated here. Here the equipment is simpler, cozier, and more forgiving. As design students Kathleen and Conrad noted, "The Nu-Step is often used for stroke patients because they can sit and relax and it can exercise all their limbs". The place feels safe, comfortable, and suitable for "somewhat impaired" older adults. It seems like a place where successful ageing is understood to be about working with and "accepting limitations and losses" as noted in the literature review (von Faber and van der Geest 2010: 27).

In addition, small pleasures add to the atmosphere when, at the end of the stretching circle, there are jokes and cookies. I rarely came without a snack to share. Food plays a part in the overall social ambiance of the centre; the monthly potlucks in another larger gym or auditorium are full of older exercisers, mostly women, who bring a range of tasty dishes from casseroles to cakes. This is a far cry from design student potlucks at the university in which packages of corn chips and salsa compete with nanaimo bars for the dish of the day. These events are about socializing. The promise of a meal can be interpreted as an easy lunch; none of the guests have to prepare the food for everyone else or clean up afterwards. One might say that is a good reason for an older person to attend, but that would be only a small part of it. These are meals of laughter, conversation, interest, and association.

The social interaction is the reason some participants love their exercise classes. Melody, an older adult, writes in her journal, "Did exercise in class and stayed to chat with the ladies. I really enjoy our time together to chat. I always come away feeling good. Good from the exercise and good from socializing with these women. I look forward each week to my exercise classes and chat times".

Cheryl, her exercise-mate, also enjoys the companionship,

"The group had a wind-down time over tea & coffee in the lounge. This social aspect of the group is important and most of them join in. Our particular group is very compatible and we have a lot of fun together. This encourages people to take part".

While the literature review addressed a number of individual aspects related to older adults' quality of life, it did not consider the social aspects of community, fun, and common experiences that reveal themselves in these vignettes. These affective aspects of older adults ways of being fit are part of the key to understanding and designing for successful ageing.

Furthermore, behind the scenes, the staff at the Seniors Centre work to support their clients' sense of belonging, as described in the next section.

4.1.2 Planning for Thoughtful Fitness Instruction

In my time at the Seniors Recreation Centre I got to know Marjorie, the Program Coordinator, and Sandra, the Integrated Fitness instructor better than other staff members. Marjorie is a gem in her own right, having evolved the Centre's programming into the most progressive (according to her) of any of the City-run senior centers in Ottawa. She welcomes research and new ideas, takes pride in the programming and social aspects of the Centre, fitting them in between making after-class snacks, snapping photos for recreation brochures, and coordinating all the centre's programming. She supports Sandra whole-heartedly. She was excited by the idea of our co-design workshop and proposed several good ideas for recruiting participants from among her clients. For Marjorie, my research promised to be an engaging activity for her clientele: they are the people who matter. She seems happy to see us taking an interest in them.

Sandra is the primary expert in this study, in the traditional sense of the term "expert". She is an exercise therapist with her Bachelors in Education from Britain and years of experience working with older adults. However, we did not begin our work with an "expert interview" as could be expected in many design research projects. My students and I got to know and work with her slowly, over time, week after week, showing up, assisting as needed, bringing snacks to her classes, asking questions, observing, and just being there. Sometimes she would explain general principles, or what she was doing with specific exercisers, "it's like a jigsaw puzzle, really, and you work on each piece to bring that puzzle together". Occasionally she would draw one of us into the exercises so we could experience them ourselves. Sandra approached fitness from a multi-modal perspective, preparing her older students for their everyday challenges and making sure they understood how to handle them.

One week, Sandra went on a Caribbean holiday. While there, she read a book called *Fallproof: A Comprehensive Balance and Mobility Training Program* (Rose 2010) that inspired her with easy-to-set-up and diverse exercises for older people. This supported her main objective of making it possible for her older clients to live their lives independently. "What are you going to do if you are walking on the sidewalk and the neighbours' dog is heading straight for you? Step out of the way quickly! We need to practice that!"

She has instructed some of the exercisers for years: partly working one-on-one with students and partly leading group activities. She keeps records of each person's routine to track and guide weekly progress, setting aside some individual time for each person in every class. She encourages her students to pay attention to their own comfort level, gently easing people into challenges that are suitable for them and creating unusual exercises for developing their bodily awareness.

In a brainstorming session with Sandra before developing our technology probes, she explained that she uses everyday metaphors for her class activities. We discussed some of them, such as rivers and gardens, as possible scenes within which exercisers can work on their stability and practice confronting simple obstacles in the environment. Shortly following our meeting, I attended a morning class in which Sandra had her students planting and tending imaginary gardens on cushioned workout mats.

While introducing this balance exercise, Sandra places five mats side by side, with a foot of space between them, calling them gardens. She tells each person to stand on a garden, and stands on one herself, saying, with her English accent, "A little element here as well, apart from the balance. So as yet, these gardens are unplanted. They are your own gardens and you can plant whatever you want — fruit, vegetable, tree. Okay so you decide what is in your garden."

While standing on the mats in a simple balance pose with feet hip distance apart, she asks each person to name what is in his or her garden. Sandra repeats what each one says, adding, “Without standing on the floor you’re going to visit somebody else’s garden… So you’ll all be moving on these mats carefully. Try not to put your foot down on the floor. Once you get to somebody else’s garden we’re going to do a more-than-moderate level challenge balance. Okay away you go”.

As they go, Angela, one of the participants, wobbles a little.

“Try not to step on the floor, but its okay, if you need to, Angela, for safety’s sake”.

Each person walks to someone else’s garden. Sandra instructs “a more-than-moderate level of challenge” and almost everyone places one foot in front of the other, except for Debbie, who looks perplexed.

“Are you okay Debbie?”

“Yeah” she giggles, “trying to remember names.”

Sure enough Sandra says, “Name your garden, we’ll go down the line.”

Percy, balancing with one foot in front of the other and slightly separated, says, “tulips.”

Then, “carrots” says Laura, a pause as Sandra, who is on one of the gardens, remembers “forget-me-nots”, then some shuffling, giggling and hands covering face before Andy says “broccoli”, and lastly Lina says “swiss chard.”

“You got it,” says Sandra. “Feet hip distance apart, step off your garden and please put your garden away.”

Variations on the same theme in other classes included bending or leaning to plant a crop, and weeding or tidying up someone else's garden. Sandra is at the same time very serious, but also laughing, and consistently encouraging. She has everyone multi-tasking: they have to work hard to remember what is planted on each mat, while they walk, and turn around, and reach, and bend.

Sandra's approach is both novel and challenging. It is the antithesis to the fast paced, music thumping, copycat, isolated muscle group aerobics classes that the students and I are used to. She is not encouraging her students to force their bodies into some Olympian ideal shape. According to her, they need to learn how "to function in activities of daily living like walking, balancing, standing, sitting, and transitioning from "sit-to-stand" in their current condition, not how to get back to the way life was before the impairment." From her perspective, a one-size-fits-all solution will not address her clients' wide-ranging and unique limitations.

If they are able to, Sandra's students develop a sense of how their bodies feel and an awareness of their specific capabilities in everyday situations. She tells each of them, "Let your pain be your guide". With her guidance, they learn to adapt their perceptions, which have been strongly influenced by their assumptions and stereotypes.

4.2 Participants' Worldviews

My twelve design research students are sitting around a table in the seminar room at Carleton University and each has given him or herself an ageing limitation. Two are wearing fogged over glasses; some have taped their fingers together in places, and others have stuffed cotton balls in their ears. No one can adequately follow my lecture about ageing since each person is missing some sensory ability that contributes to comprehending the whole message. Some quit early, pulling off their hazed over glasses (obscured vision leads to the most frustration), the tape from around their fingers or the cotton balls from their ears; a few stick it through to the end of the slides. This is an empathic design research technique for putting oneself in another's shoes. Quitting early, however, is not an option for an older person whose sensory changes are not easy to discard when they become annoying. The objective is to simulate and come to experientially understand what life may be like for the population at hand, to get a sense of another's worldview. It is a fake scenario; one that design educators like me believe to be informative. Perhaps if students were to believe that they had really lost a sense that they previously had and could not regain easily, they would be more sensitive to the issues. I suspect that peeling off the tape indicates a preference to cling to a more comfortable view, a view that separates myself from the other (Goffman 1963).

Earlier in the day, I had asked the students to think about how they perceived older people, and what they expected to learn in this research phase. As they listed their assumptions, their negative biases emerged: reduced vision, reduced hearing, poor balance, poor stamina, limited strength, and limited memories, to name some. They painted a sad picture of their future research participants, complete with stubbornness, reluctance to try new exercises or ways of doing things and a lack of trust. Remarkably, the students thought the elders might "feel intimidated" by them; that they might be self-conscious and "not view young people as having knowledge relevant to them." These revelations confirmed the literature about ageism, where loss of social acceptability and personal power identify the old as inferior to the young (Biggs 2004; Featherstone and Hepworth 1991; Wearing 1995). Not all the comments, however, had a negative slant; some students expected to find a social environment with people who were motivated to exercise in tune with their capabilities.

Imagine their relief, when over the next few weeks they found the older exercisers to be friendly, curious, talkative, and indeed, a very social bunch! Nor were they decrepit, although many did need assistance to do rather simple exercises. According to Jack, a design student, "Many things that I took for granted were a challenge for others. It was only after I participated in an exercise that I realized how challenging life must be for those with poor balance". He finally realized that there was no removing the frosted glasses for these older people. The students also discovered that "there was not as much competition between the people, they were all fairly comfortable with their own abilities and there was little one-upmanship." Fitness is a competitive activity for younger adults in our society; by identifying the lack of competition, the students uncovered another assumption that was rooted in their daily experiences.

One more example of this sort of limiting view occurred in the design of the pre-session homework assignments, where the older participants were asked to photograph the clothes in their gym bags. Without exception, they replied that they do not have gym bags. We all missed this likelihood, perhaps because the students and I all have gym bags. While it was a small faux-pas, it draws attention to a missed opportunity: missed because of our self-referencing. We could have asked them to document something they really do have.

How much is the quality of design research affected when it is hard for the researcher to recognize his or her limiting assumptions? We were fortunate to be in a situation that took us outside of our comfortable worldview in a collaborative manner that aligned us with our older participants' points of view. While this may seem obvious to an anthropologist, it is not the case in many design projects.

The older adults were also conscious of the separation between young and old in our society and appreciative of the opportunity to prove otherwise. Elizabeth, one of the seniors who later participated in the design sessions, thought it was, "very good that they came to the classes first because without that they wouldn't have realized the level of exercises that we do. Just vastly different from the exercises their age group do and the different parts of the body that are brought out by the different exercises". She felt that the students had become sensitive to their exercise routines and the key role that their instructor plays in guiding the exercisers by saying things like, "press your shoulders down" and "be aware of your exertion level". To her, the student observation visits enhanced their ability to understand her peers' design-related issues and increased their ability to communicate across the age gap when designing together. In retrospect, Elizabeth's impressions highlight how clearly the elderly realize the assumptions people have about them, "Hopefully they went away with the feeling that old people are not old and dottery, in wheelchairs, it didn't appear that had entered their minds."

While the older adults were congenial in fitness class and with the students, there was more behind their motivation to be there:

Melody describes her physical challenges in her journal: "after being in an accident 10 years ago and how it has turned my life upside down, I am left with many limitations, fears, and health issues to confront each day… I am tired after I exercise but it is good tired with a sense of accomplishment (my mobility is improving)".

Fitness classes are worth making an effort to attend, according to another participant, who writes in her journal: "take 2 buses to Centre and in order to make connections and be on time for class must leave 1 hour early. In good weather I walk part of the way."

In the co-design session Dave introduces himself: "I have had both hips replaced and I'm due for a replacement of a replacement which I'm dreading. Anyway… I'm disabled and I'm in favour of anything that favours the disabled. That's why I'm here".

Dana, a design student, reports on a conversation she had over lunch: "Two of the women I talked to had a history with exercise. One was a dancer and one was just very active in the outdoors. They both noted that they had issues in balance. Which is why they were sitting at the balance table. They stated that they had to walk a lot slower because even on slightly uneven ground, they did not feel they had the confidence to take a step forward".

These adults once had the agility and sensory capabilities of the younger students and had changed with age, naturally or dramatically by accident. While that future is farther away for the design students than it is for me, we could be seeing our future reflections in the looking glass. Will we be as wise as Melody, who says, "I have learned to go with the flow and break chores down to make my life more manageable and easier"? Acceptance really is part of successful ageing.

In the case of attitudes toward fitness attire, there was also a lot to learn.

4.2.1 Fashion Sense

I had asked the students to pay attention to what people wear to fitness class. In their report, Sue and Sarah type in bold, "**past caring about fashion"** and add under comfort "anything that allows them to exercise". I too, had observed the comfy clothes, but there were some outfits that surprised me. One ninety-three year old woman came to fitness class in a gorgeous silk blouse, white blazer, with a diamond brooch and a lovely fuchsia scarf. She was ready for choir practice, which came right after this class. Another woman on a stationary bike was in her nylon stockings and sandals, which did not stop her from pedaling slowly toward her fitness goals. Yes, there was one somewhat younger woman, in her late sixties, who did have a brand name fitness outfit as well as a heart rate monitor. She was the exception.

Design students, Kathleen and Conrad note, "When asked about clothing, the instructor says she recommends WalMart for inexpensive exercise clothes that wear well… they all agreed that cost was an important factor except one woman who was wearing LuLu Lemon, which started a discussion about cost vs. quality, brand names, etc."

Why would anyone buy expensive Lulu Lemon (the Seniors Centre is directly across the street from the Lulu Lemon store) when they are just coming to exercise? On a fixed income, it makes no sense to buy clothes that don't really make a difference in HOW one exercises. This important and somewhat disturbing clue came early in the investigation. It was disturbing because we were about to engage in working with these older people to design gadgets that incorporate technologies that will surely make the cost of their new goods even higher, and they are not purchasing them in the first place!

It's a good thing ignorance is bliss because we optimistically looked forward to the insights we would gain from the participants' own photos and descriptions of their exercise wear!

The photos the older adults took confirm they generally wear comfortable clothes (see Appendix H). In photos of six different people, we see the men and women all wearing some sort of sweat pants or jogging pants with a loose shirt, either a T-shirt or a baggy top. Evelyn is in a matching purple/blue velour zippered jacket and pants, while Janice has on a rather stylish zippered stretchy jacket that matches her black stretchy pants, with a blue pattern that matches her blue sneakers. Gord sports a checkered cotton shirt with a black knit vest over it. Three people are wearing sneakers, Dave is wearing slippers, and Evelyn is wearing sturdy shoes. They are all wearing relaxed clothes that are not particularly trendy. As Elizabeth says, the students "probably didn't know what everybody wore. Just old cotton… they are at an age where everyone wears all these snazzy outfits". She was correct, sporting fashion, which has ensnared the students, is out of the purview of the older adults.

I was puzzled by another difference in attitude toward fitness clothing — why don't people change their clothes after fitness class? I first surmised that when a person doesn't sweat and his or her clothes don't smell or get dirty, why change? Later when discussing balance issues while getting dressed, I learned that most (thirteen out of fifteen) people seem to be confident that they can put their pants on with a minimal amount of support. That means they are generally capable of changing from gym clothes to other clothes for the rest of their daily activities, but may need to hold on to something. However, in the Community Centre there are no change rooms, only bathrooms — one for men and one for women — and a cloakroom to hang up winter coats. There are no lockers. People don't expect to change there.

In addition, we learned that putting on clothes can be difficult. One woman explained that putting on her bra and shoes was difficult. I had inadvertently seen the bra problem in the ladies' bathroom, where it was a challenge for a woman to reach around her back to do the snap up. When we tried the last technology probe, the participants were asked to tie a component to one shoe. For several people leaning over that far was not easy. Shoes present their own set of problems that will be described later, but we did learn that people do invest in costly supportive shoes, depending on their unique needs. For the most part, when it comes to exercising, in contrast with the younger people's focus on fitness fashion, the older adults prefer comfortable, inexpensive, and easy to manage clothing. While Sandra, their instructor, encourages her students not to invest in expensive clothing, she values how they invest in their body awareness, as discussed in the following section.

4.3 Bodily Ways of Gathering Information

Dave, one of the two older men participating in the workshop, walks into the room at a snail's pace, leaning heavily on his rollator. He tells us that he used to go hiking with the boy scouts; he would fearlessly lead his troupe over a fallen log stretched over a river. He says this with some incredulity, as if to ask how did I get here? Why am I now stepping so slowly, holding on for fear of falling? He is in the worst shape of this bunch, but he is not the only one who needs support to stay in balance.

Our observations provided an understanding of how different exercise is for these older adults: it is slower, it is careful; it is not strenuous. It is not circuit training! Everyone has his or her own limitations and needs some sort of adaptation. For example, in a circle session Sandra asks the seniors, sitting on either single or double-stacked chairs, to place their feet firmly on the floor in front of them. Looking around, some people's knees do not bend at ninety degrees; others feet are flaring outwards; or even one foot flat and facing forward, while the other is turned sideways. Design student, Andrew says, "to get into some of the machines require more coordination and balance than the actual exercise. One lady mentioned having to grab and lift her pant leg up in order to get her legs into the machine". Once she is seated in position and the resistance setting adjusted to the appropriate level, she gently, very gently, cycles away.

At the treadmill, Steve, an older fellow, gets on and goes ever so slowly at the speed Sandra has set for him. One step, the other, one again, and so on. No need for a heart rate monitor here because he is going soooo slow. And he is thrilled. He tells me that after his stroke he couldn't walk at all, and now he can walk across the living room, up a small step into the dining room. He is very proud of his progress. It came slowly and he still expects to adjust the speed of the treadmill up a notch faster. At the same time George, another older member of the class, is using the other treadmill in its off position, placing a foam balance swimming noodle-like beam from front to back in the middle of the treads. He is trying to keep his balance while stepping along the noodle from the back of the treadmill to the front and holding onto the handrails. Indeed, everyone holds onto the treadmill handrails, without exception. It's like riding a horse with a western-style saddle; holding on is the natural thing to do, given the placement of the handhold (horn).

Not all classes incorporate exercise machines for fitness training — some of the classes also involve group activities. One sunny day, the group lines up to walk through a path of pylons weaving slalom style through the center of the room. The weaving adds a challenge — staying straight, looking where the next footstep should be, trying to avoid knocking the small orange pylons over, all without holding on to anything. Sandra laughingly offers either five hundred dollars or a beanbag to wear on your head while walking through the course and five of the six take her up on the offer (the beanbag part) and wind their way carefully around again to start all over. George gives the beanbag back, perhaps realizing he has to look down at the pylons and can't keep his head up at the same time to see where he's going. Sandra praises him wholeheartedly for knowing his limits. After these activities, she suggests that we try our terrain-mat boxes probe as a repositionable obstacle course, without the shoe-mounted feedback.

We set up the terrain-mat boxes in a line, arranging chairs beside the more challenging surfaces for a handhold, if needed. They can cross over our fake cobblestone surface, curb-height step box, hilly angled rubber surface, abandoned-lot-like strewn pipe surface, flat surface and through our mini sand-box. Sandra demonstrates ways to stay in balance, "When I say STOP you want to make sure you have a nice stable base of support. For example here, when I say stop you can choose to go here". She places both feet on the high box. "Or here," and she steps back with both feet on lower floor surface. With the chairs in place, people move one at a time along the path, trying not to hold on. In some instances my assistant Sarah, Sandra, or I offer a helping hand to an exerciser who needs some support. But there may not be a helping hand on the sidewalk later in the day. The group is rehearsing for a simple daily walk; preparing their bodies for the unknown obstacles that could stop them in their tracks.

After walking over our terrain-mat squares in a line, Sandra rearranges them into a zigzag path across the room, with more diagonal space between squares. Not everyone participates in this more complicated obstacle course, but everyone watches as each path walker responds to Sandra's instructions to "STOP", "STEP BACK", and "GO" along the way. The walkers go at a measured pace, and stepping back is, for most people, a slow and wobbly full body wiggle to regain balance on the surface they had just left. They slow down and speed up in relation to their sense of how well they can manage each obstacle. Stepping on uneven surfaces requires more attention and an even slower speed.

It seems like we are learning about how feet participate in a sense of balance. We are also learning that they send signals to the brain that could say, "don't go there", or "you can do it", or "try it slowly and see how it feels". With our probes we are not trying to speed up our older exercisers; we are just trying to understand how they gather enough information to restore their confidence so they can tackle their daily activities with less fear of falling. We have some idea that fast is good for training. Sandra says, "many clients cannot gauge when they over exert, so they hold on to the idea that more is better, even though I can see signs of fatigue, exhaustion". For an impaired older adult speeding up often means he isn't able to pay attention and could suddenly trip, fall, and break a hip, changing the quality of the rest of his life.

Our feet also connect us to where we are spatially; they are part of our proprioceptive and kinesthetic systems that help us understand where our bodies are going. When Sandra asks her older students to slow down or stop, some of them resist because they can't sense anything. A younger person may not be aware of the feedback the sensory systems give us about where our feet are and can go. For an older person, those same feet that could dance to the side without effort, to avoid an oncoming dog or child, now find they need time to register and feel the right way to go. What makes a way right? Maybe it doesn't hurt. Maybe it is a route that he or she can visually evaluate first. Maybe it is a spot where her foot feels stable. Maybe he can't see the ground or feel it, and is not comfortable moving until he finds a support he can hold on to, like a nearby wall or his son-in-law's hand.

All of these maybes crept up over time on our older exercisers. Sometimes the awareness comes slowly, as in Dave's case when he realized he could no longer balance while crossing the creek on a log; or suddenly as in Anne's when she fell in her kitchen, broke her femur, and ended up in traction for months, only to fall again a year later. How does one's body gather information when its habituated ways become impossible as in Evelyn's case when she was in a full harness traction suit for eight months after emergency back surgery, and cried every day; or in Steve's case when he suddenly had no motor control over half of his body. They muster the determination to slowly bring their bodies to a place that improves their everyday quality of life.

4.3.1 Self-Monitoring

Ask a design student what self-monitoring in fitness means to him or her and you will likely get an answer involving "wearing a heart-rate monitor". If you ask one of Sandra's older students, however, you would likely get a different answer; one that has to do with knowing one's bodily capabilities or limits. The following scene from a balance-oriented class demonstrates this:

Each person is working at a different balance station placed around the room. Observing Laura, who is standing on a squishy floor mat, one foot solidly in front of the other, Sandra instructs, while lifting her own front foot, "Then can you stand on one foot, or not: Okayyy?" While Laura bends her knee, raising her left foot Sandra bounces off, heading over to George. He is still standing, one foot in front of the other, on the swimming noodle-like foam beam on the treadmill, holding the rails. "Concentrate. Good."

She swoops over to Debbie, who is balancing on a circular textured wobble board, holding onto the back of two stacked chairs. Seeing Sandra coming, Debbie changes from clenching the top of the chair to resting her open fingers on it. Sandra leans into the seat of the chair, looking closely at Debbie's hands, "Can you go down to one finger on each hand, tell me". As she does, Sandra responds, "Yes, you can. Excellent".

These are balance activities, for which they previously received positioning directions, but now the focus is not on the correct foot or body stance. It's on learning to monitor one's own comfort levels and to take small incremental steps from two full hands of outstretched fingers to one outstretched finger on each hand — micro adjustments, really.

Sandra doesn't even stick around to see if her students can do what she asks them to try. Everyone is trying something different, working to his or her own body's capacity; Sandra is providing tips for each individual to learn to monitor him or herself.

To Laura she says, "So you know all your levels of challenges. Correct?" To Lila she says, "Comfortable? Close your eyes. Open them before you start falling". As each student progresses she suggests the next sensory experience. "Remove your vision; try to feel what balance is for you. If you don't feel safe, open your eyes".

In our co-design sessions Janice sums it up: "I think you're hearing from everybody that because of the way our older bodies are constructed we need a lot of feedback about making adjustments of whatever sort, whether its in our feet or our shoulders or whatever. And it's a reflection about how we are taught here. Well, there's a certain instilling of the awareness- awareness of your balance… how Sandra teaches and some of the other people too — where your bodies ought to be when you're doing something and a lot of us, that's something we have to spend a lot of time concentrating on and I don't know whether it's just older brains or whether we're just geared physiologically to tense up our shoulders when we're doing certain things or get our balance off kilter because we're focusing on others".

This kind of self-monitoring is about awareness, not about numbers. It is about paying conscious attention to something a younger body may have automatically adjusted to, as Abram describes, that "continuous dialogue that unfolds far below my verbal awareness"(Abram 1997: 53). In old age, it needs to be consciously trained. As in our terrain-mat probes, cobblestones, cracks in the soil, uneven surfaces, twigs on a path, and level changes are some of the challenges of daily life that, once subconsciously noticed, now require training. The once familiar has become menacing as one wrong step could lead to a fall, and worse, a fractured hip. This is a good example of how training can assist in the reversal of the dominant sensory model of subconscious bodily responses that accompanies ageing.

In our youth-oriented culture, the dominant model is a younger person whose subconscious sensory perception is attuned to adjusting itself in response to the environment. This person has no need to supplement his or her natural human behavior for everyday contingencies. On the other hand, for an older person fitness classes help in developing supplemental awareness for everyday behaviours. In this case, numerical biofeedback statistics, such as heart rate levels, would be less informative than a posture-correcting pat on the back. To the older adults in this study, self-monitoring is a state of mind, not a set of numbers on screen.

4.4 Interaction between the Senses

Today seven adults in fitness class are walking the line. This is a multi-modal activity. Students follow the line. It makes a sharp turn and leads them onto a row of four spongy mats placed end to end, which in turn leads to another taped line, sharp turn, and back to the first long taped line: an elongated rectangular perimeter with one hard and one soft surface to traverse. Everyone starts out, head up, looking forward. After their first transit, they add head turns from side to side. At this point one person steps out; she is getting dizzy from sensing the added movement. Next they walk and talk; everyone is simultaneously describing what they are going to do for the rest of the day. Intermittently Sandra says, “STOP” followed by “KEEP GOING”. Every day people walk and talk, today it makes sense to train for this sort of multi-modal awareness: proprioceptive, kinesthetic, visual, tactile, and auditory stimuli simultaneously.

Later I see Jennifer in the balance corner, stepping slowly along another line. This time she is trying to read as she goes. This is a far cry from the “Blackberry prayer” — the bowed heads we are accustomed to seeing when younger people are texting while walking down the street — but it addresses the same issue. In daily life people are used to shifting sensory modalities, without paying much attention to the shift.

Sometimes something comes along to alert a person that a shift is taking place, as in the case of Joyce, an older woman who tells her co-design table-mates, “It wasn’t until after I got my orthotics that it took the pain away from my foot and put it in my knee!” She laughs, “So they told me to get rid of the orthotics”. For the most part, however, the shift in sensory modalities is subtle and different for each individual. For example, Sue and Sarah reported that, “There was a wide variety of clothing people wore to moderate their temperatures. In the same session one person was wearing shorts and a t-shirt while another person was wearing several layers of sweaters and vests to stay warm”.

While adding or removing layers can easily regulate body temperature, it is much harder to adjust to a sense that has disappeared, like feeling in the soles of the feet. Some people, Sandra explains, lose the feeling in their toes due to diabetes. They need to retrain their heels to send them tactile messages; this is a sensory reordering. When Debbie is trying out our first pressure mat probe and shifting her weight onto her heels, I ask her, “What does it feel like going back?” She says, “I feel like when I’m going on my heels that I’m overbalancing and I will fall over so it gives me an uneasy sensation. I don't know whether it is really so". She can no longer even trust her body to send her the signals she needs to stand in one spot!

During this exchange Sandra stops by to see what's going on. I ask why she has people practice shifting their weight backwards. She says, "Sometimes we do fall backwards, especially when going upstairs. We need to counteract that weight because there's very little we can do here to help ourselves". Imagine going upstairs, looking ahead, even holding the banister, but not really feeling where your feet are: it only takes one instance of not paying attention to a sensory deficit to land in hospital. Later when we are calibrating the Wii fit to each person before doing the bubble exercise, it is quite a surprise to see the squiggle on screen showing how far off center he or she had been in just thirty seconds of trying to stay in a balanced position! Even when trying, it is not easy to attend to the body's constantly changing position in space.

In class, the older adults use their hands to help themselves maintain their balance more than they would have as their younger and fitter selves. We notice that they prefer to be in contact with the wall or a chair back in some of the balance exercises. As a result, we set our technology probes up beside a ledge or chair and we act as spotters so the participants can hold onto something. There is more holding over the weeks, as the surfaces of the probes become more complex. We see that not only is stepping backwards a challenge for most people (including my assistants and I), but stepping up and onto highly textured surfaces leads to holding on. A hold is not always a full hold; it can be a hover with fingers almost brushing the surface of the ledge; it can be a clutch onto the spotter's arm; it can be a firm finger on a chair back; it can be one hand or two or alternating between hands, which confirms the literature (Gibson 1966; Schiphorst 2009). The tactile support of the hand acts like a pinch hitter for the loss of proprioceptive and kinesthetic sensory feedback. The literature addresses these issues, noting that some sense will compensate for the losses in other senses (Quadagno 2011: 131).

In the Wii Fit technology probe we discover that not only can one sense compensate for others, it can even dominate. The visual display is so absorbing that the participants pay no conscious attention to their body positions, all the while gyrating using heels, toes, knees, hips and hands to keep that bubble on the display away from the edges of the stream. As researchers, we too, forget to watch the participants' body positions, and instead find ourselves glued to the screen, urging the player on. Aha, it seems like this multi-modal exercise is a hit, especially given the laughter, everyone's desire to try it, the playful graphics, and musical accompaniment. Later, however, when watching the videos to see what we missed, I notice that almost everyone holds onto the sets of stacked chairs we placed on either side of the Wii Fit board. Some people also hold onto my assistant's arm, or mine, or both of ours! Given everything we are learning about interaction between the senses, the Wii Fit seems to have some sort of anaesthetic effect. Is that what we want from our technology?

4.5 Sensory Roles of Artifacts

In this investigation I found four categories of artifacts: adaptive, probing, generative, and conceptual. Each kind of object contributed to the participants' sensory engagement and sensory knowledge differently, as described here.

4.5.1 Adaptive Artifacts

An artifact can play an **adaptive role** in which it provides sensory assistance, such as tactile support, in ways that enable people to build trust, feel safe, and take small risks to make progress as discussed here. For example, a chair belongs in the adaptive group of artifacts that includes chairs, walls, railings and other things used to adapt exercises for the older participants.

There are a number of chairs stacked in the small sunny room. They can be moved into the center of the Integrated Fitness exercise room, where exercisers sometimes begin or end classes seated in a circle. The chairs look like old steel-framed school auditorium chairs, with black or blue vinyl upholstered seats and backs. Some have hard skinny arms and others don't, but they all stack on top of each other in a leaning-tower-of-Pisa way to conserve space. The most significant adaptive value of their stacking ability comes into play when one chair is stacked upon another to raise the height of the seat. This sort of loving-spoons arrangement makes it easier for certain exercisers to sit without the pain of bending too far down. It also helps raise the top edge of the chair back making it easier to hold on to, especially during exercises that require balance. Stacked or not, the chairs are also recruited to play the role of handrails, counter balances, ladders, and spacers.

The adaptive artifacts, like the chairs, help people feel more stable on their feet, even if they don't actually use them for support. They can work as a team or alone. They can be considered to be front line support workers, helping exercisers learn what kind of support they need to feel braced, steady, or just safe. It only takes a couple of minutes and some inventiveness to drag a chair here, stack a chair there, or arrange a circle somewhere else to adapt to different exercisers' unique needs. The chairs invite tactile interaction and play the role of steady assistants, whatever the challenge.

4.5.2 Probing Artifacts

An artifact can play a **probing role** in which it provides self-monitoring awareness opportunities, such as the terrain-mat of square boxes, that enables people to experiment with different bodily ways of being. The terrain-mat boxes are technology members of the probing group of artifacts. This group's roles include providing multi-modal experiences for study participants, using technology and borrowing from the participants' familiar training practices. Perhaps this group of artifacts can magnify and change the researcher's perspective about the situation.

The concept of the terrain-mat probe emerged from discussions between Sandra, two of my research assistants, and myself. We wanted to simulate some of the different terrains participants might encounter outside of their homes, in the spirit of Sandra's imaginary garden exercise with mats, described earlier. Not everyone can experience the underfoot feeling of Prague's cobblestones, the Sahara desert, or the World Trade Centre destruction site on an everyday basis, but they might find themselves in a muddy parking lot or on an uneven sidewalk. We wanted the probe boxes to guide the participants to step on different surfaces, in different directions (forwards, sideways, backwards), at different speeds, depending on their abilities. The squares we fabricated required a rather sophisticated system of electronics to direct the participant to move from square to square, at different speeds and in different directions. During the probe trial at the Seniors' Centre, the guidance unit on the wearer's shoe was not fully functional, but we were able to convey the sensory feedback to the participants as if it was really working, a common way of working with physical design research probes.

All of the twelve participants who tried the terrain-mat boxes liked the potential for exercising using the changing levels and textures on what could be called the surface tactile aesthetic. There were two people who found the surface changes very challenging for different reasons, such as unsteadiness on the heavily textured surfaces and instability on the spongy surface. Some people found it hard to make the transition between squares: they had to hold on to something or someone for support. We could see difficulties we had not previously noted. For example, one woman couldn't just step to the side: from flat, to rough, sideways. She actually had to turn to face forward and then take a step.

At one point Sandra, with our enthusiastic encouragement, pulled the boxes apart and left the complicated electronics back in the sunny room. From then on the participants were playing a sort of hopscotch or age-adjusted 'stepscotch', as hopping would have been too much of a challenge. We could see that our use of technology had overcomplicated the concept. Once the squares were freed up from the system we had worked out, a different sort of complexity was revealed. It was a complexity that challenged tactile and proprioceptive abilities, without prescribing them. According to Donald Norman (2011): "Complexity is good, complicated is bad". Through using the artifacts in a probing role, we learned about the importance of uncomplicated self-monitoring and the variations possible through modular complexity.

4.5.3 Generative Artifacts

An artifact can play a generative role in which the artifact is created during discussion and/or sensory engagement. These artifacts are always created collaboratively with participants, such as the models emerging from the Co-design workshop sessions that represent ideas and issues of concern to those participating. In this study, generative artifacts were initially created during the Co-design workshop activities. These objects act like props or very rough models of products, or just representations of things; their job is to inspire people's stories, and reveal different individuals' personal knowledge. Each of the models developed in this stage of the study revealed sensory information about people's main bodily concerns. One example of a generative artifact's role is described below.

We had brought old shoes to the Co-design session. They were second hand shoes in the arsenal of clothing pieces purchased so we could modify them with imaginary sensors during our design activity. At the beginning of the activity Jack, one of the student facilitators, sparked discussion by demonstrating how stickers pasted on the sole of an old sneaker could represent pressure sensors. The group of four older women and two students talking about the sticker placement became quite animated about different balance issues. The women had contradictory ideas about the key issues around feet and balance. That led to cutting up another old running shoe and decorating it with stickers as indicators of key balance points. While the shoe underwent surgery in the hands of the participants, their stories of pain unfolded. The shoes became props for their sensory tales:

Evelyn took off her shoe and started to rock it on the table. She said, "I find my balance is wonderful in these".

However Melody expressed a completely different experience. She said, "You have to be careful. I have back problems and can't use them".

Evelyn pointed at the running shoe in Melody's hand, the one that Jack had been helping to reconstruct: "This kind of shoe. I'm dragging my foot". She rocked her shoe again, saying, "I don't drag my foot that way. I don't drag my foot. I don't drag my foot. It gives me much better balance".

At this point in the conversation everyone was talking at once, and pointing, while Dana was sketching madly. Melody raised her foot beside the table and pointed to the ball area saying, "This area right here". Eileen, an older participant with laryngitis, suddenly started waving her hands around because she wanted to get feedback from vibrations and lights. Jack stopped putting the "sensor" stickers all over the running shoes and explained how proximity sensors and measuring stride distance could help them monitor their concerns. Then Sue, the student behind the video camera, commented that they could use sensors to massage their feet. Melody gave her a thumbs-up sign. By the end of the session the shoe, looking a little overdressed, captured the essence of the participants' stories. There were a lot of areas of concern in the foot that related to balance.

4.5.4 Conceptual Artifacts

An artifact can also play a **conceptual role** in which the artifact communicates a possible product direction, such as a future use-scenario, through two- or three-dimensional synthesis of data. Designers always create these representations; drawing on their professional skills, separate from participant engagement. In the field of design, prototypes, appearance models, renderings or a series of images of situations in which people are using the product are traditionally used to communicate design ideas. In presentations to clients and other stakeholders they act as visual proposals of design solutions.

In this study, the conceptual artifacts are the eleven concepts the design students developed further to the rough ideas generated in the workshop sessions. These models are communication tools for representing the range of possible product design directions. Each one addresses an older person's bodily issue, which arose in observations and/or in the co-design activities. The artifacts are all different, and all in need of much more work to be useful.

Here the gyroscopic headband, shown in figure 4.1, is singled out. Andrew shows sketches, a video, and renderings of what it could look like to represent what it could be. But it was just a conceptual proposal, which could not yet be purchased and used. This disappointed the older adults in the final concepts presentation, because it seemed so feasible.

Andrew's conceptual artifact had been influenced by his research observations. He had spoken to a vision-impaired senior in the observation session. That fellow wanted instant feedback about his posture. Then when Andrew was videotaping the co-design session he heard Gord say, "As we walk and we work or exercise we tend to start to lean over, to lean forward and the older we are the more we lean. As an alert during our day-to-day activities or as an alert during our day-to-day exercise program a sensor in the small of the back will tell you, probably by vibration, when you've gone farther than you should and you should darn well straighten up."

When Andrew looked back over the Co-design workshop videos, he also realized that Barbara had said the same thing at a different time at a different table," If there was some sensor that could realize you're leaning…" By carefully paying attention to what he heard and saw, Andrew was able to synthesize these findings into the concept for the gyroscopic headband. He designed a simple product solution to enable a person to adjust her balance with a vibration in the right direction every time she is unaware that she is leaning over. A picture of his concept follows:

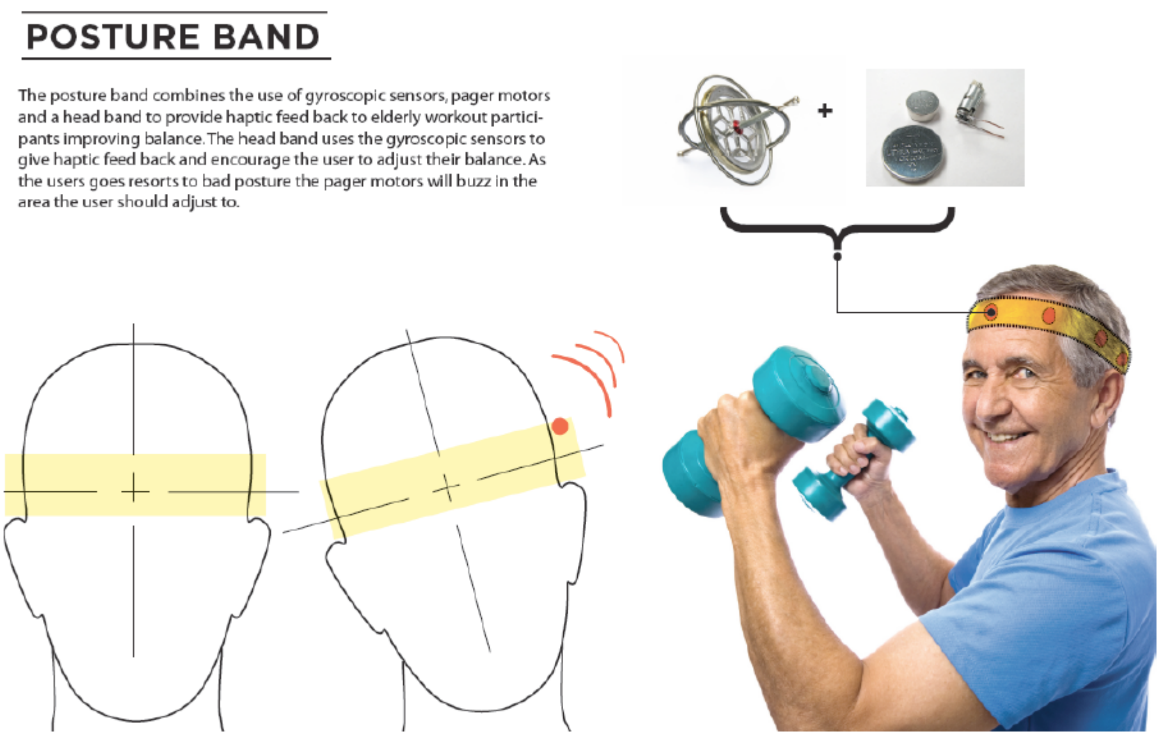


FIGURE 4.1. GYROSCOPIC SENSOR BY M. FROMOW

A simple concept like this one seems like it would be easy to produce and market. However when Andrew presented his idea to the older participants, their instructor, Sandra, saw many more possibilities for bands that could sense awkward body positions and encourage exercisers to move in different directions to feel better. She suggested a similar armband or knee band. As can be seen, the conceptual artifacts play a role in shaping future possibilities by communicating ideas that could be feasible for designers to develop.

4.6 Summary

In this chapter, a sensory anthropology perspective provides a framework for empathic design research insights into the context, the people, and the sensory fabric of the everyday interactions between them. These findings are organized into four areas derived from sensory anthropology: participants' worldviews, bodily ways of gathering information, interactions between the senses, and sensory roles of artifacts. They provide the following insights:

The Participants' Worldviews section (4.2) illustrates the importance for design researchers to become aware of their own assumptions, though this is not common practice in the applied field of industrial design. The lens of the design researchers can be fogged over by assumptions and habitual behaviours from our own daily lives, such as how and what we wear to exercise, for example. In this study the older adults also have assumptions about the younger design researchers. Over time, these views are ameliorated through interaction, casual conversation, and working together. We also find that in addition to those activities, the narratives provide insights into deeper individual issues that affect older participants' motivations for fitness such as pain, loss of sensory capabilities, degeneration, fear of falling, and social pleasures. Many of these findings confirm the literature that defines successful ageing in terms of acceptance.

The participants' views of fashion are a particular subset of their worldviews, where self-referencing and comparisons between young and old are addressed. The younger students and I tend to be more influenced by "fashion" (this is probably a thesis on its own) and the older adults choose comfortable, practical, inexpensive exercise clothing that they keep on for the whole day. However they are willing to invest in good supportive shoes.

The Bodily Ways of Gathering Information in section 4.3 provide the most insights into the seniors' sensory practices that are relevant to research for designing appropriate equipment and confirm much of what the literature says. Empathic understanding emerges through observing, discussing, and working with and around the older adults' capabilities and limitations. The issues that stand out include: slowing down to develop bodily awareness; varying physical and sensory changes that require adapting to; asymmetrical bodily limitations; holding as a strategy for stabilizing balance; interpreting body position through the feet; knowing one's limits through self-monitoring; and taking pleasure in small improvements. In addition the loss of automatic or below-conscious monitoring of body position highlights how exceptions to the dominant youthful sensory model present challenges for older people.

The sensory practices in the previous section are compounded by Interactions between the Senses (section 4.4), which are also discussed in this chapter. Multi-sensory design solutions depend on an awareness of the interplay between senses during activities. For example, it is no surprise that everyday activities are multimodal, such as walking, talking, sitting, and looking, which often occur at the same time. The surprise, however, is how important it is to train for the shifting modalities that make it challenging to engage several senses at the same time in familiar daily activities like walking and talking. In addition, diminishing sensory and physical capabilities can be dangerous and it can be hard to understand how to compensate for this state in everyday activities. For example sensory re-ordering might occur when the hands take over for diminished kinesthetic senses in a variety of tactile arrangements. Sensory dominance, especially in the case of interacting with sophisticated video games like Wii Fit, can privilege the visual over all other aspects of bodily awareness, which conflicts with learning about personal awareness.

This investigation reveals a sensory dialogue between a person and the things she or he engages with that make it hard to accept a one-size-fits-all solution. Section 4.5, the Sensory Roles of Artifacts, introduces adaptive artifacts that are repurposed to accommodate people's varied needs. In this group chairs can be used as handrails, treadmills as stationary balance trainers, and mats as gardens. This knowledge is key to understanding the need for flexibility in design solutions for these exercisers.

In addition, the three other categories of artifacts — probing, generative, and conceptual — illustrate applications for design research that contributed to this study. Their sensory roles are both exploratory and communicative. Probing catalysts such as the pressure sensor mat, the second mat, the terrain-mat boxes, and the Wii Fit, are tools for discovering a range of responsive bodily behaviours. The rough models from the Co-design workshop are collaborative generative creations that capture participants' sensory information. The final conceptual artifacts are models, renderings, and visual scenarios that communicate possible future products. The next chapter explores the creation of the generative and conceptual artifacts from another point of view.

5 Co-Design & Empathy

At the beginning of this study one of my questions was, "*How can generative co-design methods help provide empathic and sensory knowledge about designing with and for older people?*" As the investigation progressed the two methods of Participant Observation and Experimental Probes also significantly enriched the findings. I was, nonetheless, curious about generative design, which I did not fully understand. In particular, I puzzled over the exact meaning of Sanders and Stappers oft quoted line, "Over the past six decades, designers have been moving increasingly closer to the future users of what they design (2008: 5). Were they referring to coming to a deeper or closer understanding of the users' worldview?

This perspective —understanding the users' worldview — is supported in the literature about empathy in design research, where several authors refer to Sanders and Dandavate's description (Fulton Suri 2003; Green and Jordan 2002; Koskinen and Battarbee 2003; Kouprie and Sleeswijk Visser 2009; Mattelmaki 2006; Postma et al. 2012; Sleeswijk Visser et al. 2005):

> *The ability to not just know, but also to empathize with the user comes only at the deepest levels of their expression. By accessing people's feelings, dreams and imaginations, we can establish resonance with them (Sanders and Dandavate 1999: 89).*

Jane Fulton Suri, partner and chief creative officer at global design firm IDEO, adds that people are more willing to reveal their inner thoughts and feelings to someone they have rapport with (2001:1283-1284). She says that "Empathy helps us learn 'why' as well as 'how and what' people do". She also explains that observation alone cannot reveal subjective phenomena such as, "People's thoughts and feelings —

their motivations, emotions, mental models, values, priorities, preferences and inner conflicts" (2003:53).

During the course of my study Sanders and Stappers published their book, 'Convivial Toolbox: Generative Research for the Front End of Design', which I had helped edit (Sanders and Stappers 2012:92-93). The aspects of their argument that relate to coming to deeper or more empathic understandings of the user's perspective are summarized here. They say that people have four levels of knowledge: explicit, observable, tacit, and latent (Ibid: 52). Explicit knowledge is factual and easy to tell others. For example, Sandra's Integrated Fitness class is at 10:00 every Tuesday and Thursday. This fact is straightforward and requires little analysis for design research.

Observable knowledge refers to thoughts that people might not even be aware of revealing but are reflected in their behaviours. For example, I observe that Steve is walking very slowly on the treadmill, while holding on to the side rails. That observation leads me to suspect that Steve is not able to walk any faster, needs support for stability, and may be trying to be careful, especially since I am familiar with his story. This kind of knowledge often emerges through analyzing ethnographic and human factors observations, where the user is usually not contributing to the design researcher's interpretations of the data.

Tacit knowledge is that which is understood but not easily expressed, perhaps due to an internalized knowing. Polyani, who coined the term "tacit knowing", explains it succinctly, "We can know more than we can tell" (2009 (1966):4). He argues that when we are paying attention to the outcome of a situation, we are not attentive to the particulars that contribute to it and so may not be able to describe them. He provides a description that is relevant to this study:

> *… we are relying on our awareness of a combination of muscular acts for attending to the performance of a skill. We are attending from these elementary movements to the achievement of their joint purpose, and hence are usually unable to specify these elementary acts (Ibid: 10).*

Polyani's explanation can be applied to a co-design workshop example in this study where Elizabeth, who keeps rolling her shoulders back during the co-design session, is trying to figure out how to explain how she maintains her posture. She is trying to identify and articulate a range of bodily actions that she performs inattentively while attending to her posture. Moreover, during this activity Elizabeth is collaborating with the student design researchers who are also trying to mimic and verbally interpret her behaviours.

Latent knowledge, from Sanders and Stappers' point of view, hasn't even been experienced yet by the participants, but emerges from past knowledge. For example, Dave knows that something that could help him count weight repetitions when doing leg lifts would enable him to keep track and remind him to do the same number on the right as on the left. Such potential knowledge emerges in collaborative research with participants and provides a deeper knowing of what could be an appropriate solution to an existing design problem.

Therefore, Sanders and Stappers believe that explicit and observable knowledge only reveals what people think through what they say (as in interviews) or what they do (when observed) (OP CIT: 66-70). They argue however, that people sometimes say and think that they do something other than what they actually do. For example, Joan may say (and think) that she can sense when her heart rate is too high, but upon observation it becomes apparent that she is constantly looking at her heart rate monitor and seems unable to gauge her own exertion level. They believe that both explicit and observable knowledge places design researchers at a distance from the participants.

On the other hand, Sanders and Stappers are convinced that Co-creation activities have the potential to provide deeper insight into people's tacit and latent knowledge because people are turning their minds and hands to the task in the present moment, using the supplies provided to "express their thoughts and feelings" (Ibid: 70). Co-creation methods involve 'crafting' or 'making' activities that may be novel or even confusing to participants, especially for the purpose of gathering research data. This novelty may attune the participants more to the present moment, disrupting any possible planned responses for the researchers and creating an opportunity for participants to communicate their intuitive knowledge.

In this study, there are several instances of activities that confirm Sanders and Stappers' premise. One example, previously described, occurs in the co-design workshop session when the women at the balance table are immersed in making a shoe model to capture and address the range of their walking issues. They are simultaneously trying to understand and explain their shoe experiences to each other while working collaboratively with the student design researchers. The interaction between them is a "my feet" and "your hands" activity that leverages the expertise of everyone at the table. The four older participants, whose feet are the topic of the moment, are gesturing, talking, debating, and pointing (see figure 5.1). At the same time, the two student participants, whose hands are engaged in sketching and modeling, are confirming the accuracy of their representations with the older ladies. One student even commiserates, adding her own fallen arch story into the mix.

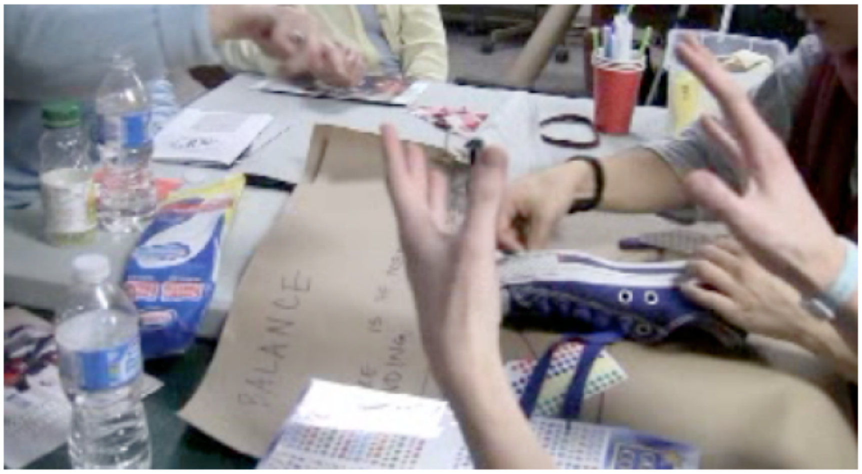


FIGURE 5.1: GESTURING AT THE BALANCE TABLE

Similar ways of working together emerge at each of the tables in the Co-design workshop session. At the other two tables the participants break into smaller and more intimate triads of collaborators communicating first among themselves and at times with the others at the table during the 'crafting' activities. In this case, the researchers literally come closer to the users! Through developing an empathic rapport with their participants, the researchers come to understand the complexity of their issues — the whys and hows of what the participants are experiencing.

5.1 Body Language in Co-design Activities

A sensory anthropology perspective is helpful to understand the nature and flurry of activities taking place during the co-design session. Many participants are using body language to communicate with one another. For example at the strength table an older participant, Barbara, tries to understand and explain "leaning" by standing up and demonstrating.

She holds onto the back of the chair and begins to do a leg exercise, moving her leg in and out to her right side. Janice, an older participant, is watching her, as is design student, Philipe. They are looking at her feet and he is sketching what she's doing. Barbara explains, "As you do these movements you tilt." Her bodily movements show that this is also true as she brings her leg to the front. She says, "You lean to the back" and she tilts back. She says, "If there was some sensor that could realize you were leaning." As she says this Philipe is sketching away (see Figure 5.2: Sketch of Tilting Exerciser):

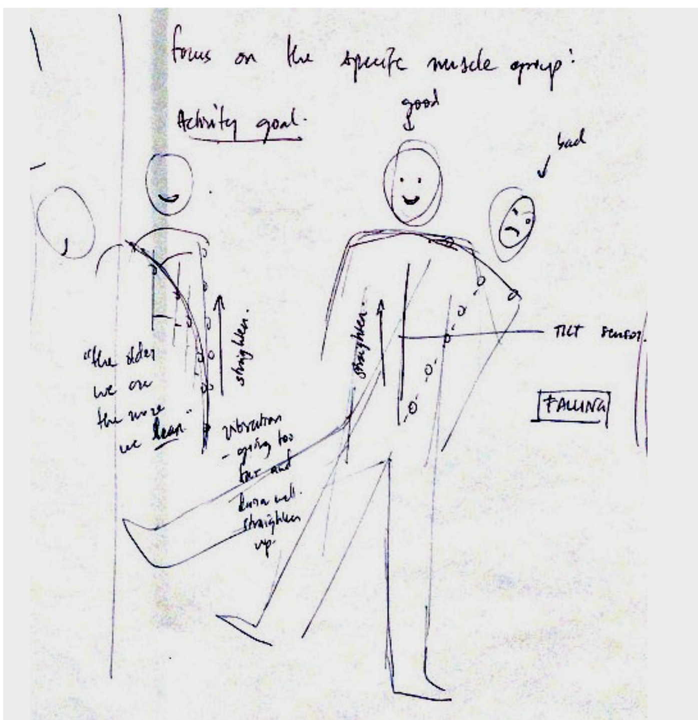


FIGURE 5.2. SKETCH OF TILTING EXERCISER. CREDIT F. LORSIGNOL (NOTE COMMENT "THE OLDER WE ARE THE MORE WE LEAN").

Barbara sits down and starts to make something to fit to her ear. She takes a couple of beads, attaches them to elastics, and slides the whole object along her eyeglasses earpiece to hang near her ear. Meanwhile Philipe is now gesturing to illustrate something that might wrap around his head and tilts from side to side. Philipe and Barbara are both gesturing. She is making circles in front of her head. He puts both of his hands on both of his shoulders as he asks questions. Barbara and Philipe are both moving their hands back and forth or up and down. At this point Barbara, Janice, and Philipe are all talking and raising their shoulders. He does another sketch (see Figure 5.3: Sketch of the Shrugbuster):

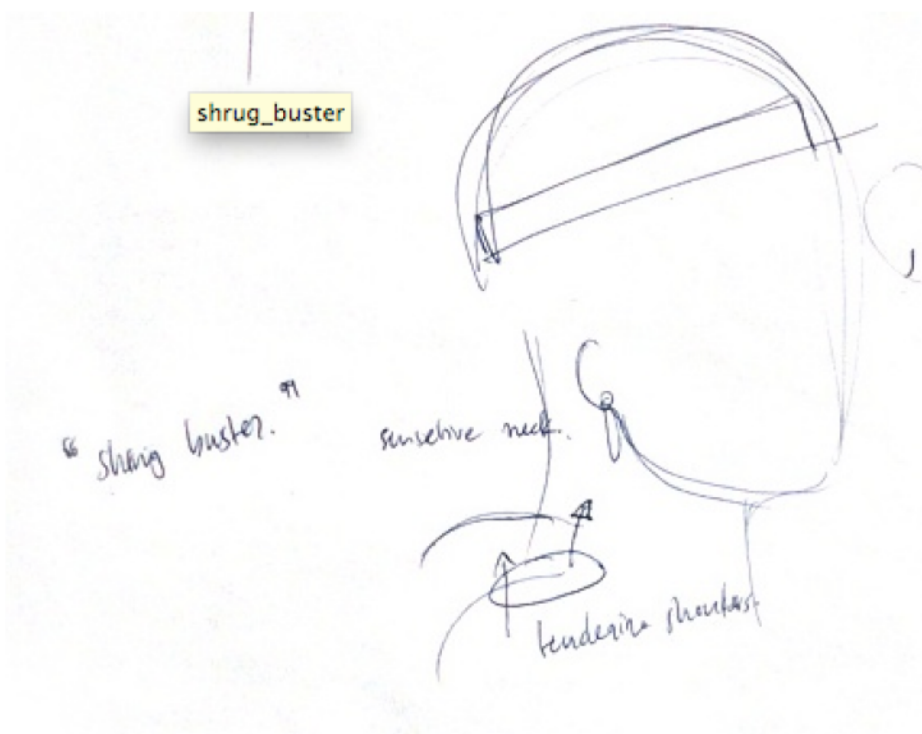


FIGURE 5.3. SKETCH OF THE "SHRUGBUSTER". CREDIT F. LORSIGNOL.

A study of these scenes reveals different kinds of spontaneous body language, some new to industrial design, some traditional; all removing boundaries between subject and researcher. They are loosely derived from the "gesture ecologies" of linguist/sociologist Jürgen Streeck, who presents "six different ways in which gestural activity can be aligned with the world, with concurrent speech, and with the interactants" (2011: 8):

i) **Evoking Gestures:** In this case, bodily movements and narrative explore and communicate tacit knowledge. Here a person is trying to remember a bodily activity by gesturing and explaining as if he or she is doing it now. These remembering-the-past gestures take place away from the normal context of the activity and are similar to the mime movements in a game of charades. They are accompanied by thinking out loud. Streeck describes this as a bodily form of conceiving, calling it "thinking by hand: gesture as conceptual action" in which the speaker uses his or her hands [or body] to give form to experience, while thinking about how to explain it (Ibid: 9). In the previous scene this occurred when Barbara demonstrated how doing leg exercises contributes to leaning.

ii) **Conjuring Gestures**: In this case, the meaning of the gestures is physically translated into an idea representing the participant's latent knowledge. Here a person uses gestures to enact and enhance his or her verbal explanation of possible ideas for something that could exist. These gestures differ from the previous ones in that they physically explore possible solutions or concepts that do not yet exist, but could be feasible. They are imaginary and only exist at the moment of being acted out. According to Streeck, these "descriptive (depicting) gestures represent worlds in collaboration with speech, and they are understood by reference to what is known about the world, not what is seen at the moment" (Ibid: 9). In the scene above this occurs after Barbara says, "If there was some sensor that could realize you were leaning". Philipe responds by tilting his head from side to side, and wrapping his hands around his forehead to conjure up the idea of a headband with tilt sensors embedded in it that might solve that problem.

iii) **Structuring Gestures**: In this case, bodily gestures are simultaneously reinforced through talking and making things that communicate tacit or latent knowledge. Here visual representations or sketches also accompany gestures. This is a way to communicate tacit and latent knowledge. In the scene above, Barbara demonstrates this when she crafts an "earring" out of beads and elastics, while she, Philipe, and Janice are talking and raising their shoulders.

Therefore, I propose that the sensory language in this study includes gestures or gestural enactments (scenes including gestures accompanied by verbal descriptions) as a means of communicating tacit and latent knowledge. This concept is presented here as new knowledge. Both oral and visual representations have a longstanding place in stages of the design research and development process. However, gestural communication, especially in this collaborative and multi-modal format, provides a new form of dynamic engagement between researcher and "user", in this case the older participants.

The design literature does not discuss the spontaneous use of body language in relation to design research activity. It addresses three main aspects of bodily movements: i) exploring theoretical views of embodiment, ii) the relationship between the bodies, things, and spaces, and iii) methods for experiencing body movements.

In the first aspect, the theoretical discussion is rooted in Merleau-Ponty's phenomenology of embodied perception as a basis for understanding how to design interactive objects that extend, support, or enhance embodied experiences (Dourish 2001; Loke and Roberston 2011; Loke and Robertson 2009; Merleau-Ponty 1962). For example, Robertson developed a theory-based taxonomy of embodied actions. These actions identify communicative functions for computer-supported cooperative work (Larssen, Robertson and Edwards 2007; Robertson 1997). This is not directly relevant to the spontaneous use of gestural body language for this study.

Second, the design literature about the relationship between bodies, spaces, and things additionally draws from Gibson's ecological theory of perception (Gibson 1966). From this point of view "artifacts, products and spaces engage with our physicality, and movement is the material in which we engage in a dialogue or conversation with these artifacts" (Larssen 2007:128). For example Larssen, Robertson, and Edwards explore the different kinesthetic and haptic ways that people engage with technology 'things' such as orienting toward the thing, acting on or using the thing, or acting through the thing as an extension of our body (2007: 274). This literature relates to my analysis of the ethnographic observations in this study, but not directly to the spontaneous use of body language.

The third aspect — methods for experiencing body movements — may provide a context within which these findings fit. This literature addresses the different ways designers use body movements to generate ideas for designs in the early stages of the design process, possibly after some field observation and before ideation development. In most of these cases, the designers enact potential users' movements through activities such as body storming, embodied storming, role-playing, design choreography, or a design movement approach (Buchenau and Fulton Suri 2000; Hummels, Overbeeke and Klooster 2007; Schleicher, Jones and Kachur 2010; Vyas et al. 2009). While solely designers perform these activities, Vyas, Dirk et al note, "that many of these bodily actions were aimed at better understanding of the design task context and at exploring new possibilities"(2009: 164). Thus they provide a precedent for the value of body movements in understanding design-related issues.

Gestures are also discussed in this third perspective. Vyas, Dirk et al note that, "in addition to their purely communicative role, they can help lighten the cognitive load when a speaker or performer uses them in combination with speech" (Klemmer, Hartman and Takayama 2006; Tang 1991: in Vyas, Dirk et al 2009: 165). In addition, Hummel and Overbeeke argue that gestures are emotive and expressive, as well as useful for stimulating idea generation. They conducted a study to compare the value of traditional sketching with the value of gestures for capturing "expressive design concepts" (2007: 684). They did not find any significant difference between the designers' satisfaction with the outcome of objects made using one technique or the other. However they note,

> *Although sketching is considered more suitable, gesturing is still believed to be an adequate design tool. These results are promising especially when considering the fact that design students have extensive training in drawing and none in gesturing (Ibid).*

Their observations confirm my experience that gestures are actually eschewed in the industrial design studio. If a student wants to discuss or receive feedback about a design concept from my colleagues in the School of Industrial Design or myself, we all say something to the effect of, "I don't understand all this arm waving, show me a sketch". Believe it or not, we discuss this "problem" at faculty meetings. We want the students to master the art of sketching, to control how others interpret the minute details of their designerly concepts, and to make sure everyone shares the same understanding. As a result, I took an interest in the nature of the gestures as a source of design knowledge in the co-design session.

5.2 The relationship between Gestures & Artifacts

This section analyzes the relationship between the gestures that emerged in the co-design sessions and the two sets of artifacts (the generative artifacts produced in the co-design sessions and the final student concepts presented a month later) that they influence. The first section presents the twelve gestural enactments that stand out in the interaction during the co-design session. This is followed by an analysis of the relationship between those gestures and the first set of eight generative artifacts that they are associated with. The next section studies the connections between the same twelve gestures, the same eight generative artifacts and the final set of eleven concepts the students present to the participants a month later.

5.2.1 The Gestures

Twelve gestural enactments stand out in the interaction during the co-design session. They are labeled CDG-01 to CDG_012, where CDG means concept development gesture. They are related to the development of the eight generative artifacts that emerge from the co-design session and are illustrated in Figure 5.4: Gestures below.

CDG_01: J GESTURING ABOUT SHOULDERS

CDG_02: B SHOWS LEG LIFT & TILT

CDG_03: E & C BOTH HAVE HANDS ON NECK

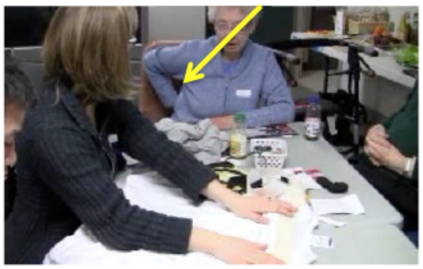
CDG_04: B DEMONSTRATES KNEE LIFTS

CDG_05: B WEARS EAR MODEL &
P GESTURES TO SHOULDERS

CDG_06: E SHOWS SHOE ROCKING

CDG_07: M SHOWS BALL OF FOOT AREA

CDG_08: T SHOWS LEANING POSTURE



CDG_09: T DEMONSTRATES LOWER BACK

CDG_10: G DEMONSTRATES EXTENDING TOO FAR

CDG_011: K SHOWS LEG EXERCISES

CDG_012: K & D CONFIRM MEANING THROUGH GESTURES

Figure 5.4: Gestures

The gestures can be grouped into the following categories of bodily experience:

- Standing and lying postures (CDG_01, CDG_02, CDG_04, CDG_05, CDG_08, CDG09);
- Shoulder and neck strain (CDG_01, CDG_03, CDG_05);

- Foot positioning and placement (CDG_06, CDG_07, CDG_012); and
- Joint flexing and bending (CDG_010, CDG_011).

Note that some gestures appear in more than one category. These embodied communications arose in the co-design sessions at three independent tables (balance, strength, and flexibility). Since the data arose from only one set of explorations, they should be considered only as examples of major areas where wearable sensor technologies could assist an older population.

Table 5.1: Gesture Analysis & Associated Artifacts below identifies each gesture and indicates which generative artifact it is associated with. Each row of the table tracks one of the above gestures and links it to the *bodily experience* it represents (tacit knowledge), the *sensory responses* that participants thought a device could provide to assist in improving that particular experience (latent knowledge), and lastly, the *generative artifact* (labeled GA001- GA008) that emerged from that exchange. The letter T stands for the participants' tables; T1 is the balance table, T2 is the strength table, and T3 is the flexibility table.

For example, in the tenth row, at table 3 in gesture CDG_010, Gord opens and closes his left arm at shoulder height to demonstrate how easy it is to overextend the arms. The freehand weight training *bodily experience* he is enacting is flexing and bending his elbows. He wants to receive *sensory responses* or feedback to help him keep his arms in the proper position. This gesture leads to the co-creation of a *Generative artifact*, a T-shirt with embedded flex and bend sensors (GA007).

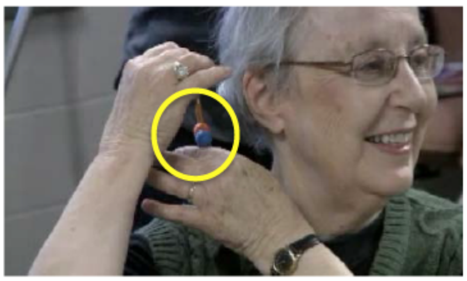
In the eleventh row, at table 3 Kathleen is enacting leg exercises, while Dave describes them in gesture CDG_011. She is enacting the *bodily experience* of bending her knees into a T-shape, while maintaining balance on both sides of the joint during leg strengthening exercises. Dave says he wants to use sound as a *sensory response* to provide feedback for proper alignment. This gestural enactment leads to the co-creation of the *Generative artifact*, pair of pants with embedded flex and bend sensors (GA008).

GESTURE	GESTURAL ENACTMENTS	BODILY EXPERIENCE	SENSORY RESPONSES	GENERATIVE ARTEFACT
CDG_01	T2: J-hands to shoulders: E: arms bend & open; B: shoulders up; P: hands to neck	Relaxing neck muscles during arm exercises Shoulders hunching	shoulder position reminder	**GA001:** Shrugbuster Earring
CDG_02	T2: B: demonstrates tilt with leg lift	leaning	recognize leaning to side or back	**GA002:**T-shirt shoulder spine
CDG_03	T2: E & C: both have hands to neck, E lower back too	neck straining; lower back contact	monitoring neck muscles	**GA003:**T-shirt neck & core
CDG_04	T2: B: demonstrates knee lifts & P sketches	for core: lifting knees & stepping	monitoring posture	**GA001 & GA002**
CDG_05	T2: B puts earring balls on eyeglass arms P: gestures around head	shrugging shoulders & tilting	sensing shoulder shrugs & tilt	**GA001 & GA002**
CDG_06	T1: V shows shoe; rocking shoe; J & D add stickers to shoe;	walking, feeling in feet; dragging feet; rolling versus sliding feet; pressure points on soles	sensing weight distribution & proper position	**GA004:** shoe & **GA005:** insole
CDG_07	T1: M lifts foot & points to ball area (also note S comments from behind camera)	circulation in feet	massasing soles of feet	**GA005:** insole
CDG_08	T3: G demonstrates leaning with hands	posture	reminder to stand up straight	**GA007:** T-shirt
CDG_09	T3: T demonstrates lower back	posture- along spine	reminder to stand up straight	**GA007:** T-shirt
CDG_010	T3: G demonstrates "extending too far"	flexing & bending at joints	sensing proper alignment	**GA007:** T-shirt
CDG_011	T3: K moves sideways on chair & shows T leg exercise D gestures with hands to indicate front & back	flexing & bending at knee joints balancing both sides of joint	maintaining proper alignment through sound	**GA008:** pants
CDG_012	T3: G circles spot on insole with fingers K confirms meaning through gestures& D gestures back	preventing foot pain	sensing pressure spots	**GA006:** insole

TABLE 5.1: GESTURAL ANALYSIS & ASSOCIATED ARTIFACTS

5.2.2 Generative Artifacts

The eight *generative artifacts* (abbreviated to GA) that emerge at the end of the Co-design session are shown here in Figure 5.5: Co-Design Session Generative Artifacts. They are labeled from GA001 to GA008.

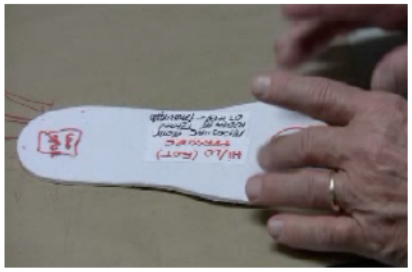


GA001: SHRUGBUSTER EARRING

GA002: T-SHIRT

GA003: T-SHIRT

GA004 7 GA005: SHOE & INSOLE



GA006: INSOLE

GA007: T-SHIRT

GA008: PANTS

FIGURE 5.5: CO-DESIGN SESSION GENERATIVE ARTIFACTS

These Generative artifacts fall into four different bodily experience groupings:

- Standing posture, which includes shoulder hunching (GA001, GA002, GA007);
- Lying posture, which includes keeping the back flat on mat and reducing neck strain (GA003);
- Foot positioning and placement, which includes pressure points (GA004, GA005, GA006); and
- Joint flexing, which includes positions, speed and number of repetitions (CD007, CD008).

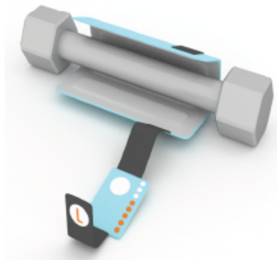
They are described in Table 5.2: Generative Artifacts Resulting from Co-design Session With Participants on the following page. A single row in this table presents, from left to right: *the generative artifact* (such as the number GA001 and name Shrugbuster earring in the first row); the proposed *bodily ways* of experience it would address (such as assisting with shoulder hunching in the first row); and the *sensory role* it would have (such as buzzing when the shoulders come up to the ears to alert the wearer to correct her posture in the first row).

ARTEFACT #	DESCRIPTION	BODILY WAYS	SENSORY ROLE
GA001	Earring: Shrugbuster	assists with shoulder hunching	buzzes when shoulder at ear
GA002	T-shirt for shoulder & spine	assists with shoulder hunching in rotator cuff exercises, upright posture, & reduces wobble standing	buzzes or maybe vibrates to alert
GA003	T-shirt for neck & core	assists keeping back flat on mat for core strer to keep neck free of strain in sitting up	buzz if you leave mat signals side & back of neck
GA004	Shoe	correcting foot placement & posiitons	vibration & pressure
GA005	Insole	provides pressure in foot at points needed	sensing pressure distribution
GA006	Insole	massages soles, transfers to other shoes	vibration
GA007	T-shirt	asists correcting posture, for leaning, for shoulder hunching & speed of repitition	vibration feedback
GA008	pants	alerts if too much activity in 1 knee, switch to other knee	light or auditory vibration at back of knee

TABLE 5.2: GENERATIVE ARTIFACTS FROM CO-DESIGN SESSION WITH PARTICIPANTS

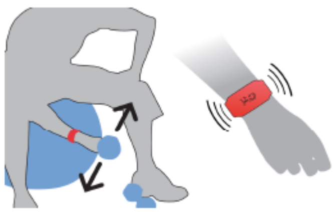
Final Student Concepts

The eleven final student design concepts or scenarios of concept use (abbreviated to FC and labeled FC001-FC011), which were developed after the co-design sessions and presented one month later to the participants, are shown below in Figure 5.6: Final Student Presentation Concepts.

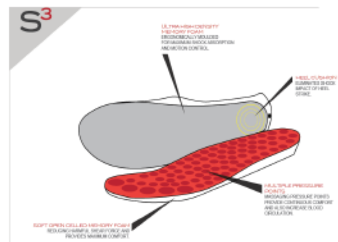


FC001: INTELLIGENT GRIP (credit FL)

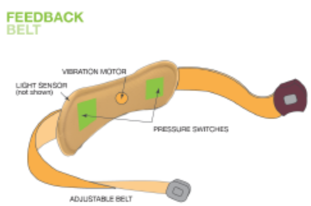
FC002: POSTURE BAND (credit MF)



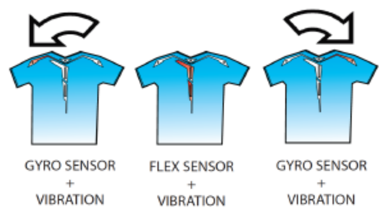
FC003: CnTRL WRISTBAND (credit TL)



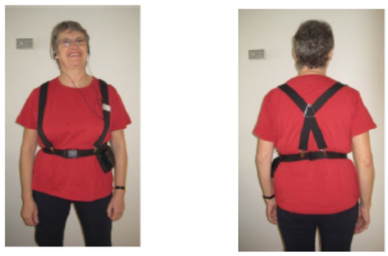
FC004: SMART SHIATSU SHOES (credit RH)



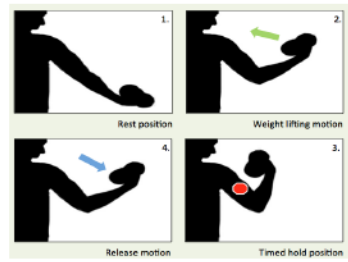
FC005: FEEDBACK BELT (credit JM)



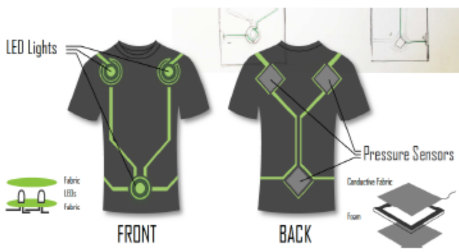
FC006: CORECTIVE POSTURE GARMENT (credit JP)



FC007: SHRUGBUSTER (credit TP)



FC008: FLEXBAND (credit JH)



FC009: MAT MATE SHIRT (credit TL)

FC0010: SMART FLEX EXERCISE SHIRT (credit MD)

FC0011: INTELLIGENT SOLE (credit CH & YP)

FIGURE 5.6: FINAL STUDENT PRESENTATION CONCEPTS. CREDITS: F. LORSIGNOL, M. FROMOW, T. LUONG, R. HO, J. MARUSAIK, J. PALMER, T. PHILLIPS, J. HEALY, T. LEE, M. DAO, C. HILL, & Y. SHERI)

These concept ideas can be grouped into the following categories:

- Standing and lying postures, incorporating neck and shoulder (FC002, FC006, FC007, FC010 [standing] and FC005, FC009 [lying]);
- Foot positioning and placement (FC004, FC011); and
- Joint flexing (FC001, FC003, FC008).

The next table (Table 5.3: Artifacts developed by Students for final presentation) maps the students' final presentation concepts to the older participants' *bodily ways* of being concerns, based on the students' observations and analysis of the Co-design sessions. It then notes the desired *sensory roles* for the proposed assistive devices, and which *category* of bodily experience the proposed device would be useful for. For example in row five, artifact FC005, the Feedback Belt, can assist a wearer in sensing the correct body position in mat work (*bodily ways*) by vibrating and lighting up to provide feedback for the wearer (*sensory role*) for better posture during lying exercises (*category*).

FINAL ARTIFACT #	DESCRIPTION	BODILY WAYS	SENSORY ROLE	CATEGORY
FC001	Intelligent grip	counts sets; attach to weights, left & right	helps remember count helps balance both sides; tracks progress during activity	Joint Flexing
FC002	Posture band	senses leaning	vibrates for adjustments	Standing
FC003	Cntrl Wristband	corrects form & pacing	vibrates to focus attention monitors speed & position	Joint Flexing
FC004	Smart Shiatsu Soles	absorbs shock; comfort; alignment	tracks pressure distribution; identifies related internal organs activates distributed pressure vibrations	Foot P & P
FC005	Feedback belt	corrects form on mat	vibrates to notify & lights	Lying
FC006	Corrective Posture Garment	senses leaning	vibrates for adjustments	Standing
FC007	Shrugbuster	leaning posture correction & shoulder position	vibrates for adjustments	Standing
FC008	Flexband	Senses weight repetition action & times hold	lights & sound for directions	Joint Flexing
FC009	Mat Mate Shirt	corrects lower back position for	senses pressure on contact;	Lying
FC0010	Smart Flex Exercise Shirt	mat exercises corrects posture & shoulder position	notifies student & instructor vibrates upon posture change	Standing
FC0011	Intelligent Sole	corrects pressure on toe, ball, arch, heel	vibrates to correct bad habits	Foot P & P

TABLE 5.3: ARTIFACTS DEVELOPED BY STUDENTS FOR FINAL PRESENTATION

In current industrial design research processes gestures have little influence on the design outcome, while rough models play a key role in articulating product features. This section demonstrates that gestures also have a strong influence on the final student concepts. The previous tables provided an overview of the relationships between the participants' gestures and the concepts at two stages of design development, a breakdown of the bodily ways of experience addressed by the concepts in both stages, and the sensory responses that each concept would provide. The next chart illustrates the number of gestural communications (CDG01- CDG012) and generative artifacts (GA001-GA008) that influenced the students' final concepts (FC001- FC0011) in Figure 5.7: The Number of Influences of both Generative Artifacts (GA) & Co-design Gestures (CDG) on Final Concepts. Communicating gestures influenced all of the final concepts more than the initial generative artifacts did. In fact, seven of the final student concepts (FC001, FC002, FC003, FC 006, FC007, FC008, and FC010) were influenced more by gestures than by generative artifacts. Three of the final concepts (FC005, FC009, and FC011) were influenced to the same degree by gestures and generative artifacts. Only one final concept was influenced less by gestures. Appendix J: Patterns of Artifacts and Gestural Enactments presents this information in more detail.

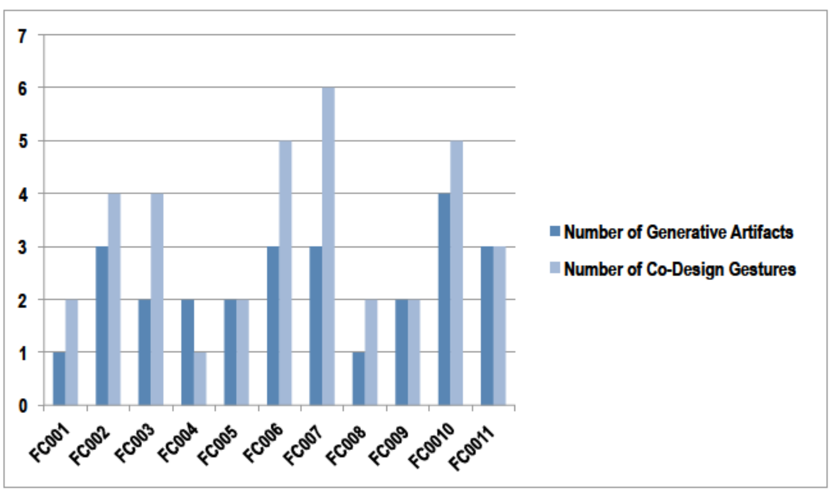


FIGURE 5.7: THE NUMBER OF INFLUENCES OF BOTH GENERATIVE ARTIFACTS (GA) &CO-DESIGN GESTURES (CDG) ON FINAL CONCEPTS (FC).

Figure 5.8: The Number of Final Concepts Influenced by Generative Artifacts (GA) shows that the students' final presentation concepts were influenced twenty-six times by the generative artifacts. This can be seen in more detail in Appendix J: Patterns of Artifacts and Gestural Enactments. In particular, eight of the eleven final students' concepts were influenced in some way by generative artifact GA007 (T-shirt). These findings could be expected since, as noted earlier, designers normally use rough models as part of their iterative design development process.

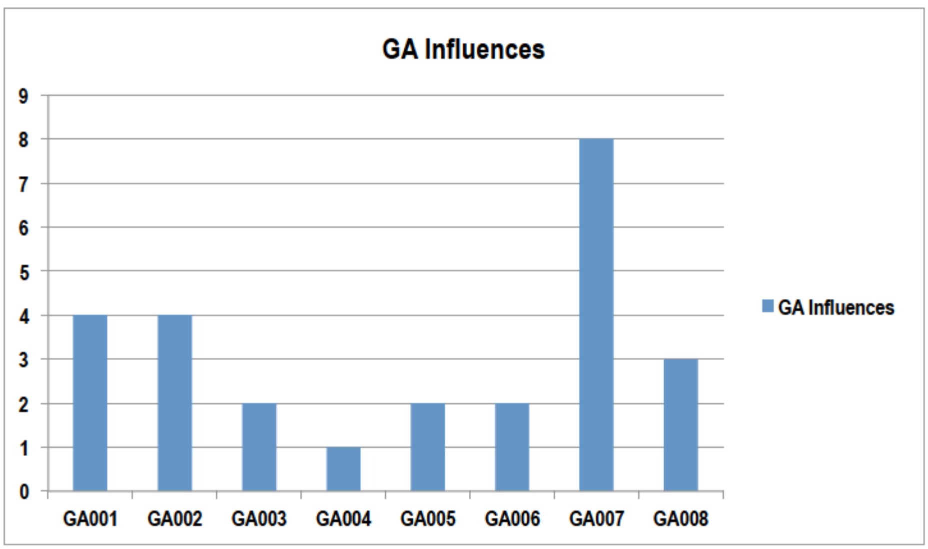


FIGURE 5.8. THE NUMBER OF FINAL CONCEPTS INFLUENCED BY GENERATIVE ARTIFACTS (GA)

However, Figure 5.9: The Number of Final Concepts Influenced by Co-design Gestures (CDG) also shows that the eleven final concepts by the students were influenced in part or whole by thirty-six of the gestural enactments generated in the Co-design session. The most influential gestures were CDG_01 (neck and shoulder shrugging), CDG_03 (hands to neck and lower back), and

CDG_09 (hands to back), each of which influenced five final concepts. Note that CDG_04 did not influence any final concepts. This is illustrated in more detail in Appendix J: Patterns of Artifacts and Gestural Enactments. It seems that overall the gestural enactments influenced the design of the final concepts more than the Co-design session artifacts did. Clearly the language of gestural enactments contributes to learning about empathic and sensory knowledge in this Co-design research study.

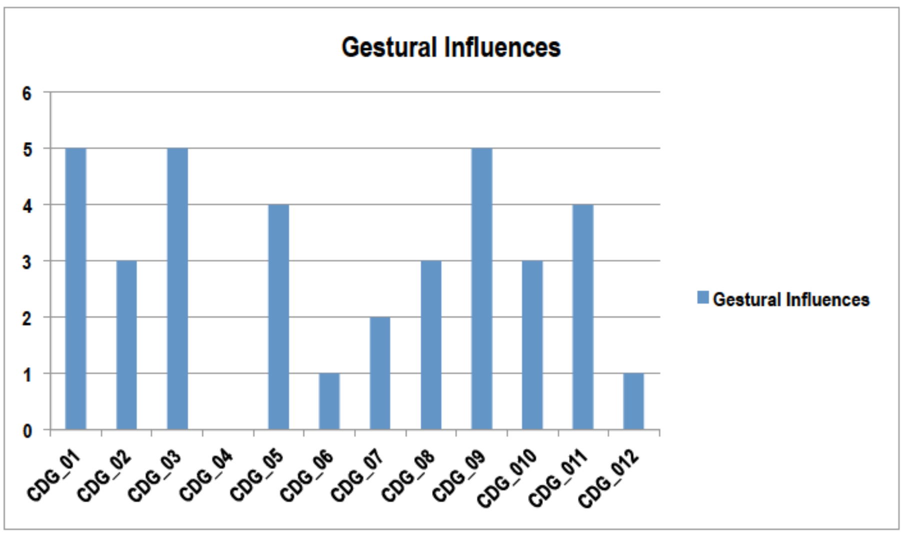


FIGURE 5.9: THE NUMBER OF FINAL CONCEPTS INFLUENCED BY CO-DESIGN GESTURES (CDG)

5.3 Synergy among research approaches

In addition to gestural communication, the multi-modal and intense engagement between the researchers and participants enhanced the empathic and sensory knowledge arising from their generative co-design activity, as Sanders and Stappers note. Co-design methods and generative tools alone would not have led to the same empathic and sensory knowledge about design with and for older people. A sensory anthropology perspective added an important operational context to this study, confirming Sanders and Stappers "say, do, make" approach (Sanders and Stappers 2012: 66-70).

Each of the three research methods of ethnographic observation, co-design, and later, technology probes engaged the older adults in a different way. Analysis of the findings from each approach revealed a range of empathic and sensory information that supported the findings from the other two methods. This confirms Sanders and Stappers perspective that interviewing, observing and engaging in generative activities are complimentary, and build on previous approaches (IBID: 67). For example, sociologist Herbert Gans (1999) claims that participant observation is the most appropriate scientific method "because it is the only one that gets close to the people. In addition it allows researchers to observe what people do, while all the other empirical methods are limited to reporting what people say about what they do". Gans made his claim in 1999, prior to the emergence of these Co-design crafting activities in design research.

In this study, participant observation also revealed many sensory qualities that are important for designing technologies for older people's fitness activities, as summarized in Chapter six, Table 6.1.3: Key themes about older people's fitness across methods. In addition, through participant observation the older people, their instructor, my students, and I developed a deeper rapport with one another. As a result, this work supports the view that the two methods of Co-design and ethnographic fieldwork are compatible with the objective of developing more empathic and sensory knowledge about designing with and for older people.

5.4 Summary

This chapter focuses primarily on the Co-design research process by addressing how generative co-design methods help empathic and sensory knowledge about design with and for older people. This is a shift from the study of older people to the study of the nature of the design research process, fitting into the category of Research about Design (refer to section 2.3.2). In particular, it looks at how tacit and latent information can be generated in the co-design process, and presents that information within a sensory framework. It highlights the way that body language contributes to collecting empathic and sensory knowledge through gestural communication. It categorizes the sensory language in this design process into evoking gestures, conjuring gestures, and structuring gestures. It presents an analysis of the influential gestural enactments in the co-design activities and tracks their influence on the artifacts developed in the co-design session and subsequently on the final concepts designed by the students. It demonstrates that body language enhances the more traditional ways of communicating design research information through iterative rough models.

The rough models and concepts are grouped into sets of artifacts that emerged at two different stages in the study. They represent ideas for sensory-enabled products that older participants could use for exercises focusing on different bodily areas: standing postures, including shoulder hunching; lying postures, including reducing neck strain and keeping the back flat; foot positioning and placement, including pressure points; and joint flexing, including positions, speeds, number of repetitions.

Co-design alone would not have provided as rich a window into sensory knowledge relevant to designing technologies for older people's fitness activities. Sensory anthropology provides a complimentary and strategic framework for this research. This sensory strategy is discussed in more detail in the next chapter.

6 Insights

A suitable approach for structuring a sensory design research investigation is to clarify fitting questions and design methods for probing into the sensory nature of a situation. This study progressed in fits and starts toward defining such a strategy. A sensory anthropology perspective offered guidance at specific times in the process and, in retrospect, could have provided direction at other times. For example, at the beginning of the investigation it would have been helpful to systematically apply sensory anthropology points of view, especially if we had focused on the five themes identified here. This chapter explores the insights that arose during this research, proposing a sensory strategy and recommendations for future work in this area.

The sensory approach that resulted from my investigation evolved over two years, beginning with the coding that emerged from the data. Initially the coded categories fell into three overriding themes with somewhat awkward titles like: Having a Sense of it (experiences); Making sense of it (design activities); and Coming to a Sense of it (awareness). It became evident that they naturally fell into place within a sensory design research context based on themes similar to those for studying cultures in sensory anthropology.

The Sensory Anthropology perspectives introduced in Chapter 2 provide a foundation for understanding the importance and position of the senses in a culture, but not necessarily for focusing on issues that could influence sensory-appropriate design decisions. They identify some areas of relevance for a sensory design research study: the role of artifacts and aesthetics in relation to the senses;

the exceptions to the dominant sensory model within the community in cases such as sensory handicaps; the inter-relation between the environment and built surroundings and the senses; and the use of language relating to the senses (Howes, 1991). They also highlight the inter-related way that senses operate, either augmenting or opposing each other (1991: 257- 285). In addition, a focus on bodily ways of gathering information serves as a window into the nuances of physical behaviour that can reveal people's sensory interactions with things (Classen 1997; Geurts 2002; Howes 2006; Howes 2003; Howes,1991; Paterson 2007). As noted by Howes and Classen (2002: 3), these sensory experiences may be directly related to the influence of cultural practices on sensory ordering.

As a result, this study highlights five themes for a structured approach to sensory design research: 1) Participants' Worldviews, 2) Sensory Practices, 3) Sensory Interactions, 4) Sensory Roles of Artifacts, and 5) Sensory Language of Gestures. In this dissertation, once the five themes emerged, the findings were organized into vignettes to empathically describe the sensory knowledge that was emerging. My intention was to generate meaningful and inspirational narratives. They would reveal sensory insights about ageing that might affect older people's willingness to accept wearable sensor technology devices. They could also provide reasons for researchers to participate with older users in the early stages of design research. This dissertation builds toward an understanding of the main question, *"How can designer researchers gain insights for designing appropriate wearable technologies for an older population?"*

This chapter breaks the question into two components, each addressing a unique interpretation of the word "insight". From the first point of view, insight refers to interpreting the true nature of a situation (American Heritage Dictionary, 1970). Section 6.1 presents Sensory Contexts Guidelines for generating design insights relevant to designing for specific populations. From the second standpoint, insight refers to providing, "an accurate and deep intuitive understanding of a person or thing" (Oxford Dictionary, 2014). Section 6.2 provides Design Insights for designers to consider when developing assistive technologies for fitness for impaired older people. These research insights are preliminary suggestions to provide the basis for technical designers to adopt a human-oriented perspective to technology development. The chapter concludes with ideas for future research in section 6.4 and a discussion of limitations in section 6.5.

6.1 Sensory Contexts Guidelines for Design Research

By focusing on the sensory aspects of human experience, design researchers can develop more awareness of people's experiences and the design qualities that would support specific situations. In particular these sensory guidelines are relevant for three major areas of design research: i) applying the five thematic sensory contexts, ii) identifying the design research stages in which they may be relevant, and iii) discussing the nature of applying them with different research methods. The explanations that follow deal with each of these areas in turn.

6.1.1 Attributes of the five sensory contexts

The five major themes identified in this study serve as design research categories for organizing sensory knowledge about specific activities or participant populations. They are presented here in the order in which they were discussed in earlier chapters: ***Participants' Worldviews, Sensory Practices, Sensory Interactions, Sensory Role of Artifacts, and Gestural Language.***

1) Participants' Worldviews: Three subcategories can provide insight into participants' cultural frames of reference that may influence the quality of the design research: ***assumptions***, ***attitudes***, and ***culturally acceptable sensory behaviours***, as shown in Table 6.1.1a below. Design researchers and "User" participants naturally come to any investigation with a preconceived set of ideas or ***assumptions***. Given their training, social scientists probably acknowledge their assumptions or biases more readily than design researchers, designers, or technically-oriented professionals. Nonetheless, designers turned researchers, such as the students in this exploration, need to be aware of judgmental viewpoints that have the potential to colour their study or cloud their understanding of participants' values. For example the students expected the older people to be stubborn and exhibit a lack of trust, which was not the case. Conversely, an older participant acknowledged that he was worried that the students would think that the older participants were "over-the-hill" and would not be interested in their situation.

The participants' ***attitudes*** toward their activities, experiences, and sensory ways of being can provide insights into how they interpret, value, or interact with them. In this study, the older participants attitude toward fashion surprised the student researchers, potentially affecting the aesthetics and features of wearable devices designed for them. In this instance it would be unlikely that an expensive hi-tech fitness device would be acceptable to users. Moreover, participants' perspectives about ***culturally acceptable sensory behaviours*** can provide insight into how they make sense of their world. For example, in this study, participants demonstrate that going slow is both an outcome of their evolving abilities and a culturally sensitive preventative behaviour. This last category may include sensory handicaps as exceptions to the dominant sensory model within a community and the effects that could have on the participants' status. For example, in this research, the participants' fitness exercises were aimed at encouraging a positive approach to "normal" everyday activities, like going for a walk, while working with sensory and bodily differences.

PARTICIPANTS' WORLDVIEWS	DESCRIPTION	EXAMPLES
ASSUMPTIONS	*Unfounded preconceived ideas, biases, or judgments on the part of design*	*Older participants believe young people dismiss them as "over-the-hill"*
ATTITUDES	*Outlook towards sensory experiences, behaviours, and interactions that affect how users accept them now and possibly in the future*	*Older participants choose clothes for comfort not sporty aesthetics*
CULTURALLY ACCEPTABLE BEHAVIOURS	*Ways of doing things that do or do not fit into the dominant cultural situation*	*Older participants are motivated to redevelop everyday capabilities that were previously automatic*

FIGURE 6.1.1.A: PARTICIPANTS' WORLDVIEWS

2) Sensory Practices: Since this section refers to the sensory practices that support bodily ways of gathering information, the name for this theme was revised. The subcategories in this section of the sensory framework draw from the Chapter 2 discussion about the sensorium of experience in which a participant gains knowledge about the world through his or her bodily senses (Classen 1997; Classen 1993; Geurts 2002: 253; Howes and Classen 1991; Paterson

2007; Stoller 1989). They include: *Extereo Sensations*, *Proprioceptive Sensations*, and *Activities, Sequences, and Rituals* as shown in table 6.1.1.b Sensory Practices.

Extereo-sensations focus on design research knowledge in relation to seven different types of sensory perception, as discussed by Geurts (2002: 8-9), see Chapter two). These are visual, auditory, olfactory, gustatory, tactile (in relation to mechanical interaction), tactile (in relation to thermal interaction), and affective (pleasant or unpleasant). The other two types of sensory perception are the tactile (in relation to kinesthetic impressions) and the labyrinth apparatus governing balance: they both fall into the following ***Proprioceptive Sensations*** subsection. Not all of these aspects would be relevant in every circumstance, they may vary in dominance over time and situations, and their interrelated nature is a thematic category of its own. For example in this study, as a self-monitoring practice, older fitness participants gathered bodily information about their own balance. Some employed their tactile sense (mechanical) when holding on to supports with both hands, or one hand, or two fingers, or one finger, depending on their comfort level.

Proprioceptive Sensations combine the tactile apparatus for responding to kinesthetic impressions with proprioceptive sensations, which provide a person with information about the "state of her deep tissue, her own movements and activity, and the effects of her displacement in space" (Ibid: 9). In all, ***Proprioceptive Sensations*** consider the position of the participant's body and its parts, the nature of the body's movements and activity, and the experience of its displacement in space. An example of this sensory practice occurs in this research when a student researcher reports that some of the older fitness participants require more bodily coordination to get onto some of the fitness training machines than the actual exercise demands. One woman even has to lift her pant leg up to move her leg slowly into position on the machine.

Lastly the subcategory of ***Activities, Sequences, and Rituals*** considers patterns of sensory experiences that involve repetition and practice, and instruction, imitation, and simulation. For example in fitness class older participants practiced going for a walk, preparing for potential obstacles like a curb or an approaching dog. To do this they repeatedly walked through a path with different qualities, ranging from weaving through pylons to stepping over different surface textures, and stopping and starting as instructed.

BODILY WAYS OF GATHERING INFORMATION	DESCRIPTION	EXAMPLES
EXTEREO SENSATIONS	*How the body gathers information through sensory systems such as visual, auditory, olfactory, gustatory, tactile-mechanical, tactile-thermal, and affective*	*Older participants experiment with how much tactile and visual support they need to maintain their balance*
PROPRIOCEPTIVE SENSATIONS	*How the body gathers information about its position and that of its parts, the nature of bodily movements and activities, and the experience of bodily displacement in space*	*An older participant carefully eases into an exercise machine, grabbing her pant leg to manoeuver her leg into position*
ACTIVITIES, SEQUENCES and RITUALS	*How the body builds new information through repetition and practice, and instruction, imitation and simulation*	*Older participants walk along a path, encountering obstacles, while training for taking a simple daily walk*

FIGURE 6.1.1.B SENSORY PRACTICES (BODILY WAYS OF GATHERING INFORMATION)

3) Sensory Interactions: This sensory theme, which focuses on interaction between senses, provides insight into people's sensory experiences relevant to design; it may on occasion even contradict the previous theme. It primarily responds to the argument in Chapter 2 that the senses operate in an inter-related way, not in an isolated fashion, augmenting or opposing each other (Classen, 1997, Geurts, 2002, Howes 2003, 2006, Howes and Classen, 1991, Paterson, 2007). It highlights three areas for study: ***Multi-modal Awareness, Sensory Deficits***, and ***Sensory Reordering*** as shown in Table 6.1.1.c Sensory Interactions.

Multi-modal Awareness is a natural state for most people, as noted in Abram's comments in Chapter 1, about how his sensory system subconsciously responds to continuous changes in the environment when he is hiking on uneven terrain (1997:49). In this perspective design researchers would pay particular attention to which sensory modes are in play, at which times during interactions, and in which order. This aspect of user-requirements design research is also discussed in Chapter 2 with an emphasis on sensory aesthetics such as the quality and kind of sensory feedback users experience (Desmet and Hekkert 2007; Gibson 1966; Jordan 2000; Norman 2004; Overbeeke et al. 2003: 9; Schifferstein and Desmet 2007; Schifferstein and Hekkert 2008). In this study an example of multi-modal awareness occurs when the older fitness participants walk the line during their fitness class. While following the textures and turns of the line participants incrementally add sensory modalities: first they look straight ahead, then they add head turns, and finally they add talking. They are in multi-modal sensory training that involves simultaneous proprioceptive, kinesthetic, visual, tactile, and auditory stimuli.

Sensory Deficits touch on the absence of familiar interaction between the senses experienced by individuals. Chapter 2 highlights Geurts' discussion of how the Anlo-Ewe people consider sensory disabilities as culturally acceptable alterations to habituated bodily sensations (2002: 212). This may be experienced differently in other cultures. For example in this study a partipant with no feeling in the soles of her feet does not receive automatic sensory feedback from her feet. This, especially when going upstairs, could result in missing a step, falling, and even ending up in hospital.

Lastly, ***Sensory Reordering*** is an extension of the previous category where one sense will compensate for another. In this category it is important to determine the way that one sense replaces or pinch-hits for another sense that is no longer functioning. This may be an evolving experience due to shifting sensory capabilites related to accidents or ageing. For example, in this study, several older participants depend more on the tactile support of their hands or fingers for stabilization while walking or moving, replacing their diminished proprioceptive and kinesthetic sensory feedback.

SENSORY INTERACTIONS	DESCRIPTION	EXAMPLES
MULTI-MODAL AWARENESS	*Attending to the quality, kind, timing, and order of simultaneous or related sensory modalities during specific activities or experiences*	*Older participants train by incrementally adding multiple sensory stimuli into their fitness walk*
SENSORY DEFICITS	*How are sensory deficits experienced in place of once-familiar body sensations?*	*One participant no longer has feeling in the soles of her feet and risks falling backwards while climbing stairs if not attending to the placement of her feet*
SENSORY REORDERING	*In what ways do senses compensate for other less capable senses and how do these sensory interactions shift over time?*	*Older participants use their hands or fingers to locate their bodies in space while moving to compensate for a lack of proprioceptive feedback*

FIGURE 6.1.1.C SENSORY INTERACTIONS

4) Sensory Role of Artifacts: This sensory theme has roots in the sensory anthropology discussion in Chapter 2 where McLuhan argued that technologies or other mechanical means have the potential to act like extensions of the body (1962 from McLuhan's The Gutenberg Galaxy: 55 in Howes 2003: xix). It also draws from points of view about functional, aesthetic, and communicative properties of artifacts in the design literature discussed in Chapters 2 and 5 (Dore et al. 2007; Gibson 1966; Salvendy 2006; Sanders and Dandavate 1999; Sleeswijk Visser 2009). The roles presented here relate directly to how artifacts support or communicate sensory insights. As a result this section includes the four roles of artifacts presented in Chapter 4: ***adaptive, probing, generative,*** and ***conceptual*** as shown in Table 6.1.1.d Sensory Role of Artifacts. These are discussed with respect to their value for providing insight into people's sensory experiences with objects they encounter in their daily activities.

Adaptive Roles of Artifacts provides a structure for noting the supportive or assistive sensorial ways in which participants use artifacts. It draws from the literature on inclusive design, but not only with the point of view of disability. The literature provides observations about people with disability problems, such as limited dexterity, and how they go about their activities of daily living, such as preparing food, with the objective of collecting data for designing more appropriate objects (Benktzon 1993; Coleman, Bendixen and Tahkokallio 2003; Pattison and Stedmon 2006). Similarly, this perspective emphasizes observing and identifying the adaptive sensory roles of objects already in the participants' daily lives for possible insights into potential design solutions. In this study, some older participants' tactile senses were engaged by holding onto the chair backs set up in front of them to help them feel stable when trying to do balance exercises.

Probing Artifacts can provide a different type of observational structure for understanding how people engage their senses during interactions with them. There are two different ways to explore probing artifacts: probing into meanings participants attribute to them and probing into experiences participants have with them. The first draws from the interaction literature discussing differing subjective meanings people have for the same artifact, where a phone may be a flirting device for one person or for "checking-that-nothing-has-happened" to another (Hallnas and Redström 2002; Larssen 2007). It looks at the "feelings, attitudes, orientations, and perceptions" people have in relation to their habituated ways of interacting with objects (Geurts 2002: 17). This was evident in the heated discussion among the participants in the stability co-design workshop group who had strong opinions about the kind of support their shoes provided, ranging from good to bad.

By contrast, the second way of probing into experiences draws from the design methods literature in which probes are inserted into people's daily activities to disrupt their habitual ways of behaving and observe how they engage with them, such as how they orient toward the thing, act on or use it, or act through it as a bodily extension (Hutchinson et al. 2003; Larssen, T. and J. 2007; Sundström et al. 2009; Westerlund 2007). In this study, terrain-mat boxes were sensory probes inserted into the exercise environment. They revealed kinesthetic, and tactile responses, where some participants could easily change terrains and others had to turn around to face forward while stepping onto specific boxes that made it easier to take a step.

Generative Artifacts are tools for communication and insights. As noted in the literature, generative artifacts are props for discussion between researchers and participants, both of whom are engaged together in their creation (Sanders and Stappers 2012; Sanders and William 2003; Sleeswijk Visser 2009). In this study, during the course of making artifacts together, researchers listened to the older participants' exercise stories, gained understanding of their experience and became aware of the issue of leaning while performing specific movements.

Lastly the ***conceptual roles*** of artifacts have long been used in design to represent potential future objects that may be more suitable for people's experiences. They can take the form of prototypes that run the gamut from very crude to highly refined, from two-dimensional scenarios to three-dimensional models (Hallgrimsson 2012). In this study the first set of artifacts produced in the co-design workshop is both generative and conceptual, whereas the second set of artifacts, such as the student produced Mat Mate T-shirt scenario of use, are purely conceptual. Note that these can serve to communicate design responses to sensory information as well as archival documentation.

SENSORY ROLES OF ARTIFACTS	DESCRIPTION	EXAMPLES
ADAPTIVE ROLES	*How do people adapt artifacts to assist or support their sensory experiences?*	*Older participants hold onto chair backs for tactile & kinesthetic assistance while doing balance exercises*
PROBING ROLES	*How can artifacts elicit information about meanings people attribute to them or ways people engage with them?*	*Two participants have very different interpretations of whether sneakers are good or bad for their feet. In addition, some participants moved easily from one terrain box to the next and others had to carefully reposition to do so*
GENERATIVE ROLES	*Artifacts can become props for discussion when researchers & participants make them together*	*Older participants demonstrate leaning & student researchers try to understand leaning while making artifacts that signal leaning to the wearer*
CONCEPTUAL ROLES	*Artifacts can visually represent design responses in the form of potential future objects through prototypes or scenarios*	*Student scenarios visually demonstrate concepts of possible products that can address sensory issues, such as the Mat Mate T-shirt scenario of use*

Figure 6.1.1.d Sensory Role of Artifacts

5) **Gestural Language** is presented here as the last of the five thematic perspectives of the Sensory Contexts Guidelines for Design Research as seen in Table 6.1.1e. Gestural Language. The three kinds of gestural enactments that emerged in this study are ***Evoking Gestures, Confirming Gestures,*** and ***Structuring Gestures;*** they build upon one another to provide deep insights for designers.

Evoking gestures communicate tacit knowledge through gestural forms. An example in this study occurs when Gord opens and closes his arms to demonstrate overextending the arms while weight training. ***Conjuring Gestures***

move one step beyond thinking gestures into the realm of design where a participant or researcher begins to depict a potential design solution on the body by gesturing to the site that communicates his or her latent knowledge. In this study, Philipe not only gestures by moving his head from side to side, but also gestures with his hands to depict something wrapping around his head. Lastly a ***Structuring Gesture*** occurs when one or more participants is gesturing while talking and making things with other participants and/or researchers to physically illustrate the participants' tacit or latent knowledge. In this study, this occurs when one participant makes an "earring" while the others at the table are talking and raising their shoulders to illustrate the problem of trying to be conscious about keeping the shoulders in their normal down position while exercising.

GESTURAL LANGUAGE	DESCRIPTION	EXAMPLES
EVOKING GESTURES	*How do people use gestures to express their tacit knowledge of specific experiences?*	*One participate opens and closes his arms to explain how he overextends the motion while weight lifting*
CONJURING GESTURES	*How do people translate their latent knowledge into gestures that illustrate a potential solution on the body?*	*One researcher is moving his head while wrapping his hands around it to show where sensors could be placed to track its movement*
STRUCTURING GESTURES	*Reinforcing bodily gestures by talking & making things that illustrate both tacit experiences & latent understandings of solutions*	*One participant crafts an earring to solve a problem the others are gesturing& talking about*

FIGURE 6.1.1.E GESTURAL LANGUAGE

6.1.2 Applying the themes in stages of design research

While the stages of academic design research have not been explicitly discussed in this study, they follow a commonly understood path: identifying and developing a researchable topic; developing and presenting the literature review, establishing a methodology and research approach; analyzing data and reporting findings; analyzing and interpreting findings; and drawing sound conclusions and presenting actionable recommendations (Bloomberg and Volpe 2008). The five contexts that contribute to these sensory guidelines for design research can be applied across each of these stages, and may be most valuable in the methods, analysis, and synthesis stages, as is the case in this investigation. Accordingly, the discussion here is based on my experience.

In the first stages of identifying and developing a researchable topic and developing and presenting the literature review, each of the five themes of the framework could have helped organize my initial contextual framework. For example, my literature review addressed older people's attitudes toward ageing, as well as ageist attitudes toward older people (*Participants' Worldviews*). It also delved into older people's changing sensory landscapes, their extereo and kinesthetic sensations, as well as sensory deficits and sensory reordering (*Sensory Practices* and *Sensory Interactions*). In addition, the literature discussed design research and methods focusing on *adaptive roles of artifacts* in inclusive design and *generative roles of artifacts* in co-design. It did not consider *Gestural Language*, as that was a surprising finding later. These five-point guidelines would have made it easier to organize my literature review and define my researchable topic. Therefore I recommend that others use it in the early stages of design research.

In the stage of establishing a methodology and research approach, the five contexts could also have provided a checklist for me to clarify what is within and outside of the scope of the investigation. For example, initial empathic exercises to sensitize the student researchers to the experiences of ageing did not prepare the researchers well enough to identify their own assumptions and attitudes about what an older exerciser might wear to fitness class (*Participants' Worldviews*). However, it was clear that ethnographic fieldwork would provide insight into the differences between exercising for young and old, shedding light on extereo sensations, proprioceptive sensations, activities, sequences, and rituals, as well as multi-modal awareness, sensory deficits, and sensory reordering (*Sensory Practices* and *Sensory Interactions*). At this stage, the role of artifacts in my study became important in two different ways: as tools for research (*Generative and Probing*) and as signifiers of observed daily and potential future interactions (*Adaptive and Conceptual)*. Had I understood these contexts, the study might have taken a different path: for example, a focus wholly on generative artifacts or only on sensory aspects of adaptive artifacts for balance relevant to design. These sensory guidelines may have helped me prioritize among appropriate research methods. Therefore I recommend that others use them to help set up their methodology and research approaches.

In the stages of analyzing data and reporting findings, and analyzing and interpreting findings, these sensory anthropology contexts evolved into a coherent structure for constructing an understanding of the findings within and across methods. Here the *assumptions, attitudes,* and *culturally acceptable sensory behaviours* were nuanced in unexpected ways, such as when an older exerciser wondered if the students might expect them to be "dottery" (*Participants' Worldviews*). In addition, the findings in each of the three methods revealed that self-monitoring is important for older exercisers *(Sensory Practices).* In this investigation self-monitoring can be understood from at least three different points of view: it takes time to learn to self monitor (participant observation finding); augmented monitoring should only augment self-monitoring, not replace it (co-design finding); and it can be difficult to monitor subtle aspects of bodily responses (technology probe finding). *Sensory deficits* and *sensory reordering*, such as tactile senses compensating for proprioceptive sensory feedback, also became apparent across methods, providing analytical triangulation (*Sensory Interactions*). Depending on their roles in the investigation, artifacts revealed sensory information about people's tacit and latent, and current and future, sensory interactions in all four categories of *adaptive, probing, generative,* and *conceptual* (*Sensory Roles of Artifacts*). Lastly, through analysis the initial awareness of *evoking, conjuring,* and *structuring gestures* emerged (*Gestural Language*). Since this approach provided extensive sensory insights, many which could be doors to further research, I recommend that it be applied in future research in the stages of analyzing data, reporting, and interpreting findings.

In the final stage of drawing sound conclusions and presenting actionable recommendations these sensory guidelines could serve as a basic structure. They are summarized in Figure 6.1.2 as Sensory Contexts for Design Research Guidelines. They also serve as a response to McCann's (2009: 46) earlier call for a design tool that identifies key considerations for understanding experiences with technological possibilities

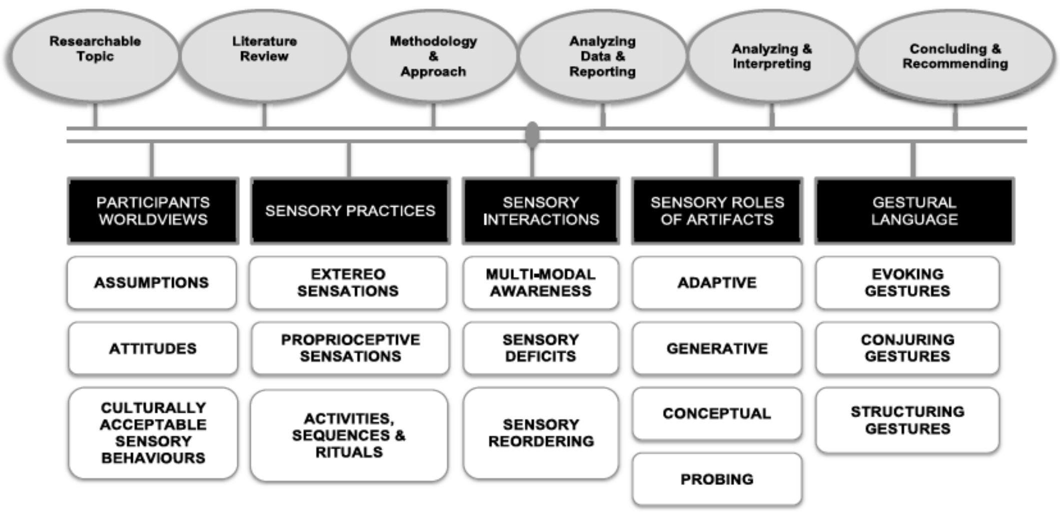


FIGURE 6.1.2 SENSORY CONTEXTS FOR DESIGN RESEARCH GUIDELINES

6.1.3 Applying the guidelines for different research methods

The methods used in this investigation are not new (ethnographic Participant Observation (PO), Co-design activities (CA), and Technology Probes (TP). However, new empathic and sensory insights arose from applying the guidelines when analyzing the data. Figure 6.1.3 below illustrates a way of organizing the insights across methods and within the five thematic categories of the sensory context guidelines. In the examples below early findings from the Participants' Worldviews and the previously named Bodily Ways of Gathering Information areas are segmented into cells. The cells correspond to the methods through which the insights emerged. If an insight emerged in only one method it only appears in that cell. For example, "engaging young and old" only happened in the Co-design (CA) activities so it is in that cell. On the other hand, if an insight emerges across multiple methods it only appears in that cell. For example "social and fun" arises across all three methods so it is only recorded in that cell (PO CA TP). The complete set of diagrams for each of the contexts in this investigation is in Appendix K. Note that for the sake of simplicity, the sub-categories for each context are not included in this diagram.

FIGURE 6.1.3: EXAMPLE OF ORGANIZING FINDINGS ACROSS METHODS

While Figure 6.1.3 demonstrates a way of capturing some of the insights emerging by context, it is specific to the three methods used in this investigation. Since there are numerous methods for user-centered design research, the Sensory Contexts for Design Research Guidelines will not be relevant for every method (Hanington and Martin 2012; Kumar 2013; Sanders and Stappers 2012; Schifferstein and Hekkert 2008; Visocky O'Grady 2006; Weinschenk 2011). Future researchers can probe into their suitability for other user-focused design research methods that focus on understanding the sensory issues relevant to design.

6.2 Design Insights

The narratives presented in Chapter 4 provide detailed description to build archival and empathic knowledge, which is often missing in design due to lack of documentation and competitive non-disclosure. However, these empathic stories can also be distilled into considerations for designing the human-oriented aspects of advanced technologies that support longer life, variable physical and cognitive states, and the ability to live independently (Keates and Clarkson 2003; Sherwood, Mintz and Vomela 2005). I followed the Sensory Contexts for Design Research Guidelines to organize the findings from this investigation into initial recommendations for the design of appropriate sensory-augmented fitness technologies (see Appendix L). In particular these initial recommendations respond to Dunne and McCann's views that a one-size-fits-all approach to wearable computing does not take the physical or cognitive limitations of older people into consideration (Dunne 2004:42; McCann 2009:347). A better approach would involve adapting to or growing with people's changing sensory experiences through the three stages of well-being: well, somewhat impaired, and frail (Quadagno 2011: 7).

McCann (2009:348) argues strongly for the importance of involving older users when identifying a broad range of personal issues that will affect their expectations for the wearable and technology-enabled products that they might use. The insights presented in the following section arise from such collaboration and provide human-oriented insights for technical designers developing technology-augmented devices. Their objective is to assist impaired older adults in learning new sensory experiences and to avoid simply extending their capabilities with prosthetics.

6.2.1 Final Design Insights

This research proposes that technology can provide assistance and more confidence through monitoring impaired older exercisers' multiple sensory demands while training. It can help them stay on track and incrementally improve their fitness levels by limiting, augmenting, or adding sensory modalities while practicing movements and body positions. The research shows that product interaction is dependent on the relationship between the person using the product and the product itself.

Since the initial design recommendations in Appendix L are organized in the format of the Sensory Contexts for Design Research Guidelines there are numerous overlapping concerns. They are distilled here into seven Final Design Insights for designers to address when developing assistive technologies for fitness for older adults.

Appropriate technologies for an impaired older population should:

1. ***Offer Alignment Assistance***

Sensory augmented technologies should assist when training impaired older exercisers in proper body alignment while standing, sitting, or lying down.

To support bodily ways of gathering information products could use sensors that identify and provide tactile, auditory or visual feedback for making micro-adjustments to accommodate painful and unstable positions, such as correcting neck strain, shoulder hunching, low back sway, and proper weight distribution. They can also monitor and encourage progress through different ranges of hand and foot adjustments from full holds or pressure to minimal touch or equal distribution.

2. ***Support Slow and Incremental Improvements***

Sensory augmented technologies should monitor and support slow, moderate, incremental improvements or adjustments while moving. They should provide gently increasing levels of challenge, while discouraging long-term dependence.

To reinforce older people's sensory practices, technologies should recognize moving positions and provide tactile and auditory feedback. That feedback would support realignment and accommodations for restrictive asymmetrical bodily challenges such as prompts to slow down, position and place the foot properly, distribute pressure symmetrically, and move forward when there is enough stability. They should also support slow and gentle backward motion, responding to changing levels, such as curbs, and signal when additional tactile support is needed. For example they could scan walking surfaces, provide warning alerts, and even alarms in worst-case scenarios. They could also assist with joint alignment by motivating exercisers to identify limits and ease beyond them.

3. ***Provide Adaptive Capabilities***

Incorporate interactive and modular features into sensory-augmented technologies that are sensitive enough to identify diminishing sensory capabilities over time and can be adapted to help a person regain trust in their own body signals.

To support changes in interactions between the senses due to ageing product features should provide varying combinations of haptic, visual, or auditory responses to sensory changes to help a person develop awareness of what senses they can compensate with.

4. ***Include Self Monitoring Features***

An interactive product experience with sensory-augmented technologies should draw attention to a person's bodily feelings and comfort levels during specific experiences.

The sensory role of interactive products should include assisting older people in developing self-monitoring awareness. Since self-monitoring is a state of mind, not numbers, numerical monitoring could be considered as a background function. For example, what is too fast, and what is a measured or doable pace? However, numerical monitoring could be activated as a memory aid for repetitions and left/right balance.

5. ***Incorporate Pleasant Characteristics***

Interactive product qualities of sensory-augmented technologies should provide positive feedback, reassurance, and opportunities for fun and collegial socializing.

Product qualities should bolster an older person's worldview by incorporating friendly auditory feedback and gentle haptic reassurance in response to small achievements. They can also be modular or work with other similar products to allow for collegial goal setting and playful social activities suitable for older people.

6. *Integrate Appropriate Aesthetics*

Sensory-augmented assistive devices should integrate visually into an older person's effects without drawing attention.

Devices should respect impaired older people's worldviews by looking ordinary, unobtrusive, not highly fashionable, not assistive or medical, and not desirable enough to steal. Building on familiar aesthetics and including features that support personal expression can encourage their acceptance. In some cases, varied surface treatments and modularity can contribute to diversity, adaptability, and multi-purpose use.

7. *Be Reliable*

Sensory-augmented product solutions need to be tested and proven reliable, and/or distributed through sources that will take responsibility for them to promote long-term product acceptance.

To fit into an impaired older person's view of acceptable product traits, they should be easy to maintain, to wash, to clean, to repair, and to replace with the identical item, if necessary.

6.3 Contributions to the field

According to Howes and Classen, "sensory evaluation is a big business and a number of methodologies have been elaborated for the study of consumer sensory preferences" (Howes and Classen, 2014: 140). As examples they cite Japanese Kansei Engineering (KE) and the Sensorial Quality Assessment Model (SEQUAM) developed in Italy by Bonapace and Buti for Fiat Auto (Bonapace 2002). Both of these approaches value subjective user sensations (including feelings and all the senses). They both, however, primarily measure and analyze user responses to an already existing product in a controlled setting to design better product features (Lévy 2013; Lee, Harada and Stappers 2002; Schütte, Eklund, et al 2009). These quantitative, controlled, and product-driven approaches differ from the qualitative, in-situ, and human experience-driven approaches discussed in this dissertation.

These approaches may contribute to the newly emerging discipline of Kansei Design (KD), which focuses on investigating users' subjective experiences for design inspiration. Lévy notes that KD "subjectivity favours possibilities over optimization, engagement over efficiency, utopian motivation over feasible goals, what makes one move over, what makes one achieve (Op Cit: 90).

The insights presented in this chapter should be viewed as preliminary offerings in a relatively new area of design research because they evolved from only one study. They make two contributions to the field: The Sensory Contexts for Design Research Guidelines and Insights for designers to consider when developing assistive technologies for fitness for an impaired older population.

6.4 Future Research

In the future, the Design Insights could also be used in a Kansei Engineering approach to investigate and evaluate the features of existing wearable and technology-enabled products. They could also be used to inspire new and innovative product solutions where further user-centered design research could ascertain their value for and with older adults.

The Sensory Contexts for Design Research Guidelines could be applied at the level of a general overview (macroscopic), such as in this investigation. For a bigger picture these guidelines could also be applied to gaining insights about the indirect users affected by the older exercisers' fitness activities: caregivers, family members, health practitioners, fitness instructors, facility resource providers, and others who are affected. In addition, they could be applied in a more focused manner (microscopic) by narrowing down to one of the five major organizing themes presented here. For example, within the theme of 'Sensory Interactions' there is potential for a deeper study of the effects of variable shifting sensory modalities of ageing and sensory re-ordering in relation to assistive technologies. Future studies can also explore the usefulness of these guidelines within other user-centered design research methods as well as for other user populations.

6.5 Limitations

As this study was exploratory, it took some time before I recognized that the outcome should not only be insights for technology-enabled products for impaired older adults, but also — and perhaps more importantly — a set of guidelines for exploring sensory design contexts. While the study began in the realm of wearable computing, it broadened into sensory-augmented technologies that were not wearable or even modular. This evolution was a response to the data emerging in previous phases of research. One of the first findings in this study was that if wearing technology meant more complexity or inconvenience, older people would not use it. Therefore, the results were not focused solely on wearable technologies for older adults.

In addition, the research tools were limited to simple sensor technologies. That reduced the learning curve and facilitated the making of prototypes. Though the original plan was to focus on the frail elderly, we worked with a convenience sample of older people who came forward, most of whom were older, but not frail. Lastly we were constrained by a time period that was framed by the participants' semesters, both in school at the fitness centre.

7 Reflections

Over my years of involvement in this study, I have noticed that a sensory anthropology approach has slowly been colouring both my worldview and professional work. This chapter provides a short look at the highlights of those influences.

7.1 Ethnographic Writing

Early on, curiosity led me to investigate the anthropological method of ethnography. As noted in Chapter 3, it is well known that designers appropriated ethnographic field methods from anthropology in the mid seventies (Wasson 2000). Design research-practitioners had developed a speedy version of participant observation driven by the need to get products to market quickly (Plowman 2003). In that act of appropriation the methods for documenting insights from the field were also altered. Instead of descriptive interpretive texts, design researchers developed forms of visually representing prescriptive research findings (Moggridge 2007: 671). I wondered if anything had been compromised in the transition and decided the best way to find out was to investigate anthropology myself.

That led me to the rich descriptive ethnographic narratives of anthropologists Clifford Geertz, Daniel Miller, Sarah Pink, and Loïc Waquant, to name a few. Slowly I came to a fuller understanding of the process of ethnography, as described by Geertz (1973: 5):

> *In anthropology…what the practitioners do is ethnography. And it is in understanding what ethnography is, or more exactly what doing ethnography is, that a start can be made toward grasping what anthropological analysis amounts to as a form of knowledge. This, it must immediately be said, is not a matter of methods. From one point of view, that of the textbook, doing ethnography is establishing rapport, selecting informants, transcribing texts, taking genealogies, mapping fields, keeping a diary, and so on. But it is not these things, techniques and received procedures that define the enterprise. What defines it is the kind of intellectual effort it is: an elaborate venture in, to borrow a notion from Gilbert Ryle, 'thick description'.*

Where designers are translating and communicating data into visual memos (scenarios, personas, and other abstract visual representations), we are not necessarily capturing the nuances of people's experiences. The cartoon-like storyboards and charts are not meaningful substitutes for rich descriptive detail, much like a play does not provide as full a synesthetic experience of the same work as an opera. I presented and published a paper exploring this in more detail at the International Association of Societies of Design Research Conference in Seoul Korea, proposing that some of the key elements of ethnographic writing would be useful in communicating design research findings. In particular, designer-researchers could adopt ethnographic writing techniques to become more articulate at describing and preserving design knowledge (Frankel 2009).

I am not alone in wondering if rich user-centered description could provide engineers and other technically oriented professionals with deeper insights into users' experiences. Other design researchers are also exploring the use of descriptive narratives to communicate "ways that artifacts are implicated in human understanding and meaningful interpretation and stressing that the use, display, and ownership of individual artifacts cannot be understood in isolation from context and environment" (Jung et al. 2011: 60; Spaulding and

Faste 2013). A question that remains for future research is whether narratives such as those described in Chapter 4 would attune the techies to deeper human needs?

7.2 Empathy

The narratives present a descriptive alternative to prescriptive solutions that lead to specific product applications (see the introduction to Chapter 4). They represent what Kolko refers to as abductive magic. He explains that an abductive approach to design research can lead to "the hypothesis that makes the most sense given observed phenomenon or data and based on prior experience" (Roger Martin as quoted in Kolko 2011: 23). This conditional point of view allows for empathic interpretations of the data, or what Margolin refers to as idealistic scenarios (2007).

In addition, this conditional perspective contrasts with what Margolin refers to as predictive scenarios in which "strongly articulated visions of what should happen" lead to pragmatic design solutions (Ibid: 6). Similar contrasts appear throughout this document, where discussions reveal my conflicting views about the credibility of the intuitive and exploratory in the face of rigorous scientific and technical methods for gathering, interpreting, and applying data in designing and making products. In discussions and experiences with peers, I am learning that these tensions exist in the field, and are not easily resolved. As a result, the narratives, insights, and especially, the guidelines in this dissertation are not rigid; they are intentionally broad to pave the way for more empathic research with older people and other special populations.

Moreover, it was a privilege to participate in a small aspect of other people's lives. They were no longer objects of study along the way to accomplishing the goal of producing an end product; I was getting to know them, and walking home from my field sessions I felt alive, in touch, and oddly relaxed. I enjoyed just being there and connecting with people, and that connection seemed to be mutually rewarding. It led to a major studio project during the 2013-2014 academic year where five of my fourth year industrial design students held co-design sessions with visually impaired students to explore potential ways their navigation decision making could be improved. The students' journey began with the stories and models the vision impaired students shared and evolved with their ongoing mutual participation over the next six months.

Another, and somewhat different aspect of connecting closely with the older participants arose for me. I was seeing my potential future self. This insight is addressed in the inclusive design literature, and always struck me as an interesting, but abstract, concept. However, over the seven years my own body changed, in ways parallel to some of the stories the older participants were sharing with me. One day, an older man told me that he noticed he really could not walk in a straight line, one foot in front of the other, anymore. This was scarily prescient and I finally succumbed to reporting to my doctor that my feet were simply not walking right anymore, which led to simultaneous arthroscopic surgery on both knees.

One woman told me she no longer participated in some sports, and had replaced them with other less aggressive activities. I too had given up downhill skiing, which was unbearably painful for my knees, and timidly replaced it with cross-country skiing. In addition, during the course of this study I took up and gave up masters swim training; replacing it with aquafit classes due to rotator cuff injuries that developed over the three years of swim training. This telling is not meant to be a lament of woes, as much as an admission of unexpected opportunities for empathy with the older participants.

7.3 Senses

Since 1994, I have taught a studio course entitled “Form and Colour Fundamentals” more than any other course in my career in the School of Industrial Design at Carleton University. I have changed the format three times, each time with the objective of helping students engage more deeply with the basic principles of three-dimensional design and colour applications in product design. While doing this research, I received permission to completely alter the course to address a sensory approach to the principles of form and colour; turning away from prescriptive studio-based fundamentals of design to a user-focused lecture and tutorial-based investigation of sensory aspects of design. In 2012 I taught the first version of this course, followed by a somewhat more refined version in 2013.

I published two papers about this course, in Chicago at the IDSA (Industrial Designers Society of America) Education Symposium 2012 and in Umeå, Sweden at the DRS (Design Research Society) 2014 Conference (Frankel 2014; Frankel 2013). Each paper addresses different perceptions that arose from student projects. Both papers draw from the original Gestalt approaches of the

Bauhaus, Sensory Anthropology, and the work on multi-sensory aesthetic studies conducted at the Delft University of Technology (Schifferstein and Hekkert 2008). They reveal that the visual aesthetic treatment of products, while initially important, can be augmented and sometimes overridden by tactile and auditory product qualities.

As a result, and through further research, I recognized the value of my work in relation to other academic sensory research in design (Chang and Ishii 2006; Heylighen and Strickfaden 2012; Schifferstein 2011; Schiphorst 2009; Sonnenveld, Ludden and Schifferstein 2008). In addition, recently my masters thesis students are exploring sensory design topics, leading to three sensory related investigations: Examining sensorial interfaces as the stimuli for remote affective communication; Investigating Interactive Biophilic Wearable Objects; and Changing the Context of Experience: Applying designed sensory elements toward mindful eating. While this is timely work, it has a different perspective than that of the sensory framework presented here.

7.4 Quantified Self

When I began this research I was unaware of the emerging Quantified Self movement in which people use technology to capture and monitor biometric and other data about themselves. I am currently Co-supervising another Masters of Design thesis with a Professor in Electrical Engineering entitled, “Design Implications of User Experience for Tracking with Technology: Semantics of Self-Tracking and the Quantified Self Movement”. This project is aligned with the kind of products that could emerge from the insights and guidelines in this research.

Along with our student, I am exploring the capabilities of wearable devices to provide me with useful information for my own fitness activities. To my amazement, the fitness devices we are testing are not capable of providing any sensory feedback. My Striiv Play pedometer and its competitors, the Fitbit Zip and the Misfit Shine, can capture the distance and steps I take, but not the quality of my motions. My Striiv Play encourages me to reach higher goals by cheering me on with celebratory icons and game tokens, but it doesn't give me any information about my body position or other sensory guidance. I believe my research can also add value in the growing market of wearable fitness monitors.

8 Conclusions

As I am preparing to write this chapter I am reminded of this morning's email from one of my graduate students. He says, "I've been thinking to do something around an Interaction Design Framework for Sensor Technologies". He proceeds to describe his interest in the environments and objects in the home, and adds, seemingly as an afterthought, "…adapting interactions with them for the end user". The results of my investigation might shift his primary point of view from the spaces and objects to the people's sensory contexts. That would make it easier for him to gain sensory and empathic knowledge that could lead to designing suitable technologies for people. He should approach his interaction questions with more of a sensory discerning perspective.

These thoughts take me back to the introduction to this dissertation, where I wondered about what, if any, technological products would fit into an older person's everyday fitness experiences. At the time, I believed that sensory anthropology would hold a key to developing insights for designers, engineers, technology-driven professionals, and others in the blossoming field of wearable technology. A sensory anthropology approach to design might provide a deeper understanding of older persons' uniquely different and evolving sensory modalities, resulting in the design of appropriate sensory-augmented technologies for them. The results of this study suggest that I was on the right track, one that complements existing scholarly activity in this area. The conclusions presented here summarize my findings and interpretations into two actionable areas: (1) Perceptions that should influence technology design for

Older People and Fitness and (2) Sensory Contexts for Design Research Guidelines for discovering empathic and sensory knowledge.

8.1 Perceptions that should influence technology design

A key finding in this study is that older participants are learning to bring more awareness into their fitness activities than they did in their younger years. The dichotomy between the older exercisers and the younger researchers highlights the older participants' attributes. The sometimes abrupt and other times gradual changes in an older person's bodily capabilities can make once-habitual activities challenging. The findings from this study portray the type of training necessary to tackle some of the older exercisers' demanding everyday movements. For example, the impaired students were learning to become conscious of their multi-modal sensory practices, like looking, talking, and touching, at the same time as they were performing routine tasks requiring proprioception and kinaesthetic awareness. All of this embodied awareness was needed simply to stay upright! The contributions of this research may make it possible to assist them in becoming more conscious of their bodily interactions during fitness and in their daily activities.

Even though they represent a very small group of older people, the findings corroborate the facts noted in the gerontology literature. The narratives in chapter 4 compliment the literature by providing deeper stories as illustrations. The observations revealed in the stories contribute to actionable design insights in Chapter 6. Both the narratives and the insights serve as partial responses to the call for sensitivity when designing for the needs of older people discussed in chapter 2 (Bauer, Streefkerk et al, 2005; Coleman, 2003, Hardy and Baird, 2003, Mollenkopf, 2003; McCann, 2009).

8.1.1 The Narratives

The narratives are the first contribution of this research. Here the findings are presented as an ethnographic record and a richly descriptive resource for designers. They provide a knowledge base for highly skilled technology-oriented professionals who design sensor-augmented wearable technologies for older exercisers. It is my intention to make empathic and sensory knowledge available through detailed description organized into sensory categories.

The stories are certainly lesser substitutes than personal observations, but they portray deeper understandings than a gerontology text or an illustrated design scenario would. For example, Chapter 2 notes that sensory organs age resulting in deficiencies in processing incoming sensory information (Glass 2007; Huppert 2003). In Chapter 4 this is illustrated through descriptive ethnographic interpretation,

> *For an older person, those same feet that could dance to the side without effort, to avoid an oncoming dog or child, now find they need time to register and feel the right way to go. What makes a way right? Maybe it doesn't hurt. Maybe it is a route that he or she can visually evaluate first. Maybe it is a spot where her foot feels stable. Maybe he can't see the ground or feel it, and is not comfortable moving until he finds a support he can hold on to, like a nearby wall or his son-in-law's hand.*

The narratives of this dissertation are a way to present empathic perceptions that may influence the design of products for older people and fitness.

8.1.2 The Design Insights

The second set of contributions emerging from this research, the Design Insights for designers, is described in Chapter 6. These are design considerations for sensor-augmented technologies suitable for impaired older people's everyday fitness use. They should initially be studied when designing devices used for a range of monitoring and feedback information for the following: standing and lying postures; foot positioning and placement; joint flexing; and include speeds and number of repetitions. They address a range of needs, which should allow for a degree of customization and product adaptability over time. They could also be explored in future research to verify their usefulness and potential for implementation.

Sensor-augmented technologies for impaired older people's fitness activities should address the following design characteristics:

1. **Offer Alignment Assistance** by using sensors that identify and provide tactile, auditory, or visual feedback for making micro-adjustments to ease pain and increase stability in standing, sitting, and lying postures, and placement of hands and feet.

2. **Support Slow and Incremental Improvements** by recognizing moving positions. Provide tactile and auditory feedback, prompts, or alarms for increasing challenge levels through speed, pacing, bodily symmetry, direction changes, and varied walking surface heights and textures.

3. **Provide Adaptive Capabilities** by incorporating technologies and modular features that learn about and reinforce a person's ability to compensate for diminishing capabilities in one sense by activating another sense.

4. **Include Self Monitoring Features** that measure and draw attention to variations in bodily feelings and comfort levels, with background numerical support as required.

5. **Incorporate Pleasant Characteristics** through auditory and haptic responses to achievements that also encourage collegial goal setting and playful social activities suitable for older people.

6. **Integrate Appropriate Aesthetics** through visual features that support personal expression, while looking ordinary: not highly fashionable, not assistive or medical, and not desirable enough to steal.

7. **Be Reliable** for older people to easily maintain, wash, clean, repair, and replace with the identical item on their own or through a responsible source.

These are preliminary offerings because they evolved from one case study. However they indicate that the one-size-fits-all solutions currently on the market may not address the nuances that sensory-augmented technologies for impaired older people's fitness activities require.

During the study it became apparent that opportunities for assisting with many sensory needs would be excluded by only focusing on wearable sensory augmented technologies. As a result, these Insights may also be useful for technologies that are not wearable, but still oriented toward fitness training for older adults.

8.2 The Sensory Contexts for Design Research Guidelines

Exploring the nature of and the solution to a problem can be as interesting or useful as the solution itself. In this case my explorations resulted in new approaches to design research. The Sensory Contexts for Design Research Guidelines are discussed as a contribution to the field of design research that may provide insightful and empathic sensory knowledge for designers exploring a wide range of user-centred design issues.

8.2.1 Sensory Contexts for Design Research Guidelines

The most significant contribution of this dissertation is the development of guidelines that emerged from working with perspectives of sensory anthropology. The guidelines touch five themes that are summarized below:

1. Participants Worldviews

The participants' and the researchers' *assumptions, attitudes*, and *culturally acceptable sensory behaviours* influence and contribute to design research knowledge. While this may be taken for granted in social science research it is not always considered in design research.

2. Sensory Practices

Empathic product design research insights depend on understanding the participants' *extereo sensations*, *proprioceptive sensations*, and *activities, sequences and* *rituals*. It should be easier for researchers to observe this kind of sensory knowledge than it is for participants to discuss since it delves into automatic and repetitive sensory experiences.

3. Sensory Interactions

Sensory knowledge can contribute to innovative product design by addressing *multi-modal awareness*, *sensory deficits*, and *sensory reordering,* particularly for special needs populations. It is natural for the senses to interact with one another and, for the most part, they should not be considered separately.

4. Sensory Roles of Artifacts

Artifacts are important and useful for design research. They support and communicate sensory insights at different stages of the research process: in participants' daily events (*adaptive artifacts*), in researchers' exploratory activities with participants (*probing artifacts*), in creating props for mutual discussion between researchers and participants (*generative artifacts*), and in representing potential future objects (*conceptual artifacts)*.

5. Gestural Language

Three kinds of gestural language can contribute to communicating and depicting tacit and latent design research information. *Evoking gestures* and *conjuring gestures* are transient actions, accompanied by explanations of tacit knowledge in the first case and latent knowledge in the second case. *Structuring* *gestures* are communications that provide a structure for sketching or modeling product ideas. This is a way to communicate tacit and latent knowledge.

Since these guidelines also emerged from a case study, they are a preliminary contribution to the field of design research. There is an opportunity for more research into the breadth and depth of their application. Any of these themes can be singled out for study at different stages in the design research process. Each theme may be applicable to clinical and applied design research, and possibly basic research. The exploration into gestural language in this case study suggests that sketching and modeling are not the only ways to communicate design ideas, and that gestures may contribute more to conceptual design development than designers acknowledge.

8.3 Closing Note

This research began with the objective of gathering multi-layered insights to inform the design of wearable assistive technology products. I hoped to explore how designer researchers could gain insights for designing for an older population. This chapter summarizes the insights that emerged from this study and the process that led to them. The insights start to demonstrate how a sensory anthropology perspective can inform industrial design research by providing empathic and sensory knowledge about designing with and for older people. Hopefully this sensory approach will benefit the field of design research in two ways: by adding new levels of rich holistic knowledge about people and by becoming a tool for framing and analyzing sensory design research. Rather than an end, this is just the beginning.

9 Aperçu

My foray into sensory anthropology has been informative and exciting. It has, moreover, altered my approach to industrial design and, indeed, how I teach industrial design.

This chapter, after a brief anecdote about the current context of industrial design thinking at Carleton University, introduces the content of my course, Sensory Aspects of Design. Then, future considerations for incorporating aspects of sensory design research from this dissertation into course teaching resources — to make the material more accessible for students and other design educators — are discussed. Finally this chapter reflects on the impact this study should have on design education.

9.1 A Snapshot on Studio Review Day

I am sitting with my colleagues in the windowless, third-year studio in the School of Industrial Design at Carleton University. We are reviewing the studio courses in a semester-end behind-closed-doors session. The studio is packed with displays of students' full-scale models (ergonomic models in wood, form-development models in card stock and blue foam, appearance models painted to look like the real product). An array of food processors, camping cook stoves, hotel irons and ironing boards, pneumatic hand tools, and other prototypes of appliances surround us.

The models are placed in front of presentation boards that illustrate each design concept through renderings and three-dimensional CAD drawings. The students' herculean efforts in exploring three-dimensional forms are impressive.

Most have successfully risen to the challenge of unifying all of the compositional elements, for example: the processor bowl and lid, the motor housing, the handle, and the controls all flow together to look like one whole artifact. That artifact is meant to be an incremental improvement over existing comparable and competing appliances in the same product category. In spite of the formal quality and quantity of the explorations, I find the work lacking sensory relevance.

Their professor laments that after resolving all of the formal details, the students spent an additional two weeks at the end of the semester, in the lab, making their final appearance (looks-like) models. Another ask, “Why not forgo the appearance models and just have virtual models” (full three-dimensional CAD renderings and technical drawings)? I ask, “Did they consider what the surfaces feel like, the tactile aspects of the materials, textures, hardness, softness? Did they consider what these things sound like, the consequential sounds and the intentional feedback sounds?” They look at me as if I am from another planet. “Lois, they already have too much to do, what more do you want to fit in?”

This is the state of industrial design education at Carleton and mostly elsewhere. One year ago, the students in this studio took my course IDES2205 Sensory Aspects of Design. Yet not one of the forty-five students explored anything other than formal and physical ergonomic factors. No one addressed the sounds their appliances could make or the way a snap fit could provide tactile feedback or how a sticky grip could provide a more secure handhold. I wonder how to support both my colleagues and our students in addressing other sensory aspects of design in their studio projects?

I know they are listening. At the end of each semester we meet like this, behind closed doors to review the work produced in each studio course, from years one to three. We discuss all the projects and identify what was successful and what could be improved. We use these walkabouts to reflect on our curriculum and the student experience from one course to the next. Earlier in the morning, during the second year Studio review, I had briefly described the content of Sensory Aspects of Design. At the end of the day, the third year studio Professor walked into my office and sat down, saying, "Next year I want to work with you when I'm developing the student projects. Let's get more sensory aspects into them."

Some of my colleagues recognize that sensory awareness can enrich product design; for them this is not news. A few have visited my class, on invitation, to discuss different aspects of multi-modal design. One professor brought a collection of products his company had designed, including rubber massage ducks that had failed on the market due to their multi-sensory complexity. He also brought a highly successful product his firm had designed — a hand-held explosives detonator for the mining industry that required auditory and tactile feedback for safe operation. Another brought a giant chain bicycle lock and demonstrated its visual, auditory, and tactile qualities. Yet another Skype visitor discussed the sustainable qualities of surfaces that wear with age, as opposed to glossy surfaces that are ruined by a single scratch and thrown away. Often, however, these added sensory features are instinctive, rather than part of a well-organized set of design considerations.

9.2 Sensory Aspects of Design and Related Student Work

This course builds analytical sensory awareness over twelve weeks, incorporating material from its predecessor IDES2203 Fundamentals of Form and Colour, as discussed earlier in section 7.3. It interweaves traditional design form-factor principles with more holistic sensory points of view. Much of the content draws from product psychology studies at Delft University of Technology and focuses primarily on analyzing existing products and product interactions.

It begins by introducing students to the theory of "Design and Emotion". The theory provides a sustainable context for clarifying the importance of designing for (mostly) positive product experiences that encourage long-term relationships between people and the things they own or use. The students then engage in exploring their own objects' sensory attributes, first as independent sensory modalities: visual features that contribute to form development; tactile features that provide passive and/or active clues about product interaction and longevity; and auditory features that communicate messages about operation and interaction. Gustatory and olfactory experiences occur less often, but may also provide important alerts. These are brought together in investigations of multi-modal layering of sensory features, including kinetic properties of movement, in hierarchies of sensory experience and different stages of sensory dominance.

This course fits into the evolving context of design education today. In addition to drawing from the coursework at Delft University of Technology ID Studio Lab, it relates to course themes in Design Anthropology at Swinburne University in Melbourne, Australia and to graduate research in industrial design for architecture at the Politecnico di Milano in Italy, and at the National College of Art and Design in Dublin, to name a few.

It may, however, be the only course of its kind that integrates traditional design principles with sensory considerations. In the university calendar it is described as, "An exploration of multi-sensory qualities derived from and designed into products to optimize sensory experiences. Visual, tactile, auditory, and other related design elements and principles that contribute to the product multi-sensory characteristics while adding meaning and emotional value".

The key learning outcomes are to:

- Understand how sensory attributes are integrated into designed products.
- Explain a variety of sensory experiences derived from products.
- Evaluate (qualitatively) the sensory design factors that may contribute to meanings and emotional responses derived from products.
- Conduct multi-sensory observations of interactions between people and products in contexts of use.
- Analyze the multi-sensory experiences with a product with respect to human-object interactions.
- Use course resources to support opinions about how sensory features enhance experiences between people, the products they use, and the contexts of use.

In addition, in recent years, these perspectives have influenced my fourth year major studio undergraduate students in their yearlong projects. As noted in Chapter 7, in 2013 a group of five students engaged with vision-impaired students at Carleton University in a co-design project to generate product ideas for the latters' unmet everyday needs. In the 2014 Council of Ontario Universities

IDeA (Innovative Designs for Accessibility) Competition, one of those students won an award for her design, "Ami-go". Ami-go is a *haptic and auditory* feedback wristband and application for sensing if friends are nearby that navigates the wearer toward them. Another fourth year major group looked at alternative modes of communication that led to one student's set of paired, remote, multi-modal devices for couples separated over long distances using *coloured lights and haptic vibrations* to communicate presence, and to another's interactive digital memory cone for *visual, tactile, and auditory* features connecting people with early stages of Alzheimer's disease with family members.

At the graduate level, in addition to the work described in section 7.3, one of my students is exploring fictional depictions of *gestures* as sources for studying actual alternatives to traditional keyboard and touch screen inputs. Another student is investigating how elderly people would use gestures and body movements to activate input sensors during exercise to playfully create music. And another is studying the use of *multi-modal* exhibits in science museums to interactively and sensorially engage visitors.

9.3 Future Changes to Course Resources

Design students are visually oriented: a strong graphic message is more inspiring to them than a written text. Unless forced they won't read an academic tome. In fact, they would find the Sensory Contexts for Design Research Guidelines boring to look at! So, in the long term, the guidelines have to be presented as an attractive visual and practical set of design research exercises.

In recent years, students appear to have less time and more activities that compete with their schoolwork, and hence less ability to concentrate. Consequently, I have integrated a number of short, engaging activities into my weekly lectures, where experience and reflection add to their opportunity for sensory learning. As an example, in one tactile-themed class, pairs of students each received an envelope containing a rather elaborate button. One student had to feel the button, still in the envelope, sight unseen, and describe it in detail to his or her partner. The partner drew it, while listening to the details. At the end, they both looked at the button to see if they had captured its detailed textures and forms. Later each student investigated his or her own semester-long analysis product and posted a visual & tactile-surface analysis on the class Pinterest site. Near the end of the semester we held a short exhibition of some of the class' sensory analysis illustrations from Pinterest along with the real tools they studied (see figure 9.1).

FIGURE 9.1: INVITATION TO SENSORY ANALYSIS EXHIBITION

In our last class I asked the students to write answers to two questions, to help me plan next year's classes: "What is the most memorable thing you learned in this class and why?" and "What was the most difficult thing you experienced in this course and why?" Without ethics approval it would be inappropriate to go into details here, however it became apparent that the students value the importance of sensory aspects of design and don't remember theory. They remember doing. They are doers. To truly benefit from the guidelines and sensory insights emerging from this dissertation they need an accessible, applicable, sensorially appealing, and interactive set of tools.

Therefore, over the longer term, the sensory design research aspects of my dissertation should be translated from the written academic chapters to graphically designed segments of information. This could take the form of a workbook that integrates the guidelines and insights from the dissertation with the Sensory Aspects of Design course content. It should be engaging and playful so students and instructors will want to work with it. Parts of it could take the form of activity cards with instructions. For example, a Touch card could illustrate the question, "Is the product touching the person or is the person touching the product? What is the nature of the touch?" A similarly attractive proprioceptive card may ask, "Is the person moving quickly, slowly, all at once or in spurts? What is the nature of speed and direction?" A striking-looking ritual card may ask, "Is the order the same every time, or does it vary over time? What is the repetitive nature of the person-product interaction?" These cards could become resources for future sensory awareness design research workshops.

9.4 Impact on Design Education

As I have written elsewhere (2014) industrial designers have traditionally determined the visual and three-dimensional aesthetic of products. In product design schools these are initially taught as prescriptive, form-giving principles in studio courses, while specific user-centred design issues are taught, at first, in separate ergonomics or human factors courses. A "creative" approach to design applies rules of compositional unity to achieve aesthetic harmony or disharmony, and a user-centred approach to design responds to users' needs, feelings, and goals to refine product features. However, this separation between the "creative" skill set and the human-oriented approach is unrealistic. And it can be argued that the aesthetic features of a product are part of the same domain as the functional user-centred features.

Furthermore, user-oriented design encompasses a broader range of subjective multi-sensory experiences. Hence, the students' introduction to form giving should be expanded from a largely visually oriented approach to a multi-layered approach that includes detailing the multi-sensory characteristics of products, especially auditory and tactile features.

A sensorial design pedagogy should prepare emerging designers to be aware of multi-sensory design elements that contribute to holistic, long term, evolving relationships between people and their everyday products. The Sensory Context for Design Guidelines presented in this dissertation can provide significant insights for integrating a range of sensory modalities into a designer's aesthetic approach. This perspective sets the stage for future research into ways of extending traditional approaches to teaching product aesthetics.

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Appendices

Appendix A: Student Consent Form

Appendix 3.1

Carleton UNIVERSITY Canada's Capital University

UNIVERSITÉ Concordia UNIVERSITY

Feeling Fit: Sensory Co-Design Research to inspire wearable technologies for aging well

CONSENT FORM

I, ________________________________, agree to participate in a program of research being conducted by Lois Frankel, a PhD candidate in the Special Individualized Program at Concordia University and an Associate Professor at Carleton University. (Email: lois_frankel@carleton.ca Phone: 613-520-5675).

The purpose of this study is to learn about what older people wear when exercising and to explore new design opportunities based on real feedback.

Student participants may be asked to meet with the researcher for 1 or 2 - 30 minute debriefing interviews after the collaborative sessions.

Participants agree to meet with elderly participants and join them in design activities during February and March. There will be 2 collaborative sessions of approximately 2 hours each at a time suitable for all participants.

I understand that the information provided in my interviews, and the information documented in the collaborative sessions will not be evaluated as part of the coursework and will only be used as research data.

I agree to have my interviews tape recorded…YES______ NO_______

I agree to have my collaborative sessions video –taped…YES_____ NO_____

There are no anticipated risks involved in this study. At any time before February 28, I may withdraw and indicate which, if any, data that I have contributed is to be destroyed.

All data will be kept on a dedicated hard drive. It will be kept for 7 years and any confidential information will be erased after that. Anonymous data may be used in future related projects. Research findings will be made available to participants upon request.

This project has been reviewed and received ethics approval and clearance by

Professor Antonio Gualtieri, Chair
Research Ethics Board
Carleton University Research Office
Carleton University
1125 Colonel By Drive
Ottawa, Ontario K1S 5B6
Tel: 613: 520-2517
Email: ethics@carleton.ca

Human Research Ethics Committee
Concordia University
1455 De Maisonneuve Blvd. West,
Montreal, Quebec,
Canada H3G 1M8
Tel: 514: 848-2424 x 7481
Email: ethics@alcor.concordia.ca

I_______________________________have read the above letter and voluntarily consent to participate in the study as described above.

Signature of participant_________________________ Date________________

Signature of Researcher________________________ Date________________

If at any time you have questions about your rights as a research participant, please contact the Research Ethics and Compliance Advisor, Concordia University, at (514) 848-2424 x7481 or by email at ethics@alcor.concordia.ca

Note: Sign two copies. One is for the participant and one is for the research record.

Appendix B: IDES 4305 Course Outline

Appendix 3.2 Course Outline

CARLETON UNIVERSITY
School of Industrial Design

COURSE OUTLINE **IDES 4305 Co-Design Explorations for Wearable Computing for Aging**
Winter 2011

Instructor	Lois Frankel
Office	3472 Mackenzie Building (ME) Tel: 613 520-5675 E-mail: lois_frankel@carleton.ca
Office Hours	by appointment
Course Time and Location	Monday 11:35am - 2:25pm, Mackenzie 3464 & ID-Tronics Lab

Course Description
This course will focus on the co-design process at the front end of a design project to generate ideas and concepts for wearable computing devices and/or clothing for elderly people during exercise. The emphasis will be on sensor-enabled explorations that involve the elderly as participants in specific activities in the initial design process.

The course will involve activities that include: observing older people exercising and documenting what they wear and what they do; designing and making simple paper-based and electronic resources for engaging the older people in design activities; and interacting with older people to generate design ideas design together. This course is intended to be experimental and the research component is subject to ethics approvals from at least 2 universities, Carleton and Concordia.

Rationale

The course introduces participatory design research processes and wearable sensor technologies to students in a "hands-on" fashion. It complements the research of the instructor who is investigating how "sensitive" (computer/sensor enabled) clothing or devices could augment the feel (sense of touch) of exercise experiences for the independent elderly (aged 70 and above) and how the elderly can be involved in the initial design development process.

Students will learn about co-design approaches to participatory design research through preparing for and conducting sensitizing activities, co-design activity sessions, and evaluation sessions. Students will also learn about preparing and using technology probes as a tool for design exploration.

Course Objectives

* To develop an understanding of the steps involved in co-design research,
* To develop a structured research plan and apply it in the design process,
* To experiment with technologies appropriate for design research probes,
* To develop the ability to interpret experimental research findings into design concepts
* To create well-documented archives of the design activities

Course Format

The course schedule is split into three roughly equal phases.

Phase 1
In the first phase (3-Jan start) students will explore the topic generally in order to understand the different aspects of the co-design process. This phase will be characterized by initial discussions and exercises. This phase includes a trip to Montreal on January 10 where we will be engaged in a morning electronics workshop and an afternoon class at Concordia University.

Phase 2

In the second phase (24-Jan start) the focus will be on preparing for and interacting with elderly people through observation and co-design activities. This phase will involve electronics kit development and use.

Phase 3
The final phase (28-Feb. start) will respond to the previous phase through reflective sessions and scenario development.

Required Materials
Students are required to keep a **course-dedicated journal/sketchbook and/or blog** that is updated on a weekly basis with both notes and sketches as appropriate. These will be reviewed periodically throughout the course. Journals will be handed in at the end of the course and not returned, unless otherwise discussed.
Materials required for sensitizing, session kits, and conceptual examples will be borrowed from the ID-Tronics Lab supplies as much as possible.

Course Evaluation Information

* Weekly participation (discussions, exercises, & blog/journal contributions)	10%
* Individual Frameworks (ethnographic or competitive)	10%
* Individual Scenarios (final concept presentations)	35%
* Group sensitizing preparation (plans for use, components, documentation, & feedback)	15%
* Group co-design session planning (kits, activities, documentation & feedback)	25%
* Peer Evaluation	05%

Course Schedule

3- Jan	Course Introduction, **Lecture** on Aging Bodies Frameworks assignment introduced Time for investigation & blog/journal set up
10-Jan	Trip to Montreal Arrive at Concordia University at 9:45 am; bring sketchbooks, drawing supplies; digital cameras Note: as this trip consists of a morning workshop and an afternoon class this is considered equal to 2 classes

17-Jan	**Lecture** about sensitizing and co-design session activity preparation & documentation Time for brainstorming and sensitizing activity preparation Observations begin **Frameworks assignment due**
24-Jan	Class Discussion: Observations feedback & kit development Work on sensitizing activity preparation continues to end of class & co-design session planning begins Observations continue
31-Jan	Class Discussion: Observations and Planning Sensitizing Kits distributed, Session planning finalized in class **Sensitizing Activity documentation due**
7-Feb	Class Discussion: Planning & Analysis Methods **All session plans finalized and due at beginning of class** Dry run for all sessions
14- Feb	Co-Design Sessions take place Sensitizing kits returned by participants Analysis occurs directly afterwards & posted on blog/journal within 24 hours of session
21-Feb	BREAK
28-Feb	Discussion: Co-design sessions & Next Steps Redesign of probes and session activities in class **Plans finalized for round 2 of sessions and due at end of class**
7-March	Second Round of Co-design sessions take place Analysis occurs directly afterwards & posted on blog/journal within 24 hours of session
14-March	**Final Individual Scenarios** presented (and handed in/posted on blog) with Elderly participants in attendance
21-March	Final class to debrief and wrap final reports for Sensitizing & Co-design Sessions, archive, and make recommendations for future sessions

- **Individual/Group Work**
  Courses may include various combinations of individual and group work. Students must demonstrate individual aptitude, and achieve a passing grade for individual work, in order to pass the course. Where the evaluation for individual work is below a passing grade, that grade will be awarded for the course. <u>It is important where collaborative work is undertaken that students be able to clearly demonstrate that individual contribution has been made.</u>

- **Late Submission of Deliverables**
  All deliverables submitted late will accrue a 10% per day or part of day deduction from the determined grade, to a maximum of 3 days, from the original deadline time and date. Failure to submit within 3 school days, without approval from the instructor, will result in a grade of F.

- **Academic Accommodation** (Paul Menton Centre)
  Students with disabilities requiring academic accommodations in this course must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC every term to have a Letter of Accommodation sent to the Instructor by their Coordinator. In addition, students are expected to confirm their need for accommodation with the Instructor no later than two weeks before the first assignment is due or the first in-class test/midterm. If you require accommodations only for formally scheduled exam(s) in this course, you must request accommodations by the official accommodation deadline published on the PMC website.

- **Instructional Offenses / Plagiarism**
  The regulations of the university require that we bring to your attention regulations on *Instructional Offenses*, descriptions of which can be found in the current *Carleton University Graduate Calendar*. At the same time it seems that students do not always understand the meaning of plagiarism and how to avoid it. Please refer to the *Guide to Engineering Program* available at the Engineering Registrar's office.

- **Student Responsibility**
  The student is responsible for knowing the content of this course outline, the schedule of classes, assignments, and examinations; and material covered during any absence from scheduled classes.

- **Changes to the Course Outline**
  The course outline may be subject to change in the event of extenuating circumstances.

PLEASE NOTE: Participation with the older participants in the Co-design sessions is not mandatory as these sessions are being analyzed for a PhD research project. Students who do participate will be asked to sign a consent form, and can withdraw ahead of time. Students who do not want to join in the co-design session activities should make this known at an early stage in the course and will be offered a technical support (video or photo) role.

Resources

Fashion
http://www.fashioningtech.com/
http://www.iheartswitch.com/
XS Labs: http://www.xslabs.net
http://subtela.hexagram.ca/
http://www.cutecircuit.com/
http://www.5050ltd.com/

Electronics "how-to"
http://www.kobakant.at/DIY/
http://blog.makezine.com/
LED's (read this for sure): http://members.misty.com/don/ledd.html
INPUT devices: http://www.billbuxton.com/InputSources.html

Physical computing: http://tigoe.net/pcomp/index.shtml
http://electronics.stackexchange.com/

Readings

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Igoe, Tom (2007). *Making Things Talk,* Sebastopol, California: O'Reilly Media.

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Techno- stuff

http://blog.makezine.com/
http://www.electroniccrafts.org/
http://www.we-make-money-not-art.com/
http://www.design.philips.com/

Schools

http://ttt.media.mit.edu/research/research.html
http://www.di.research.rca.ac.uk/content/home#
http://hlt.media.mit.edu/

Resources & Suppliers

http://www.sparkfun.com/
http://ca.mouser.com/
http://www.active123.com/
http://www.abra-electronics.com/
http://www.digikey.com/
http://www.robotshop.ca/
http://www.hvwtech.com/
http://techdiy.blogspot.com

Appendix C: Observation Criteria

OBSERVATION CRITERIA	formulated on January 17 by IDES4305 CLASS
ACTIVITIES	
Types of activities	
Sequence of activities (stretching/ warming up)	
PHYSICAL ABILITIES	
Adaptability	
Coordination	
Balance	
SENSORY INTERACTIONS	
Touch	
Dexterity	
Pressure	
temperature	
kinesthetics	
Sight	
What are they looking at?	
Visual cues to using equipment	
Audio	
Smell/ Taste	
PEOPLE	
Age ranges	
ENVIRONMENT	
The equipment	
Furniture (mats, balls, chairs)	
Lighting	
Color	
ATTITUDES	
Emotional Health	
Communication and interaction	
Comfort	
Motivation/ expectation/ interaction/ benefits	
COGNITIVE ABILITIES	
Memory	
Self monitoring	

Appendix D: Recruiting Notice

Fitness Clothing

RESEARCH STUDY

Photo by Jane Marusaik

Are you around 70 years of age (or older)?

Do you participate in regular fitness classes at the Churchill Seniors Recreation Centre or another fitness facility?

Do you have an interest in arts & crafts projects?

To inquire about participation please contact:
Lois Frankel before February 11, 2011
Phone: 613- 520-5675
Email: lois_frankel@carleton.ca
with the message title "PARTICIPATION & FITNESS"

Carleton University Canada's Capital University
Concordia University

Appendix E: Older Participant Consent Form

Feeling Fit: Sensory Co-Design Research to inspire wearable technologies for aging well

CONSENT FORM

I, ________________________________, agree to participate in a program of research being conducted by Lois Frankel, a PhD candidate in the Special Individualized Program at Concordia University and an Associate Professor at Carleton University, under the supervision of Dr David Howes.
(Email: howesd@alcor.concordia.ca Phone: 514-848-2424 ext 3843
Email: lois_frankel@carleton.ca Phone: 613-520-5675).

The purpose of this study is to learn about what mature adults wear when exercising and to explore new design ideas in hands-on workshop sessions with design students.
Participants will be asked to meet with the researcher for 1 60 minute interviews and to answer follow-up questions for clarification, if necessary). Participants will also meet with design students and join them in design activities during February and March. There will be 1 collaborative session of approximately 3 hours on Wednesday February 16, 2011.
Prior to the sessions, participants will be asked to fill in journals that will be provided, and to take pictures with cameras that will be provided, and to bring them to the sessions and leave them with the researchers. At the sessions participants will work with students to cut, stick, and draw designs onto supplied articles of clothing to indicate areas where sensors could be applied. Through discussion participants will explore how these rough prototypes might work if they were real. Following the collaborative working sessions participants will be invited to a final presentation of the students' design work and asked for their opinions.

I agree to have my interviews tape recorded…yes______ no_______

I agree to have my collaborative sessions video –taped…yes_____ no_____

The data collected in this research will be published in a PhD thesis, as well as in journal articles, scholarly presentations, and lectures. Participants will be anonymous.

I agree to have my picture or a video clip of my interaction in this project included in the published or presented materials as noted in the previous paragraph…yes__ no___
I request to have my image blurred …yes_____ no____.

Participants may request the results of this study at any time from Lois Frankel lois_frankel@carleton.ca or phone 613 520-5675.

There are no anticipated risks involved in this study. At any time before February 28, I may withdraw and indicate which, if any, data that I have contributed is to be destroyed. I am aware that by participating in this study my name will be entered in a draw for a $100.00 gift certificate for a local sporting goods store.

All data will be kept on a dedicated hard drive. It will be kept for 7 years and any confidential information will be erased after that. Anonymous data may be used in future related projects. Research findings will be made available to participants upon request.

This project has been reviewed and received ethics approval and clearance by

Professor Antonio Gualtieri, Chair
Research Ethics Board
Carleton University Research Office
Carleton University
1125 Colonel By Drive
Ottawa, Ontario K1S 5B6
Tel: 613: 520-2517
Email: ethics@carleton.ca

Human Research Ethics Committee
Concordia University
1455 De Maisonneuve Blvd. West,
Montreal, Quebec,
Canada H3G 1M8
Tel: 514: 848-2424 x 7481
Email: ethics@alcor.concordia.ca

I________________________________have read the above letter and voluntarily consent to participate in the study as described above.

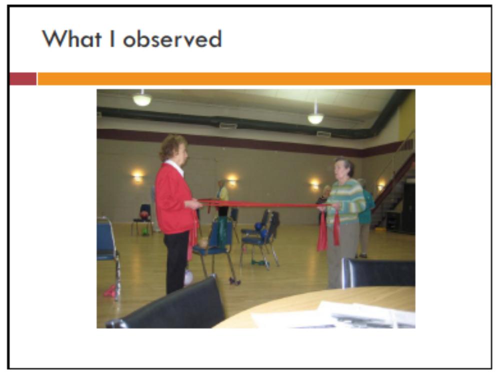
Signature of participant__________________________ Date________________

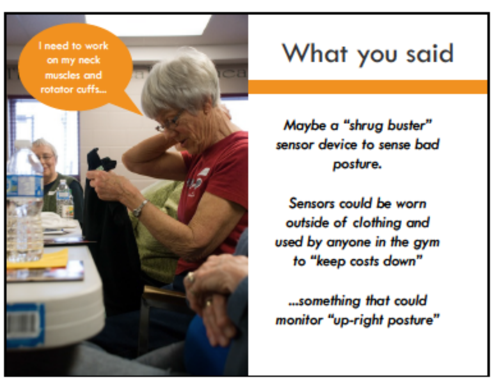
Signature of Researcher_________________________ Date________________

If at any time you have questions about your rights as a research participant, please contact the Research Ethics and Compliance Advisor, Concordia University, at (514) 848-2424 x7481 or by email at ethics@alcor.concordia.ca

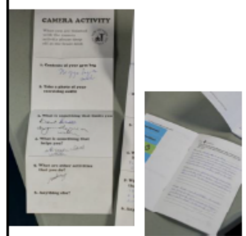
Note: Sign two copies. One is for the participant and one is for the research record.

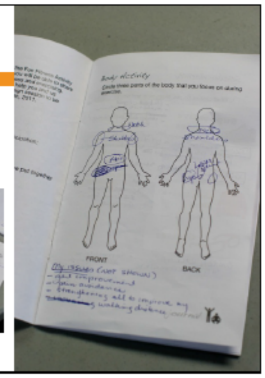
Appendix F: Example of a Final Student Slide Presentation (credit: T. Phillips)





What you wrote





What you made

Identifying key areas for potential sensory feedback

What is the Issue?
Bad Posture during exercise

- muscles in the upper back that *shrug the shoulder* become fatigued and strained causing pain
- Poor posture during exercise *affects proper breathing* and energy flow.
- Muscles between the shoulder blades can become *strained from slouching or bad posture*.
- Slouching causes the head to come forward and the *neck muscles need to work harder* to support the head.
- Slouching decreases the space the rotator cuff passes through and *puts undue stress on the shoulder joint*.

What are the benefits?
Good Posture during exercise

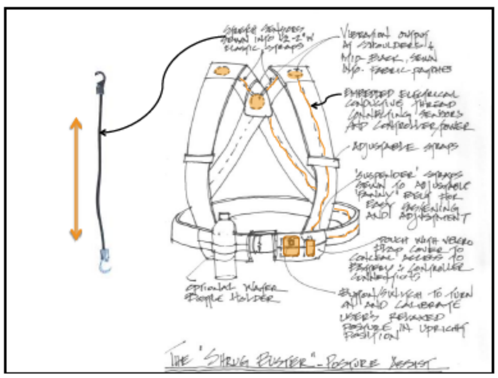
Improves balance, muscle function, range of motion in the joints and allows the shoulders to relax and the head to move more freely.

Available products

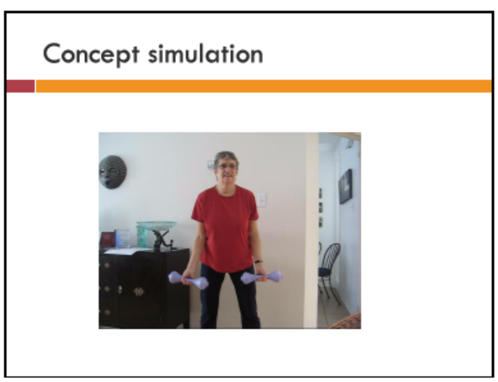
Posture corrective braces


Concept Inspiration


Best Suspenders
Show them your style
Suspenders For Women


VIBRATION OUTPUT AT SHOULDERS & MID-BACK, SEWN INTO FABRIC POCKETS
EMBEDDED ELECTRICAL CONDUCTIVE THREAD CONNECTING SENSORS AND CONTROLLER/POWER
ADJUSTABLE STRAPS
'SUSPENDER' STRAPS SEWN TO ADJUSTABLE 'FANNY' BELT FOR EASY FASTENING AND ADJUSTMENT
POUCH WITH VELCRO STRAP COVER TO CONCEAL ACCESS TO BATTERY & CONTROLLER CONNECTIONS
OPTIONAL WATER BOTTLE HOLDER
BUTTON/SWITCH TO TURN ON AND CALIBRATE USER'S REQUIRED POSTURE IN UPRIGHT POSITION
THE 'SHRUG BUSTER' - POSTURE ASSIST


Concept: SHRUG BUSTER posture-assist


Concept simulation

Appendix G: Questions for Semi-Structured Interviews

Phase 1:

- What exercise are you doing? Why?
- What other exercises do you do? How many times a week?
- What do you wear when you exercise? Why?
- What exercises do you like most? Why?
- What exercises do you like least? Why?
- How do you feel before or after exercising?
- Where do you notice the difference?
- Is your exercise activity different now than in the past? If so, why? How?
- Have you noticed a change over time?
- What are your limitations?
  Strength, flexibility, balance, adapting….

Phase 2:

1. Have you ever had a fall?
2. Are you concerned about falling?
3. Do you know anyone else who had a fall? What do you think of their experience?
4. How has your awareness of your own balance changed over time?
5. What activities do you do? Do any of them require good balance? Have your activities changed over time due to balance concerns? How have you risen to the challenge to maintain or improve your balance?
6. Do you do any balance exercises outside of class?
7. What role does balance play in daily life, and in interactions with others?
8. If your balance has changed over time, How does this affect who you spend time with-family, friends work.? Or what you spend your active time doing?
9. How do you feel about your balance when around younger people or in public?
10. Do you use any kind of assistive devices for your balance?
11. If so, what are they, how do you use them? Please show me what you do with it? What do you like about it? What do you wish was different? Do you always use it or are there times, events, places where you use them? Why then and not other times? Do you experience designed solutions (rollators, canes, etc.) as improvements or impediments to their sensory experiences, and how do they fit into your evolving sensorium?
12. Are there places that you enjoy navigating through? Others that you do not like being in-walking, running, standing, etc.?
13. Do you have routines that make it easier to feel balanced or safe when facing balance challenges?
14. What are the boundaries of your daily environments and have they changed?
15. Do you find yourself compensating for your changes in balance in ways that are different than when you were younger? How do you accept and adapt to those sensory changes?

Appendix H: Photos taken by participants

Appendix I: Analysis Iteration Codes

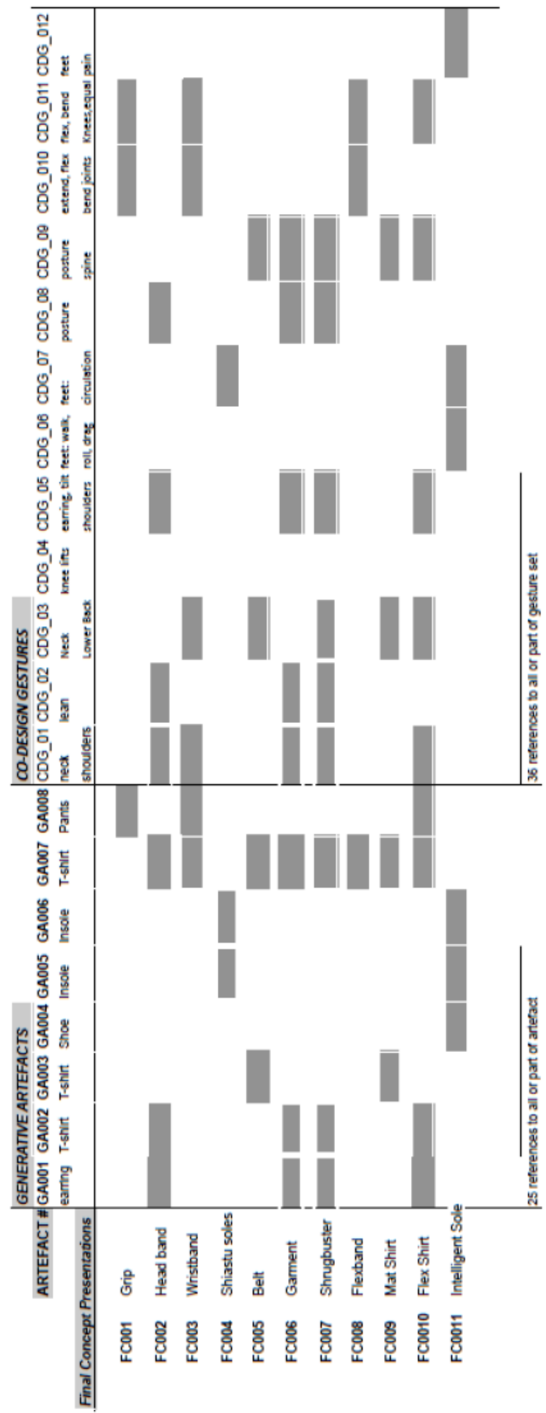
Initial Organization	Revised Organization- 2
1. What is your Sense of it? (experience-based)	**1. Having a Sense of it (experiences)**
Assumptions about ageing (really fashion) *	*Assumptions & Attitudes* *
Surprises around bodily experiences *	*Fashion Sense* *
shifting sensory modalities	*Importance of Instructor & Expert Info* *
engaging with elders	*Exercising* *
design explorations with elders	* *Adapting & Surprises around bodily experiences* *Slowing Down*
	Shifting Sensory Modalities & Exceptions to dominant sensory mode *
	Socializing & Playing &sharing stories over food & laughing & playing *

2. How does it **affect** your **senses**? (thing based)	**3. Coming to A Sense of it**
what is to blame	Balance & Posture
slowing down	Self-monitoring & Technology reinforces
Pushing back	pushing back
trusting things	*trusting things & what is to blame*
expert information *	*trusting things*
sharing stories over food	*What do we really know*
laughing & playing	
listening & observing	
making a contribution	

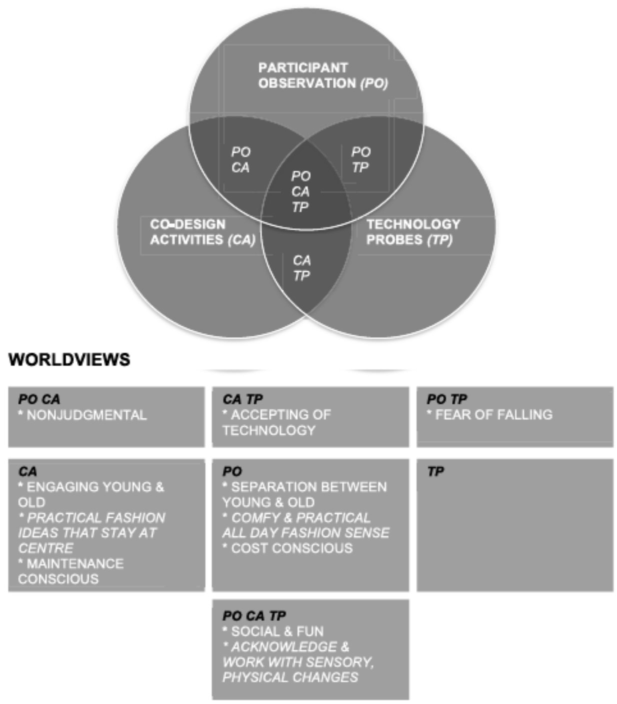
3. How can we **make sense** of it? (hybrid)	**2. Making Sense of it (design activities)**
Is technology a challenge	*Design Process*
training for trust	*listening & observing*
coming closer to the user	*Design Explorations with Elders*
My hands and your feet	*Engaging with Elders & coming closer to the user*
It's only a concept	*My hands and your feet*
what do we take away	*Is technology a challenge*
What do we really know	Training for trust & practical solutions
	making a contribution
	It's only a concept
	what do we take away

Appendix J: Patterns of Artifacts and Gestural Enactments

TABLE Xd: CORRELATION BETWEEN ARTEFACTS & GESTURAL ENACTMENTS



Appendix K: Insights Organized Across Methods



BODILY WAYS OF GATHERING INFORMATION

PO CA

CA TP

PO TP
* MULTI-MODAL & LOW TECH
* *TRAINING FOR EVERYDAY CHALLENGES TO POSTURE, BALANCE, & FLEXIBILITY*
* SLOW, NOT STRENUOUS
* *LARGE SENSORY VARIATIONS AMONG PEOPLE*
* AWARENESS COMES FROM UNDERSTANDING LIMITS (SELF-MONITORING)

CA
* FEWER SENSORY MODES & HIGHER TECH
* *AUGMENT AWARENESS TO IMPROVE BODY POSITION*
* TRAINING FOR POSTURE, BALANCE & FLEXIBILITY INCLUDES REALIGNMENT & REDUCING INJURY
* *OVERALL FITNESS IMPROVEMENT THROUGH SELF-MONITORING TRAINING*
* LOOK FOR WAYS TO ACCOMMODATE SENSORY DIFFERENCES AWARENESS COMES FROM GETTING FEEDBACK ABOUT LIMITS (SELF MONITORING)
* *AUGMENTED MONTORING SHOULD SUPPORT SELF-MONITORING NOT REPLACE IT*

PO
* LOSS OF AWARENESS = LOSS OF CONFIDENCE
* *INCREMENTAL BALANCE IMPROVEMENT THROUGH SWAY ENVELOPE*
*TRAINING ROTUINES HAVE INCREMENTAL CHANGES, INNOVATION IS APPRECIATED
* *TAKES TIME TO LEARN TO SLEF-MONITOR*

PO CA TP

TP
* LOSS OF AWARENESS = LOSS OF CAPABILITY
* *INCREMENTAL FITNESS IMPROVEMENT THROUGH SWAY ENVELOPE TRAINING*
*TRAINING ROTUINES HAVE INCREMENTAL CHANGES, INNOVATION IS EXPLORED
* *CAN BE DIFFICULT TO MONITOR SUBTLE ASPECTS OF BODY (CROSS-OVER VS. TURN & FACE DIRECTION)*

SENSORY INTERACTIONS

PO CA

CA TP

PO TP
* TRAINING SENSES TO COMPENSATE FOR OTHER BODILY DEFICITS (CLOSE EYES & TOUCH)
**VISUAL DOMINANCE*
* LAYERING OF SENSORY MODALITIES TO TRAIN FOR EVERYDAY
* *TACTILE SENSE IS VERY IMPORTANT & IT HAS A RANGE OF QUALITIES*

CA
* PROVIDE WAYS TO COMPENSATE FOR SENSORY CHANGES THROUGH A RANGE OF SHIFTING SENSORY MODALITIES
* TACTILE, KINESTHETIC, & AUDITORY SENSES CAN BE AUGMENTED THROUGH TECHNOLOGY
* *PAIN & DEFICITS NEED BETTER DESIGN SOLUTIONS*

PO
* PAIN & DEFICITS PROVIDE MOTIVATION

PO CA TP

TP

SENSORY ROLES OF ARTIFACTS

PO CA

CA TP

PO TP
* FINDING WAYS TO ADAPT FOR SUPPORT

CA
* FINDING WAYS TO ADAPT FOR SENSORY ASSISTANCE
* *CREATIVE DEVELOPMENT OF FUTURE CONCEPTS FOR TRAINING*
* TECHNOLOGY SHOULD SUPPORT AWARENESS & EXTEND CAPABILITIES
* *HIGH TECH EQUIPMENT THAT MUST BE SIMPLE TO USE & SEAMLESSLY DO WHAT IT PROMISES TO DO*

PO
* CREATIVE USE OF EVERYDAY OBJECTS FOR TRAINING
* *TECHNOLOGY (LOW & HIHG) SUPPORTS AWARENESS*
* *LOW TECH EQUIPMENT THAT CN BE QUICKLY MODIFIED TO ACCOMMODATE EXERCISE DEMANDS*

PO CA TP
* USED FOR BUILDING TRUST
* *ARTIFACTS PROVIDE A SENSE OF SELF NOT A MEASURE OF SELF*

TP
* MODULAR & RECONFIGURABLE USE OF OBJECTS FOR TRAINING
* *TECHNOLOGY SHOULD SUPPORT AWARENESS & CAN CONTRIBUTE TO RISK OF SENSORY DOMINANCE REDUCING AWARENESS*
* LOW OR HIGH TECH EQUIPMENT CAN BE TOO LIMITING & SOMETIMES NOT EVEN HELPFUL (LIGHTS ON PROBES)

GESTURAL LANGUAGE

PO CA

CA TP

PO TP

CA
* STANDING POSTURE CONCERNS
* *LYING POSTURE CONCERNS*
* FOOT POSIITONING & PLACEMENT CONCERNS
* *JOINT BENDING & FLEXING CONCERNS*

PO

PO CA TP

TP

Appendix L: Initial Design Insights

INSIGHTS	INITIAL DESIGN RECOMMENDATIONS
Participants' Worldviews	
Assumptions	
Ageist assumptions limit the potential for meaningful design solutions.	Engage directly with older people, not experts, to develop empathic awareness of their sensory experiences (McCann 09: 366, Hallnas & Redstrom 02, Larssen 07)
Attitudes	
These older people are social, non-competitive, accepting of their limitations, not judgmental of others' limitations, & playful in situations where they are accepted.	Interactive product qualities should provide positive feedback, reassurance & opportunities for fun & collegial socializing.
Fear of falling is a common response to evolving sensory changes, leading to risk aversion or worse to movement avoidance.	Incorporate features that enhance a person's ability to trust their own body signals, regain stability, & provide a sense of security. They should be adaptive & sensitive to changes over time.
These older people do not want more stuff, or more responsibility for maintaining stuff.	Product solutions need to be tested and proven reliable, and/or distributed through sources that will take responsibility for them to promote long term product acceptance.
Culturally acceptable sensory behaviours	
Using assistive things (devices) can make everyday activities easier, but will be rejected if they look assistive or overly "fashionable", are expensive or technically challenging.	One-size-fits-all is not as satisfactory as simple features that afford personal expression & integrate into an older person's everyday personal effects without drawing attention.

Bodily Ways of Gathering Information

Extereo-Sensations

As ageing sensory capabilities change one needs to develop more awareness, to "know your limits" through self-monitoring (McCann 09:357). Self-monitoring is a state-of-mind, not numbers.	Product features could provide background numerical monitoring, but it is more important to provide interactive feedback that draws attention to a person's bodily feelings & comfort levels during specific experiences. eg. What is too fast, what is a measured or doable pace?
Over time older people's fitness goals may focus on training or retraining for everyday activities like walking down the street, reducing injury, standing straight, or stepping side to avoid obstacles.	Appropriate technologies should support slow, moderate, incremental improvements or adjustments, and gently increasing levels of challenges, while discouraging long-term dependence. Such technologies can focus on body position in standing, sitting & walking positions (for reducing shoulder hunching & neck strain).
Bodily changes may not occur symmetrically, for example one foot may face forward & the other sideways.	Sensory augmented technologies should provide feedback that supports realignment or awareness of how to accommodate restrictive asymmetrical bodily challenges, such as reminders to slow down, place the foot properly, enough stability to move forward. An emphasis on foot positioning, pressure, & placement would fit here.
Hands take on new importance in providing tactile support & maintaining balance.	Wearable & technology enabled devices should assist, train, & instruct users to recognize different strategies for holding, from fully holding, to clutching, to partially placing 5 fingers, to brushing with 1 finger.

Proprioceptive Sensations

With ageing, balance is no longer automatic and uneven surfaces often contribute to falls or injury. It takes longer to recover from a loss of stability, if recovery is even possible.	Sensory augmented technologies should assist users in identifying painful & unstable positions, and in making micro-adjustments to accommodate them. In addition technologies could scan walking surfaces, provide warning alerts, & even alarms in worst-case scenarios.
Backward movements are especially difficult, can be wobbly, and lead to falls, even on stairs. Most people are not even aware of losing this capability since people mostly move forward.	An assistive solution should provide the opportunity for slow and gentle backwards motion, incorporating changing levels, such as curbs, while providing handholds for additional tactile support.

Interaction between Senses

Multi-Modal

Walking is a multi-modal activity, once undertaken naturally, but with ageing may need training to maintain location awareness while talking, moving, changing direction, turning heads, listening, and looking.	Technology should provide assistance in monitoring multiple sensory demands while training to stay on track by limiting, augmenting or adding sensory modalities during practice sessions.

Sensory Deficits

Fitness training may be more like rehabilitation exercises for impaired older people whose habituated senses are no longer functioning as they did in a younger body.	Fitness assistance devices should recognize diminishing capabilities & assist users to adjust through haptic, visual, or auditory feedback.
The dominant visual sense can have an anesthetic effect by removing awareness of sensory deficits & bodily movements.	An assistive device should support whole body awareness & provide signals that bring the user's attention to bodily positions.

Sensory Reordering

A natural sensory reordering can occur as sensory & cognitive capabilities disappear or change. The heel of the foot can take over for the tactile messages from the soles; the hands can assist with proprioceptive location awareness & stability.

Technology features that assist in the development of new neural pathways and adjusting to "incremental sensory lapses" (Quadrango 911:131) should provide support about the body's changing spatial position & coordination abilities to help build or reinforce trust.

Sensory Roles of Artifacts

Adaptive

Older people are already adapting to their bodily limitations by relying on assistive modes like grabbing pant legs to aid in bending exercises or relying on handholds for support.

People want assistance. Assistive devices that assume an aesthetic that is ordinary, unobtrusive, not highly fashionable, not assistive or medical looking, or desirable enough to steal will be more readily accepted than the flashy one-size-fits-all sporty devices currently on the market.

Tactile support leads to building trust & feeling safe, and can be used singly or in multiples as needed.

Technology add-ons for chairs or tables should provide feedback about body positions, weight distribution, and pressure points that can be used for training and incremental body awareness singly or in multiples.

Probing

Older people prefer familiar objects in their environment, as learning how to operate new things may take longer than in the past.

Acceptance can be encouraged by building on familiar aesthetics and affordances (mechanical parts that activate responses like a light switch that turns on a light), however once the device is activated it should provide a challenge that encourages or motivates training.

Make sure that the artifacts are easy to maintain, to wash, to clean, to

	repair, and to replace with the identical item, if necessary.
Generative	
The older participants in this study seemed to really enjoy the collaborative making activities.	Spend time with older people making models or prototypes of things that might help them, or looking at things that bug them, or just observing what they really do.
Conceptual Aesthetics are not only visual, older people enjoy interacting with things that are comfortable, fun & simple to use.	Consider surface textures & modularity to increase awareness. Note that modularity can contribute to variety, diversity, adaptability & multi-purpose use. Do not confuse complexity with complicated. Technology is a vehicle, not an end result.