MAKING STORES AGE- FRIENDLY:

MODIFICATIONS FOR REDUCED MOBILITY

CAPABILITY AND VISUAL CAPABILITY OF OLDER

ADULTS

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Abstract

The ability to shop for everyday products is an important instrumental activity for daily living (IADL) that contributes to successful independent living. As individuals age, the prevalence of osteoarthritis (Woolf, Erwin, & March, 2012) and issues with vision (West et al., 2002) increase, affecting the performance of IADLs. The current retail environment is not ready for the older population. Store merchandising such as shelf arrangements and reading materials are often not suitable for older consumers (Yin, Pei, & Ranchhod, 2013), increasing the gap between shopping task demands and consumers' performance abilities. Because the older population in the U.S. is projected to grow substantially in the next few years, retailers face the challenge and an opportunity of making their stores age-friendly.

A laboratory experiment using performance-based and perceived self-efficacy measures examined the influence of reduced mobility capability and visual capability of older adults on shopping tasks in grocery stores. Older adults with OA and good vision (N=10), older adults with OA and not so good vision (N=10), older adults without OA and good vision (N=10), older adults without OA and not so good vision (N=10) and young adults without OA and good vision (N=20) formed the sample. The findings indicate that older adults with OA took a longer time to walk and also had walking scores indicating risk of future fall. To accommodate for this, products like dairy products, produce, breakfast, and lunch items should be kept within closer proximity to the door. The results also indicate that shelf heights 29.5 to 42.5 inches from the floor were the most comfortable for older adults to reach. Shelf heights in the stores should be adjusted to have daily use products only in these height ranges. The highest and lowest shelves were very hard to reach. Helvetica and Century Gothic fonts in a 14 point size were found to be most readable while fonts in 6 point size, a standard size for many product labels, were difficult or impossible to read. Overall, these findings indicate a need for action on the part of store designers to accommodate the needs of the growing older population.

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CHAPTER I

INTRODUCTION

Background to the problem

As individuals age, it is vital for them to continue to sustain their instrumental activities of daily living (IADL) for an independent life. Mobility or the ability to walk safely and independently is an essential attribute to complete IADLs by older adults. In the United States (U.S.), individuals over 65 years of age were numbered at 46.2 million in 2014. For the first time in U.S. history are expected to edge out children in population size to grow to 78.0 million by 2035, while children under age 18 will be 76.4 million (Nasser, 2018). People are living longer, are more active, are entering old age in better health, and are working longer. The economy has to shift to focus on this mass group of older consumers, called the "longevity economy" (Coughlin, 2017). This trend emphasizes the need to make the surrounding environment friendly for older adults as they age. To age with good health, it is imperative that older adults sustain their IADLs, defined as complex, real-world human behaviors that require independence, volition, organizational ability, judgment and sequencing (Katz, 1983; Lawton, 1988).

The aging process contributes to the prevalence of musculoskeletal disorders (MSDs) including osteoarthritis and osteoporosis, and this in turn could affect quality of life and IADL (Woolf, Erwin, & March, 2012(Monov & Kopchev, 2017; Sinigaglia et al., 2017). MSDs have been described as one of the major health priorities internationally (WHO Technical Report

Series, 2003; Choong & Brooks, 2012). These disorders often result in ambulatory or mobility issues. It was reported that 23% of older adults experience ambulatory or mobility issues (U.S. Census Bureau's American Community Survey, 2015). Due to decline in these physiological abilities, performing IADLs could become challenging for older adults.

Osteoarthritis (OA), the most common MSD, is a degenerative joint disease that involves the cartilage and surrounding tissues of the joints (Litwic, Edwards, Dennison, & Cooper, 2013; Thoma, White, Risberg, & Snyder-Mackler, 2018), and it is an increasingly important health problem in older adults leading to movement disability (Ahn, Woods, Choi, Padhye, & Fillingim, 2017; Cushnaghan & Dieppe, 1991; Helmick et al., 2008; Lawrence et al., 2008). OA is related to age, and the most common joints affected in the body are knee, hip and hands (Helmick et al., 2008; Summers, Haley, Reveille, & AlarcOan, 1988; Tubach et al., 2005). Knee and hip OA are leading causes of mobility problems among older adults (French, Smart, & Doyle, 2017; Litwic et al., 2013). Women have more common prevalence of OA than men, and the intensity increases with age (Cross et al., 2014; Y. Hu et al., 2017). Among all the types of OA in the body, knee and hip OA contributes most to the OA burden that results in movement restrictions in older adults in performing the IADL (Cooper, Javaid, & Arden, 2014; Cross et al., 2014; Litwic et al., 2013). Mobility restrictions further lead to disablement or the condition of being unable to perform in various daily tasks like walking without support in the community (Clarke & George, 2005; Verbrugge & Jette, 1994). OA increases the risk of fall and chances of fractures. The most commonly considered sites of fractures are wrist, hip and spine (Boonen et al., 2004; G. Jones et al., 1994). A global longitudinal study of osteoporosis in women that studied a sample of 57,141 women across 10 countries, found that about 40% of white women age 50 years and above experience at least one clinically recognized fracture due to fall (Adachi et al., 2010). In addition to this fear of fall is also known to increase the chances of fall and fractures in older adults (Young & Williams, 2015). Knee OA has been found to be independently associated with increased risk of injurious falls that substantially limits the mobility of older adults (Barbour et al., 2018). Research also indicates that the burden of OA will become a major problem for health systems globally (Ackerman, Pratt, Gorelik, & Liew, 2018; Cross et al., 2014; Zlatkovic-Svenda et al., 2017).

Aging is also associated with decline in vision capability and can affect how older adults conduct daily functions (Heesterbeek, van der Aa, van Rens, Twisk, & van Nispen, 2017; West et al., 2002). Significant association has been found in self-reported mobility limitations and poor performance of visual acuity or ability to discern between letters and numbers at a given distance (Dillon, Duffy, Tiedemann, & Keay, 2018; Lin et al., 2004; West et al., 2002). Vision impairment in older adults associated with cognitive and functional decline leads to difficulties in performing IADLs (Davidson & Guthrie, 2017; Lin et al., 2004; Owsley, McGwin, Sloane, Stalvey, & Wells, 2001). When combined with vision impairment in older adults, OA is known to have exacerbating effects with further increase in difficulties in walking, personal care and other IADLs (Althomali & Leat, 2017; Fried, Bandeen-Roche, Kasper, & Guralnik, 1999; Verbrugge, 1995).

Shopping for daily needs is an important IADL. Shopping plays an important role regarding independent healthy living among older adults, and food has been recognized as critical for physiological well-being of an older adult (Bernstein & Munoz, 2012; Hughes et al., 2018). More specifically, nutrition has been identified as a major determinant toward successful healthy aging as it promotes health and functionality (Arjuna et al., 2018; Vergis et al., 2018). With nutrition being so important, unfortunately, many older adults are at risk of poor nutrition due to their low confidence in shopping ability, as the stores are not age friendly. For this research, age-friendly is defined as environments that suit older adults' mobility and visual capabilities and those that make the tasks easy to perform. With knee OA having been found to be independently associated with increased risk of injurious falls (Barbour et al., 2018) and fractures (Adachi et al.,

2010) it is imperative that shopping environment should be safe to avoid any injury to the fall susceptible older population.

The need for the study

Older adults face difficulties while shopping in grocery stores for their daily needs due to their mobility and visual limitations, yet the current retail environment is unprepared to facilitate a growing older population (Celeski et al., 2017; Moore & Conn, 1985; Underhill, 2009). Words are often too small to be read by old eyes on food packages, newspapers, medicine bottles, and product labels as well as wash care labels (Darroch, Goodman, Brewster, & Gray, 2005; Moore & Conn, 1985; George P. Moschis, Ferguson, & Zhu, 2011; Underhill, 2009). It has been well recognized in the literature that older adults face difficulty in reaching high and low shelves, reading displays, product labels and pushing trolleys in the store (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003). Procuring and eating healthy food is critical not only for physiological well being but also for the social, cultural and psychological quality of life (Bernstein & Munoz, 2012). Moreover, the economy is shifting towards a "longevity economy" with higher projected spending by older consumers (Coughlin, 2017), so it is important for retailers to prepare the retail environment to facilitate shopping for a growing older population.

There is a need to match older adults' capabilities to the grocery store environment demands, and the research into understanding this capability gap between older adults' capabilities and grocery store environment has been both general and sparse. The seminal and current literature provides information on importance of healthy living and active aging (de São José, Timonen, Amado, & Santos, 2017; Foster & Walker, 2014; Phelan, Anderson, Lacroix, & Larson, 2004; Rowe & Kahn, 1997), age related mobility limitations of older adults (Cawthon, 2011; Choong & Brooks, 2012; Cromwell & Eagar, 2003; Katz, 1983; Lawton, 1988; Lawton & Brody, 1969; Leveille et al. 1999; Potter, Grealy, & Connor, 2009; Woolf, Erwin, & March, 2012), and age related visual limitation in older adults (Crews & Campbell, 2004; Heinemann, Colorez, Frank, & Taylor, 1988; Kelly, 1995; Lin et al., 2004; McGrath, Rudman, Polgar, Spafford, & Trentham, 2016; Owsley, Sekuler, & Boldt, 1981; Sekuler & Hutman, 1980; West et al., 2002). Yet, there is a lack of understanding about the mobility and visual capabilities of older adults while performing shopping tasks in a grocery store, an essential IADL. This understanding would be useful for preparing the current retail store environment to suit older adults' capabilities. This would reduce the capability gap between store environment demands and older adults' capabilities. If older adults find the shopping environment safe and easy to use, then they will feel less nervous to navigate in the store environment and this will lead to their higher self-efficacy levels to perform shopping tasks while fulfilling their daily needs.

The current research acknowledges the findings from literature about age related mobility and visual limitations of older adults and creates an experimental scenario to understand the influence of these limitations on specific tasks of food shopping and implicates the findings to improve the grocery store environment to match older adults' limitations. Shopping is an essential IADL to sustain independent living; hence with growing older population, *there is a critical need to make shopping tasks accessible for older adults to perform and ultimately make stores age-friendly.* By identifying the challenges that older adults face while shopping, this research bridges the gap between the store environment and the physical limitations of older adults, helping them transition toward healthy aging.

The purpose of this study was to investigate the mobility and visual capabilities of older adults while performing shopping tasks in a grocery store environment. Shopping in a grocery store involves completion of various shopping tasks to buy daily grocery items. For this study, the shopping task is defined as the series of activities completed for procuring a desired product from a grocery store (Taylor & O'Reilly, 2000). The theoretical background for the study was based on the seminal work by Nagi's disablement model and the disability model by Verbrugee and Jette

(1994) who described disability as a gap between persons' capabilities and the physical environment. Disability or disablement to perform an activity or a task occurs when there is a mismatch between the person's capabilities and the activity's demand. This mismatch in the surrounding environments of older adults, like in a grocery store, and older adults' capabilities creates the disablement in performing the shopping task in a desired manner.

Research objectives

The goal of the proposed project was to help support the health and independence of older adults. Being able to shop for their daily needs in a grocery store is an essential aspect of independent living. If community retail stores are responsive to the physical limitations of older adults, this could help increase their independence and their quality of life. To achieve this, the focus of this study was to investigate the ways in which the grocery environment may better enable aging adults to complete shopping tasks, given their mobility and visual limitations. Hence, the objectives of the study included:

- To assess the mobility and visual capabilities of older adults with OA as they complete shopping tasks in a grocery store. The sub objectives are as below:
    - To determine in what ways reduced mobility capability of older adults influences the performance of shopping tasks inside the grocery store.
    - To determine in what ways reduced visual capability for reading text on the packages by older adults influence the performance of shopping tasks inside the grocery store.
- To develop recommendations for retailers about older adults' capabilities and limitations while shopping in a grocery store in order for retailers to improve accessibility for a growing population of older adults.

Methods Overview

As stated above, OA is a major cause of mobility impairment in older adults. Thus, older adult females with OA formed the study group. A set of screening questions assessed the participants for self-reported OA before assigning them to a study group. OA conditions peak and cause mobility limitations in the 60–75 age group. Women have more common prevalence of OA than men, and the intensity increases with age (Cross et al., 2014; Y. Hu et al., 2017). Research also indicates that women shoulder the majority of the grocery shopping responsibility (Krishnamurti & Gupta, 2017; Morganosky & Cude, 2000; Raskind et al., 2017; Roy Dholakia, 1999). Therefore, adult females in the group 60–79 years were assessed for the study. Patients with knee OA have been found to have significantly poorer quality of life as compared to hip and hand OA (Alkan, Fidan, Tosun, & Ardıçoğlu, 2014). Screening questions asked participants to self-report the location in the body of OA (knee, hip or hand). Control groups were formed to provide contrast of mobility and visual impairment conditions to the study group. Control groups were chosen in the age group of 60-79 years who do not have OA and young adults in the age group of 20-30 years in good health, to provide contrast in shopping difficulties aggravated due to OA and old age. Two simulations of grocery store environments were created, one with current measurements taken from an actual grocery store chain and the other per universal guidelines and functional reach guidelines from the literature (Duncan, Studenski, Chandler, & Prescott, 1992; Farage, Miller, Ajayi, & Hutchins, 2012). A series of performance-based tests were applied to measure the mobility and visual capabilities of older adults in the store environments. Perceived mobility self-efficacy was measured to have a holistic view of mobility capability of older adults.

Contribution of the study

The outcome of this research was the identification of mobility and visual capabilities of older adults in the grocery store environment. Knowing these capabilities permits changes to in-store environments, so the demands of shopping tasks suit the capabilities of older adults. The literature shows that disability occurs when demands of a task do not match the capabilities of an individual (Alkan et al., 2014; S. Nagi, 1965; S. Z. Nagi, 1979, 1991; Salaffi, Cavalieri, Nolli, & Ferraccioli, 1991). A call to action brochure was developed with a purpose to spread awareness in retail sector about the need to accommodate for older adults needs. It is expected that these recommendations will better ensure the health and independence of older adults by making shopping easier, an important IADL for independent living. These recommendations could also be used by community-based organizations like the service industry including sales and hospitality to help older adults remain healthy, independent, and productively engaged by shopping for healthy food and living in their own homes and communities.

Assumptions and limitations

The proposed study was subject to certain assumptions. It was assumed that older adults shop for their groceries in the grocery store. It was also assumed that older adults would honestly report their perceptions related to daily tasks and shopping in the grocery store. Concerning the performance-based laboratory tests, it was assumed that participants would follow the directions and perform the task as they would in a grocery store. For the survey questions, it was assumed that the respondents would read and follow the directions and answer to the best of their abilities.

There were several limitations associated with this study. First, the sample selection was made from a small town in the U.S. due to access limitations, but the researcher believes that older adults who live in this town of the U.S. have similar mobility and visual limitations as most of the older adults living in the U.S. Secondly, the young adult sample was comprised of undergraduate students from one university in a predominantly female college due to access limitations, but similar to above, researcher believes that young adults who live in this town of U.S. have similar health status as most of the young adults living in the U.S.. Thirdly, though utmost care was taken to simulate the grocery store environment in the laboratory-based tests, it is possible that the simulation environment does not represent the store environment precisely. Fourthly, the answers to the perceived self-efficacy survey instrument might be subjected to the self-report bias based on social acceptance of the disability of mobility

CHAPTER II

REVIEW OF LITERATURE

The following review of literature confirms that grocery store environments present problems that go beyond mere general difficulties to locate the product in the store. This review discusses specific and general solutions available in existing literature and concludes that initiatives are needed to improve the grocery store environment to suit the needs of the older adults. This literature review provides support for the hypotheses and the theoretical model that will be used to identify the mobility capability and visual capability of older adults while performing daily shopping tasks in a grocery store.

The first section discusses aging of older adults to understand age-related factors, the importance of successful aging, age-friendly communities and a review on current retail environment for older adults. The second section that reviews the literature on OA, mobility and visual capabilities of older adults follows this. This section ends with a comparative review of the measures most widely used in the literature to measure mobility and visual limitations of older adults. Hypotheses for this study were developed with this literature and are integrated into the following discussion about mobility capability and visual capability of older adults. Finally, the theories of aging are reviewed followed by the theoretical model for this research study. This review concludes with current research gaps, substantiating the need for further study.

Aging

Biological aging leads to changes in humans' functional capacity resulting from changes in cells and tissues (Cristofalo, 1988). Aging is inevitable, and the way our body reacts to the aging process is linked to the genes, race, gender and socioeconomic aspects. Although each older adult demonstrates individual differences, they do have much in common in terms of biological, psychological and social dimensions of aging (Czaja, Rogers, Fisk, Charness, & Sharit, 2009). These similarities that the aging process brings in the older individuals, allows designers to make changes in the environment to suit most of the older population. Musculoskeletal diseases (MSDs) like osteoarthritis or osteoporosis and back pain are major diseases worldwide, which cause impairment in quality of life (Woolf, Erwin, March, 2012). MSDs are defined as injuries and disorders that affect the human body's movement by affecting musculoskeletal systems like muscles, tendons, ligaments, nerves and discs (Centre of disease control and prevention, 2016). MSDs limit bending or kneeling down, climbing stairs up or down, walking 500 m without walking aids (Stamm, Pieber, Crevenna, & Dorner, 2016) and continuing these basic activities is important for independent living. However, improvements in living environment, better nutrition, housing, medical care and public health facilities decrease the chance of death during aging (Harman, 1991). Aging is inevitable, but if living conditions in society are made more suitable for older adults, it increases the possibility of healthy aging.

Successful aging has been associated with the continuation of activities in old age and is defined to include the low probability of disease or disease-related disability, high cognitive and functional capacity, and active engagement with life (Rowe & Kahn, 1997). This concept of 'aging well' has been described using other terms in the literature like active aging (Foster & Walker, 2014), healthy aging, positive aging (McGrath et al., 2016) and productive aging (Luo & Chui, 2016). Social networks and community living of older adults have been strongly associated with improved health outcomes (Glass & Vander Plaats, 2013). Glass and Plaats (2013) conducted personal in-depth interviews of older adults in a cohousing community that revealed the healthy aging was accompanied by existence of mutual support between older adults, increased acceptance of aging and better feelings of safety, less worry and reduced social isolation in living in their community. Another, ethnographic research study on older adults with aging-related vision loss revealed that responding positively to vision loss and remaining active while managing risks related to vision loss were the markers for positive successful aging (McGrath et al., 2016). Successful aging facilitates the rights of older adults to remain healthy by reducing the cost of health and social care, remain in employment for a longer time and participate in local community life (Foster & Walker, 2014). The literature on successful aging recognizes the importance of the community and shopping for an independent living and wellbeing of older adults (de São José et al., 2017; Foster & Walker, 2014; Phelan et al., 2004; Rowe & Kahn, 1997). A livable community includes elements that help to maintain independence and quality of life for which the physical characteristics of a community play an important role. Community features like safe pedestrian walking, proper access to grocery stores and other shops, a mix of housing types, health centers and recreational facilities are important for independent living (Kihl, Brennan, Gabhawala, List, & Mittal, 2005). Being able to continue to shop for essential items has been considered an important measure for living independently in the community (Lawton & Brody, 1969).

Age-friendly communities. Making the built environment age-friendly is an essential determinant to successful aging. Age-friendly buildings must be accessible, provide elevators, ramps, adequate signage, railing on stairs, stairs that are not too high or steep, non-slip floors, rest areas with comfortable chairs, and sufficient numbers of public toilets (Organization, 2007). There are global initiatives to promote age-friendly buildings for healthy living of older adults like WHO's global network of age-friendly cities and communities that started in 2010, highlighting age-friendly cities and their importance in the world. Developed countries like the U.S. have organizations such as the American Association of Retired Persons Livable Communities (AARP) and Advant Age that are taking initiatives towards developing age-friendly community development (Plouffe & Kalache, 2010). These age-friendly cities provide suitable environments for older adults to move around the community. Social interaction and movement of an older adult in their community is an essential task that contributes to independent living. Neighborhoods or the physical and subjective bordered spaces around the places of living of an older adult play an important role in their well-being (Gardner, 2011; Massey & Allen, 1984). Neighborhoods are defined as the physically and subjectively bordered spaces of materiality as well as meaning, of people as well as places (Gardner, 2011). Local business like diners, bakeries, barbershops and small grocery stores have been found to be the favorite neighborhood places of older adults (Baker, Bodner, & Allman, 2003; Gardner, 2011). Older adults feel comfortable in these stores as they know the staff and are able to easily find the items they need inside (Gardner, 2011). If built environment is age friendly then older adults are more likely to visit them and physical activity for older adults has been well recognized in the literature to support their wellbeing (Hale & Marshall, 2017; Smith, Banting, Eime, O'Sullivan, & Van Uffelen, 2017). Physical activity in older adults is known to reduce morbidity, mortality, reduce disability in performing tasks and also improve the quality of life (Barengo, Antikainen, Borodulin, Harald, & Jousilahti, 2017; Hale & Marshall, 2017). Built environment can be made age friendly by focusing on capabilities of the end user.

User-centered design and Universal design. User-centered design (UCD) approaches focus on the end user and adhere to four principles of design: 1) while designing, the focus is on the user and the tasks the user will be performing, 2) the product is designed considering empirical data from usability studies of using the product, 3) prototype development and testing with the user, and 4) final testing and evaluation of the design (Czaja et al., 2009). Universal (or inclusive) design is an extension of UCD and advocates for thoughtfully designing products, communication material and physical environments to meet needs of all ages. The designs should be flexible enough to be used by people with no limitations and also by people with disabilities related to any circumstances (Czaja et al., 2009).

It is noteworthy here to understand what makes a product usable. Czaja et al. (2009), in their book *Designing for Older Adults*, describe that a product can be considered useful by evaluating its "utility" and "usability". Utility means if the functionality of the product provides what is needed, and usability refers to how well the users can access that functionality. Relating this to the food-shopping environment, it is essential to understand if the store is able to provide what is needed and is accessible by people with no limitations and also by people with physical limitations. To understand this further, it is important to mention all six principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort and size and space for approach and use (Sanford, 2016). The first principle of equitable use states that a design should be usable by people with diverse abilities. The design should avoid segregating the users and provide same means of use for all users. It should be appealing to all users. This is important for design in public places and places where people of diverse abilities frequently visit. Another principle of universal design is flexibility of use. This principle states that the design should accommodate for preferences and abilities of wide range of people and should be flexible to provide choice in methods of use. An example of this would be to provide flexibility in design to accommodate right- or left-handed use. The third principle of universal design is simple and intuitive use; design should always be easy to understand by all users. It should accommodate a wide range of literacy and language skills. The fourth principle of universal design is perceptible information that states that the design should communicate necessary information effectively to the user. Providing different modes of presentation like pictorial, verbal, and tactile for essential information, providing adequate contrast between essential information and surroundings, and maximizing legibility of the information are some of the ways to improve perceptibility of the information for the users. Fifth principle of universal design is tolerance of error. The design should minimize hazards or possible accidents. This is a critical element for designers to think while designing, as many elements in the design could be safe for some users but could prove a hazard for others. Some of the ways could be by providing warnings, and isolating or eliminating hazardous elements from the design. The sixth principle of universal design is low physical effort. The design should be used comfortably with minimum fatigue. The design should allow users to maintain a neutral body position and use reasonable operating force. Repetitive actions and physical effort should be minimized. The seventh principle of universal design is about providing appropriate size and space for approach, reach and use for users with different body sizes, posture or mobility. This principle emphasizes to make comfortable for both seated or standing users, accommodate for hand and grip size variations and also provide adequate space for the users using assistive devices or needing personal assistance (Sanford, 2016).

Designing for older adults must be inclusive, making products or environments suitable for any age (Farage et al., 2012). The principles of universal design emphasize making design within comfortable reach, easily accessible to users with less physical effort. One of the most fundamental and common methods to design user-centered design is task analysis. In task analysis (Czaja et al., 2009), the task is considered as a goal and the steps are broken down into hierarchical plans to complete the final goal. For example, for completing a task of buying a bag of cereal, an individual will have to enter the grocery store, take a shopping cart, walk to the aisle with cereals, find the preferred cereal bag on the shelf, reach for the cereal bag, and put it in the shopping cart, walk to check out section, pay for it and exit the grocery store. Task analysis helps the designer to design the product to suit the user as they perform the task. Another important method for designing for older adults is usability testing. This method calls for users to perform the specified task with the product in a controlled test environment while being watched by the design team. This method could reveal the problems and also judge the satisfaction of user with the product or environment (Czaja et al., 2009). Post occupancy evaluation (POE) plan has also been used to evaluate the store environment after it has been in use to learn about effective design features (Menezes, Cripps, Bouchlaghem, & Buswell, 2012). POE is the structured process of evaluating the performance of the environment and can provide store managers with valuable information regarding the in-use performance of the design changes made in the store environment. These UCD methods could be used during new design process or even to evaluate an existing environment.

Aging and current retail environments. In coming years, retailers will have to cater to a growing population of older adults; in some cases, this population may become the majority of their target customer segment. Yet, the current retail environment is not ready (Celeski et al., 2017; Moore & Conn, 1985; Underhill, 2009). A recent study done in a Brazilian supermarket identified four major problems that older adults face while shopping for their groceries: 1) frequent use products were located too high or too far below the shelf for older adults to reach, 2) walking space between aisles was narrow, 3) loading and removing products from the shopping cart was difficult, 4) no place to rest, and slippery floor (Celeski et al., 2017). Stepping into the shoes of older adults can help us understand the difficulties they face while performing IADLs. Patricia Moore, founder of a research, design and marketing firm specializing in creating environments that meet individual needs, took a similar initiative. She disguised herself as an eighty-year-old woman and found that world around her was very difficult for an older adult (Moore & Conn, 1985). She had difficulty in reading text, many times she needed help to pick up items placed higher on shelves and other times a cashier thought she would not notice less cash change given to her. These narrated real life experiences (Moore & Conn, 1985) call for action to understand the plight of older adults and make changes in our surrounding environment to accommodate this important segment of population. A group of young adults also experienced a similar disguise experience by wearing an “Age Suit” developed by MIT AgeLab to simulate the physical difficulties that older adults face. These young participants completed shopping tasks in a grocery store while wearing the age simulation suit (Lavallière et al., 2017). The results indicated that young participants had difficulty in locating aisles, the signs were not visible properly, and aisles were too narrow for them to navigate. In addition to this, the distance seemed longer to them as gait was reduced, visual impairment caused by yellow glasses made it difficult it read on packages and most importantly viewing higher shelves and picking up items from higher and lower shelves was very difficult (Lavallière et al., 2017). This research builds empathy and emphasizes the fact that there is a dire necessity to improve the retail store environment to suit the older population.

Satisfaction is an important factor in the retail environment that is often used as a measure to identify problems. Hare (2003) studied the food shopping experience of older consumers in U.K. supermarkets and found that three key areas: store environment, merchandise, staff and service were important to achieve satisfaction of consumers. She indicates that major areas of dissatisfaction among older consumers from the U.K. were higher price for smaller quantities and the way the stock was managed and displayed in the stores. In particular stock being moved around frequently and the on-availability of stock lead to dissatisfaction among older consumers. In a similar study about older US consumers, a majority of them felt food shopping was a problem for them and reported the following dissatisfactions: 1) difficulty in seeing labels, 2) package sizes were too large for older households, 3) supermarkets were too cold for older people, 4) handling shopping carts were reported as problem, 5) places to sit and rest while shopping were not available (Mason & Bearden, 1979). Further studies also report similar problems in reaching high and low shelves, reading price displays, and pushing trolleys by older adults (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003).

Retail stores have generally catered to the younger population (Moore & Conn, 1985). Store merchandising, such as displays and shelf arrangements, are not suitable for older consumers (Yin, Pei, & Ranchhod, 2013). As discussed before in this chapter, the aging process causes mobility limitations, and this becomes a major cause for different needs of older consumers. Older adults develop certain patronage behaviors for particular grocery stores due to ease of locating merchandise, ease of shopping at local stores near the residence (Meneely, Strugnell, & Burns, 2009), availability of familiar brands, and fast check-out (G. Moschis, Curasi, & Bellenger, 2004). This further leads to approach and avoidance behaviors of the consumers in the retail store (Mehrabian, & Russell, 1974). Approach and avoidance behaviors in older adults could be specific to their mobility and cognitive restrictions (George P Moschis, 2003; Willis et al., 2006). It could lead older adults to not return to an environment where they feel uncomfortable. Moye, & Giddings (2002) studied the retail approach-avoidance behavior of older apparel consumers' aged 65 and over and found that older adults would avoid stores without chairs or benches, especially when it was difficult to locate them.

Overall the difficulties faced by older adults have been reported under four major categories: a) problems with trolley: pushing heavy trolley, trolley lock not working properly, and the trolley being too deep (Yin, Pei, & Ranchhod, 2013). The trolley though was found to serve as walking aid (Meneely, Burns, & Strugnell, 2009; Yin et al., 2013), b) store layout were found to be either congested with narrow passageways between the aisles (Yin et al., 2013) or too big for older adults to walk round and thus are avoided by most (Meneely, Burns, et al., 2009; Meneely, Strugnell, et al., 2009; Thompson et al., 2011); c) items placed too high or too low on shelves were difficult to reach for older adults (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003; Yin et al., 2013) and d) reading information on product packages, and labels was reported to be difficult by older adults (Underhill, 2009, Klein, & Linton, 1992; Midena, Degli Angeli, Blarzino, Valenti, & Segato, 1997). The methods used in the literature to study problems faced by older adults in the retail store were majorly survey, interview, and focus groups that hightlight the problem for example shelves being too high or low for older adults to reach, but donot specify quantitatively the suitable shelf heights that retailers should adopt to accommodate for older adults. The current study created simulation of various shopping tasks and used performance based measures to identify specific changes needed to make the tasks easy for older adults. To acheive this, theories of disablement and person-environment fit, helped in understanding the gap between older adults capabilities and retail store environment. Literature on reduced mobility capability and vision capability is discussed further.

Aging and reduced mobility capability

Mobility is recognized as an important activity to sustain independent living (Gill et al., 2017; Hirvensalo, Rantanen, & Heikkinen, 2000). In the gerontology literature, mobility research has focused on movement in the physical space in the community. Mobility has been measured in terms of the number of daily or weekly trips within the community made by the older adults and the distances covered (Fobker & Grotz, 2006). Older adults with good health had spatially broad patterns of movement and utilized more opportunities for leisure activities involving movement than they had prior to their retirement. As age increases, older adults show reduction in the leisure activities involving movement and their activity space reduces (Fobker & Grotz, 2006). The aging process increases the prevalence of musculoskeletal disorders (MSDs) including osteoarthritis and osteoporosis, and this in turn could reduce the mobility of an older adult (Monov & Kopchev, 2017; Sinigaglia et al., 2017).

Osteoarthritis (OA), a most common MSD, is a degenerative joint disease that effects the joints and the surrounding tissue around the joints (Litwic et al., 2013). This disease progresses slowly but can ultimately cause disability and affect the mobility of older adults. The most common OA is in the knees and is known to cause major disability in movement because it affects weight-bearing joints (Cushnaghan & Dieppe, 1991; Felson et al., 1997; Kovar et al., 1992; Litwic et al., 2013). Since OA has been identified to cause movement disability, older adults with OA are studied to understand the influence of mobility limitations on completing the shopping tasks in a grocery store in this study. Primary symptoms of OA are joint pain, stiffness and swelling, and difficulty in movement (Cross et al., 2014). Knee OA is more common in women than in men. Statistics show the prevalence of knee OA in men to be 5.6% as compared to

30.5% in women (Bijlsma & Knahr, 2007). Hip OA is less common than knee OA but causes major difficulty in walking and performing IADLs (Cross et al., 2014; Litwic et al., 2013). Risk factors of OA are obesity, age, gender, smoking, and bone mineral density (Litwic et al., 2013). Obesity, defined as body mass index (BMI) more than 30, is a major risk factor in the literature to influence the progression of knee OA (Grotle, Hagen, Natvig, Dahl, & Kvien, 2008). Controlling obesity is important to maintaining musculoskeletal health and reducing the risk of OA (Woolf, Breedveld, & Kvien, 2006).

Determinants of mobility capability. Maintaining continued physical mobility is important for older adults. Activities that depend on mobility capability are bathing, dressing, and shopping. These activities are essential IADLs (Fobker & Grotz, 2006). To complete shopping tasks in a grocery store activities that depend on mobility capability are bending and stretching to reach for products and walking to reach the desired aisle where product is located.

OA limits the functional reach of older adults. Functional reach is defined as the maximum difference between arm-length and maximum distance reached forward without moving the feet (Duncan, Weiner, Chandler, & Studenski, 1990). Functional reach declines with age, and OA is known to increase the reach disability in older adults (Takahashi et al., 2004). Reach has been found as a frequent problem in performing daily tasks by older adults, 66% of which are found to occur in grocery shopping and laundry tasks (Clark, Czaja, & Weber, 1990b) when an individual is reaching to reposition or retrieve an object. Underhill (2009) also found that in supermarkets, products are stocked either too high or too low, making them off-limits to older shoppers. In addition to this, heavy items like soft drink cases and large boxes of detergents are too bulky for older adults to move. Clark et al. (1990) proposed to examine demands presented by specific task environments to understand interventions required to make IADL tasks easier. They video-taped older adults in their homes and did task analysis to find that reach was frequently reported as a problem. They recommended that height and depth of cabinets in a kitchen area should match the reach capability of older adults and suggested that this could be achieved by environmental redesign or use of simple assistive technology to lower shelves in the kitchen. Similarly, examining grocery store shopping task environments might be useful to understand interventions required in the grocery store to assist in performing the task.

Previous studies on universal design provide guidelines to make the product or environment suitable for older adults. The guidelines for mobility and balance limitations of older adults suggest using strong color contrast to distinguish between floor and walls, and product placement to accommodate the lowest trunk heights of older people (Czaja et al., 2009; Farage et al., 2012).These recommendations support the development of two simulations of store environments that were created for the current study, one with current measurements taken from actual grocery store and the other per universal guidelines and functional reach guidelines from the literature (Duncan et al., 1992; Farage et al., 2012). Therefore, it is hypothesized that:

- Functional reach capability of older adults with OA will be better in shelf heights as per universal guidelines as compared to shelf heights as per existing store measurements.
- Functional reach of older adults without OA and young adults will be better than older adults with OA in shelf heights as per universal guidelines in literature.

Mobility restrictions are part of old age. Walk capability or the ability to walk safely and independently has been recognized as fundamental for successful aging. The extent of walking ability varies depending upon the circumstances and types of diseases like OA affecting an older adult. Due to age-related disabilities in older adults, IADLs become increasingly difficult to perform (Stamm, Pieber, Crevenna, & Dorner, 2016). To maintain independence, an older adult should be mobile and be able to walk in the community. All eight items of IADLs that require this mobility are telephone use, shopping, meal preparation, housekeeping, laundry, use of transportation, can take medication, and handling finances. Finlayson, Mallinson, and Barbosa

(2005) have shown that when older adults begin facing difficulty like completing shopping tasks independently, they may be at risk of requiring in-home services. This shows how IADLs are important for an older adult's independent living. Walking capability of older adults while performing shopping task was tested in the current study with following hypothesis:

- Walking capability of older adults without OA and young adults will be better as compared to older adults with OA.
- Walking capability of older adults with OA will be better with shopping cart than without shopping cart.

Perceived motor-efficacy or the capability beliefs of healthy older adults affect their mobility patterns. Self-efficacy has been defined as individuals' perceived ability to perform specific behavior or tasks sometime in near future (Potter, Grealy, & Connor, 2009). Perceived motor efficacy is, therefore, useful in identifying older adults who are at risk of functional limitations and helping them with interventions before the onset of the actual mobility restrictions. In cases of OA in older adults, the arthritis self-efficacy scale (ASES) has been used to identify research participants' beliefs to complete the tasks; a scale that has been found to be valid and reliable (Barlow, Williams, & Wright, 1996; Gao et al., 2017; Garratt, Klokkerud, Løchting, & Hagen, 2017; Lorig, Chastain, Ung, Shoor, & Holman, 1989; Lorig, Ung, & Holman, 1989). ASES was used to measure older adult's beliefs to complete shopping task and further the relationship with walking capability and reach capability was examined. Accordingly, it is hypothesized that:

- Low arthritis self-efficacy scores of older adults with OA will have negative relationship with walking capability of older adults in a grocery store.
- Low arthritis self-efficacy scores of older adults with OA will have positive relationship with reach capability in a grocery store.

Older adults with OA have high tendency to lose their balance while performing daily activities (Yardley et al., 2005). The fall efficacy scale (FES) is a validated and reliable scale used in literature to identify the fear of falling in older adults. Fear of falling has been defined as the low perceived self-efficacy to avoid falls during essential, nonhazardous activities of daily living (Tinetti, Richman, & Powell, 1990). The fear of falling increases with OA, and specifically, in knee OA the balance and weight taking problems in the knee joints increases the fear of falling (Levinger et al., 2011; Rejeski, Miller, Foy, Messier, & Rapp, 2001). Fear of falling has been found to have a relationship with perceived difficulty with grocery shopping, and a majority of older adults who have a fear of falling reported difficulty in performing grocery shopping independently (Johnson & McLeod, 2017). Thus, in older adults with OA, fear of falling could affect walking and performing tasks in a grocery store. Therefore, it is hypothesized that:

- Low fall efficacy scores of older adults with OA will have a negative relationship with walking ability of older adults in a grocery store.
- Low fall efficacy scores of older adults with OA will have a positive relationship with reach capability inside the grocery store.

Aging and reduced visual capability

Impaired vision aggravates the physical risk factors associated with OA due to increase in the walking difficulties and risk of falling (Creamer, Lethbridge‐Cejku, & Hochberg, 2000; De Boer et al., 2004; Verbrugge, 1995). Visual impairment in older adults has also been reported to cause disparities in health, in performing regular activities, and in social participation (Crews & Campbell, 2004). This relationship between age-related visual impairment and mobility difficulties of OA patients makes it important to consider vision and mobility limitations together to study the difficulties that OA patients might face in performing daily activities. Impaired vision is also associated with decreases in leisure activities like watching television, doing craft work and reading (Heinemann et al., 1988; Kelly, 1995), decrease in IADLs and social function (Branch, Horowitz, & Carr, 1989), and increased disability in performing IADL (Rudberg, Furner, Dunn, & Cassel, 1993). Visual impairment, defined as a near visual acuity of 20/70 or less (Crews & Campbell, 2004), reduces the community travel of older adults, and dissatisfaction associated with their ability to travel independently was found to increase (Long, Boyette, & Griffin-Shirley, 1996; Salive et al., 1994). Thus, visual impairment decreases the quality of life with reduced self-sufficiency in daily activities, increases in risk of depression, and reduced social relationships (Carabellese et al., 1993).

Older adults with low visual acuity and low contrast sensitivity have a higher risk of physical dependence (Dargent-Molina, Hays, & Breart, 1996). Contrast sensitivity is defined as the ability to see the targets of various sizes and contrast in the everyday environment as compared to visual acuity, which is the sharpness of vision and is measured by the ability to discern the smallest letter and number under the highest contrast (black over white) (Dargent-Molina, Hays, et al., 1996). Thus, contrast sensitivity could better show the visual difficulties that older adults face while performing daily activities like reading a label or sign, locating products in a grocery store, and moving through around grocery store aisles with confidence (Marron & Bailey, 1982; Owsley et al., 1981). Despite good visual acuity, older adults require high contrast to see the scenes with low to intermediate spatial frequencies (Owsley et al., 1981). Spatial frequencies are the level of details present in the scene. The high spatial frequency or the scenes with sharp edges were clearly seen by the older adults (Sekuler, Hutman, & Owsley, 1980). Therefore, this reduced sensitivity of older adults to scenes with less sharp details or low spatial frequency might affect the daily perceptual activities (Sekuler & Hutman, 1980), such as recognizing product packages on shelves with a number of packages and reading the text on product labels, tags, and packages.

Human eyes deteriorate with age and research indicates that signs of age related macular degeneration are common in older adults, the eye lens becomes rigid and muscles become weak, making it difficult for older adults to focus on small print (Klein, Klein, & Linton, 1992; Midena, Degli Angeli, Blarzino, Valenti, & Segato, 1997). Another eye problem that causes difficulty in reading is yellowing of the cornea, which changes the perception of colors (Farage et al., 2012; Moore & Conn, 1985; Underhill, 2009). Hence the print in colors in violet, blue, green spectrum become less noticeable by older eye (Johnson, Adams, Twelker, & Quigg, 1988). Warm colors are better recognized than cool colors by older adults (Wijk, Berg, Sivik, & Steen, 1999a, 1999b). So, smaller print and cool colors will be hard to read for older consumers in the retail stores. Interestingly, newspaper print, print on medicine bottles and many product labels, wash care labels ranges from 6 point to 9 point, which is be very difficult for older adults to read (Darroch et al., 2005; Moore & Conn, 1985; George P. Moschis et al., 2011; Underhill, 2009). Similar results were indicated by a study done by Nielsen in 2014, with 59% of older adults having problem in finding easy-to-read product labels ("The Age Gap," 2014). This is one of the major problems that need attention in the retail stores. If product packages, brochures and medicine bottles are not readable then it can cause a serious problem to procure these items of necessity. It has been identified in the literature that older adults have different needs due to their aging process and different life circumstances they have experienced that change their needs for products. This also changes their perception and response to stimuli in the retail stores (George P Moschis, 2003). Hence, it is important to understand that many print types and product shelving that might work for younger population might not be suitable for older adult population.

To accommodate for visual limitations, the universal design guidelines suggested by Farage et al (2012) include providing higher illumination without glare, and avoiding visual clutter. Important information should be large with font sizes 12 point and above, should be conspicuous, un-crowded and in central visual field. Decorative fonts and backgrounds should be avoided. Upper case is useful to highlight but it should be avoided in excess (Farage et al., 2012). Underhill (2009) suggests a minimum font size of 13 point to be used to make it readable by older adult population. The author further states that with a growing population of older adults, there is a dire necessity to improve the reading conditions for older adults. Consequently, it is hypothesized that:

- Print characteristics like font size, and font type will affect reading preference of older adults.
- Low visual acuity of older adults will have a positive relationship with forward reach scores of older adults.
- Low visual acuity of older adults will have negative relationship with walking capability scores of older adults.

Mobility and visual limitations: a review of research methods

Since the aim of this study was to measure mobility and visual capability of older adults, it is relevant to review the methods used in the literature to measure them. A review and comparison of tests that measure mobility limitations in OA patients and age-related visual impairment is presented here to identify measures most amenable to measuring the suitability of grocery store environments that provide good reliability and validity. This section provides an overview of common measures that have been used in previous research. Each measure, its description, and similar studies that have implicated these measures are summarized in Table 1.

Mobility limitations in older adults with OA are most commonly reported to affect walking, stair climbing and transferring (for example transferring from a chair to standing) (Felson et al., 1995; Guccione et al., 1994). Measures of mobility impairment in OA patients consist of the six-minute walk test (Ko, Naylor, Harris, Crosbie, & Yeo, 2013; Kovar et al., 1992; Montgomery & Gardner, 1998; Steffen, Hacker, & Mollinger, 2002), timed-up-and-go test

(Podsiadlo & Richardson, 1991; Steffen et al., 2002), and a stair-climbing test (Rejeski, Craven, Ettinger, McFarlane, & Shumaker, 1996). As described earlier in this chapter, diseases like OA reduce the reach capability of older adults. Reach capability of older adults has been measured by a functional reach test (Duncan et al., 1992; Lin et al., 2004; Rikli & Jones, 1999), and multi-dimensional reach test (Bainbridge, Bevans, Keeley, & Oriel, 2011; Holbein-Jenny, McDermott, Shaw, & Demchak, 2007; Newton, 2001; Rantz et al., 2013; Stone, Skubic, Rantz, Abbott, & Miller, 2015). Visual impairment in older adults affects the performance of IADLs. Measures for visual limitations consist of a visual acuity measure (Adams & Lovie, 2004; Bailey & Lovie, 1976; Bambridge, 2001; Ferris, Kassoff, Bresnick, & Bailey, 1982; West et al., 2002; Winther, 2016) and performance-based reading tests (Owsley et al., 2001; Owsley, Sloane, McGwin Jr, & Ball, 2002).

Table 1.

Measures for mobility and visual capability of older adults from literature

Tests		To measure	Description	References
	Six-minute walk test	Walking ability of older adults	This test measures the distance older adults cover while walking indoors at their own pace for six minutes	(Ko, Naylor, Harris, Crosbie, & Yeo, 2013; Kovar et al., 1992; Montgomery & Gardner, 1998; Steffen, Hacker, & Mollinger, 2002)
	Stair climbing	Ability to climb stairs	Ascend 5 steps, turn around and descend 5 steps was used	(Rejeski, Craven, Ettinger, McFarlane, & Shumaker, 1996)
Mobility measures related to older adults with OA	Timed up-and-go test (TUG)	Measures older adults' independence in performing the daily activities that require mobility	Stand up from a chair with arm rests, walk 3 meters, turn, walk back and sit down quickly and safely	(Podsiadlo & Richardson, 1991; Steffen et al., 2002)
	Multi- directional reach test (MDRT)	Measures the reach of older adults over four directions	Extend the arm and reach without moving feet or take a step, reach as far as possible and keep hand along the yardstick	(Bainbridge et al., 2011; Holbein-Jenny et al., 2007; Newton, 2001; Rantz et al., 2013; Stone et al., 2015)
	Functional reach test	Measures the reach of older adults in front	The maximum the subject is able to reach forward from the initial upright position to maximum leaning posture without moving the feet	(Duncan et al., 1992; M. R. Lin et al., 2004; Rikli & Jones, 1999)
	One-leg stand	Measures balance	Stand unassisted on one leg	(M.-H. Hu & Woollacott, 1994; C. J. Jones, Rikli, & Beam, 1999; M. R. Lin et al., 2004; Schlicht, Camaione, & Owen, 2001)

Visual acuity measures	High-contrast acuity (Bailey-Lovie chart)- This is a seminal chart used widely in literature.	Ability to see fine detail at a distance with good lighting and high contrast	Snellen acuity 20/70 or worse	(Adams & Lovie-Kitchin, 2004; I. Bailey & Lovie, 1976; Bambridge, 2001; Ferris, Kassoff, Bresnick, & Bailey, 1982; West et al., 2002; Winther, 2016)
	High-contrast acuity (Bailey-Lovie chart). This is a seminal chart used widely in literature.	Ability to see fine detail at a distance with good lighting and low contrast	Snellen acuity 20/115 or worse	(Bailey & Jackson, 2016; I. Bailey & Lovie, 1976; Ferris et al., 1982; West et al., 2002; Winther, 2016)
	The Freiburg Visual Acuity test	Visual acuity	An automated procedure using computer for self-administered measurement of visual acuity	(Bach, 1996)
	Visual acuity through smart phone app	Visual acuity	Smart phone app shows the acuity chart for the patients to read.	(Pathipati, Wood, Lam, Sáles, & Moshfeghi, 2016)
Visual capability measures	Timed independent activities of daily living (TIADL) tasks	Timed independent activities of daily living (TIADL	The tasks address the five domains of IADL- (1) communication; (2) finance (3) food (4) shopping (5) Medicine.	(Owsley et al., 2001; C. Owsley, Sloane, McGwin Jr, & Ball, 2002).
	Reading performance test	Reading performance for a given test	Participants read a given set of text and time taken to read it is recorded.	Liao, & Mills, (2001), Darroch, Goodman, Brewster, & Gray, (2005)
	Reading preference test	Ease of reading text, Appropriateness of size, Clearness of type	Participant’s rate given font type and size on likert scale for ease of reading, appropriateness of size and clearness of type.	Liao, & Mills, (2001), Darroch, Goodman, Brewster, & Gray, (2005)

Theories of aging and disablement model

Activity theory of aging (Lemon, Bengtson, & Peterson, 1972) suggests that maintaining activity is essential for older adults to attain high levels of satisfaction in life. Activity includes daily activities and roles that an individual plays in the society. Activity theory of aging posits that as there is loss of activity in the life of an older adult, the life satisfaction values decrease. Hence, it is imperative for an older adult to maintain the activities in life.

Social psychologist, Kurt Lewin (1951) suggested that a person's behavior in a space is a function of the individual interacting with the environment. Theories of person-environment fit were studied further in the 1980's and focused on the relationship of individual to the environment where they lived, and measured performance as a function of both the person and the environment (Kiernat, 1982). This theory was later expanded to include the role of occupation and interactions between person, occupation and environment were considered important (Law et al., 1996). Lawton and Nahemow (1973) further looked at the environmental pressure that an environment presents on an individual. According to their competence press model, if the environment presents a lot of stress then there will be a marked decline in the competence of the person to perform the task. Competence press model also indicates that if the environment is adjusted to present less stress to the individual, then competence of the person to perform the task might increase. This idea was further supported by a congruence model of the person-environment fit theory by Kahana, Liang, and Felton (1980) who suggest that people prefer the environments that meet their needs and try to avoid the environments that present difficulty in completing the required task. A mismatch between the demands of the environment and person's capability leads to disability.

Disability occurs due to interactions of an individual with the environment. Disability is defined as difficulty in doing activities in any domain of life due to health and physical problems (Verbrugge & Jette, 1994). The social models of disability suggest that disability occurs due to mismatch between the environment and the individual's capability (Hahn, 1994; Lawton & Nahemow, 1973; Pope & Brandt, 1997). This mismatch between environment and individuals' capacity, leads to problems in daily functioning of older adults. Hence, disability is shown as a gap between personal capabilities and environment demand (Verbrugge & Jette, 1994). The further part of this section describes the existing disablement theories, which form the foundation for developing the theoretical framework for this study.

Disablement is defined as the impact that chronic diseases like OA have on the functioning of specific body systems of older adults (Clarke & George, 2005; Verbrugge & Jette, 1994). Disablement has been studied via two main conceptual schemes: 1) the international classification of impairments, disabilities and handicaps (ICIDH); and 2) Nagi's model of disablement. ICIDH is developed by World Health Organization (WHO) and has three main central concepts: Impairment, disability and handicap. According to ICIDH (Figure 1), a disease like OA causes impairment or abnormality in functioning of an organ in the body, which further leads to disability or lack of ability to perform activities in a normal manner; ultimately leading to handicap status or disadvantage due to the disability.

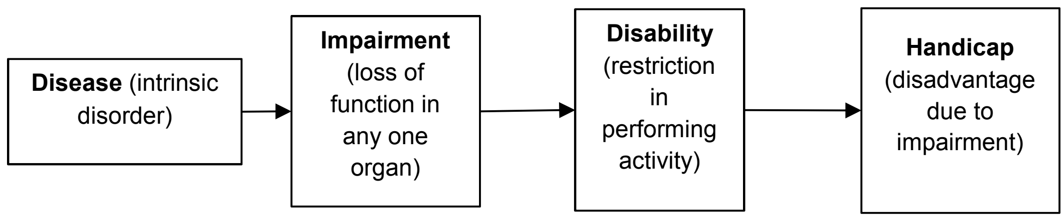

Figure 1: The international classification of impairments, disabilities and handicaps (ICIDH).

Another conceptual scheme that describes disablement is Nagi's model of disablement (S. Nagi, 1965; S. Z. Nagi, 1979, 1991), which is a seminal work and has been widely referred to in the literature for understanding the disablement process. This model (Figure 2) has four components 1) active pathology; effects of a disease to interrupt the normal process in the body, like disease OA causes degeneration of tissues around the joints, 2) impairment; loss of functioning in any part of the body, like OA causes the impairment in knees, 3) functional limitation; the reduction in performance of daily activities and lastly 4) the disability; the limitation in social roles and tasks in the environment.

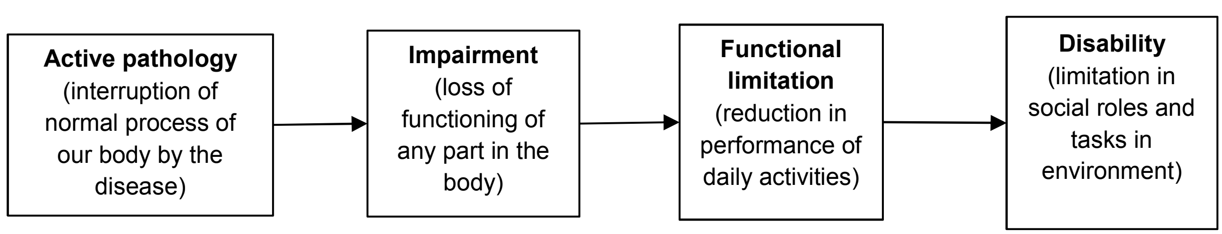

Figure 2: Nagi's disablement model (S. Z. Nagi, 1979)

Theoretical model for the study

The theoretical model for this study has its foundation in Nagi's disablement model and disability model by Verbrugee and Jette (1994) who describe disability as a gap between persons' capabilities and the physical environment. Disability occurs when there is a mismatch between individual capabilities and demand of the environment where the task is performed. This study identifies the mobility capabilities and visual capabilities of older adults while performing the shopping tasks in a grocery store. A good example given by Verbrugge and Jette (1994) to describe the disability of an older women with OA in performing the daily activities follows:

> A woman age 74 with osteoarthritis in both hands (pathology) has weak grip and restricted finger flex- ion (impairments). This causes difficulty in grasping and rotating fixed objects (functional limitations), and she has trouble opening jars or doors (disability). She purchases kitchen devices and special door handles (interventions) to overcome the difficulty.

As is clear in the above example, Verbrugge and Jette (1994) suggest that disability can be reduced if the demands by the activity or tasks are reduced. This could be achieved by making the environment suitable for the capabilities of older adults. It is important to understand the person-environment fit (Kahana et al., 1980; Law et al., 1996; Lawton & Nahemow, 1973) to ultimately make the environment suitable for an individual. For example, to reduce disability of older adults in a grocery store environment, it is important to make the demands of that environment suitable for the older adults capabilities. The seven principles of universal design describe that the design should be usable by people with diverse abilities. This research focuses on the universal design principle of accessibility of space that states products should be accessible for a range of body sizes, posture and mobility; the universal design principle of low physical effort states that the product or environment should be used comfortably with minimal strain or fatigue (Farage et al., 2012). The current research study acknowledges the demand-capability gap between older adults reduced mobility, visual capabilities and grocery store environment; and identifies the difficulties that older adults face while performing shopping tasks like walking in the grocery store, reaching for products on the shelves, reading the labels and packages. The research further provides suggestions for retailers to reduce this demand-capability gap in their stores. If older adults find the shopping environment safe and easy to use, then they will feel less nervous to navigate in the store environment and this will lead to their higher self-efficacy levels to perform shopping tasks while fulfilling their daily needs. Figure 3 illustrates the theoretical model for this study.

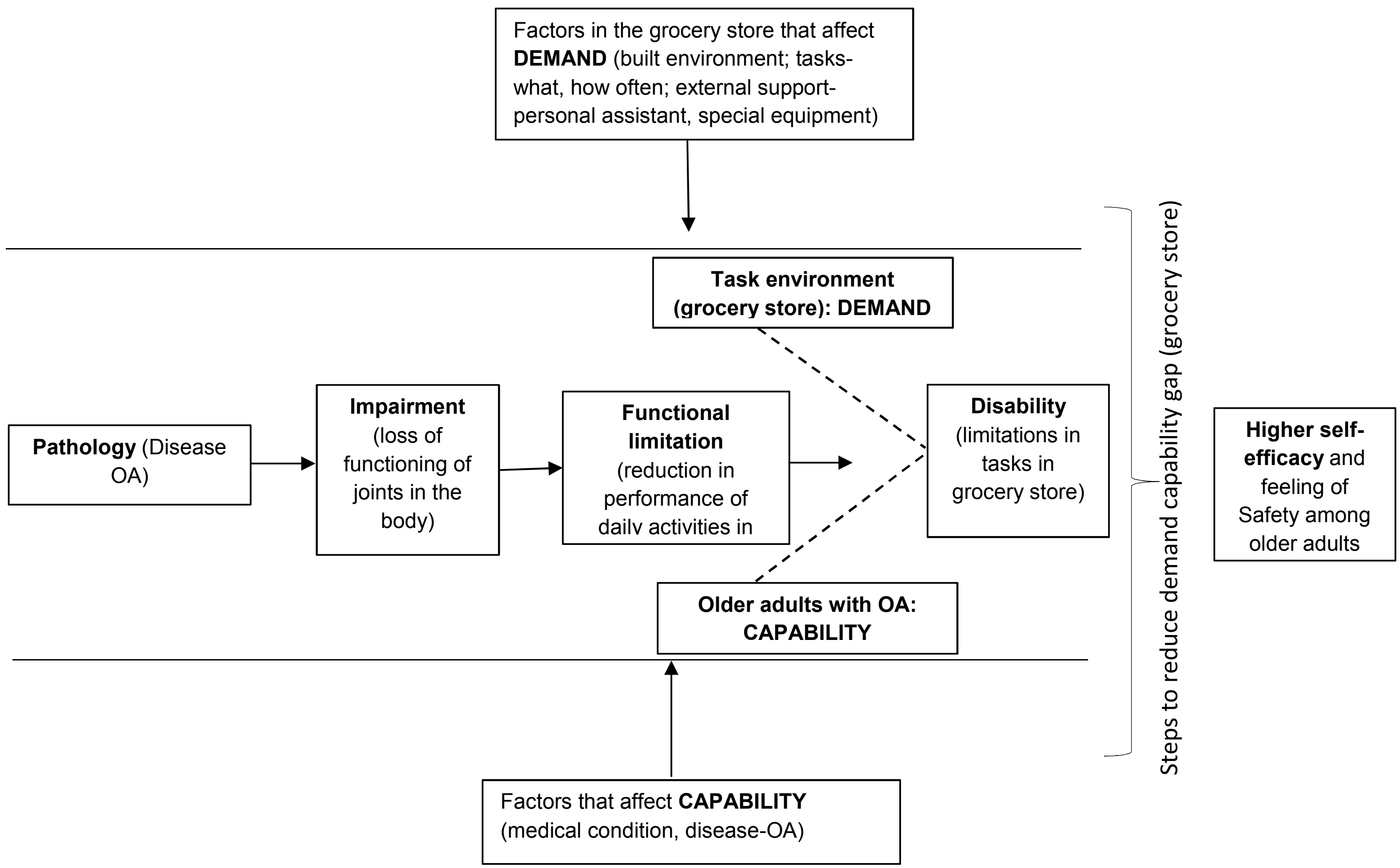

Figure 3. Theoretical model for this study

Conclusion

For the first time in US history, the older adult population is expected to grow to 78.0 million by 2035 exceeding children under age 18 by over two million (Nasser, 2018). Unfortunately, the literature indicates that retail stores are not ready to serve the older population. There is a need to match older adults' capabilities to the grocery store environment demands, and the research into understanding this capability gap between older adults' capabilities and grocery store environment has been both general and sparse. The current literature (Table 2) provides information on successful aging (de São José et al., 2017; Foster & Walker, 2014; Phelan et al., 2004; Rowe & Kahn, 1997) reduced mobility of older adults (Baker et al., 2003; Fobker & Grotz, 2006; May, Nayak, & Isaacs, 1985; Webber, Porter, & Menec, 2010a; Ziegler & Schwanen, 2011), mobility limitations of older adults (Cawthon, 2011; Choong & Brooks, 2012; Cromwell & Eagar, 2003; Katz, 1983; Lawton, 1988; Lawton & Brody, 1969; Leveille et al. 1999; Potter, Grealy, & Connor, 2009; Woolf, Erwin, & March, 2012), and age-related visual loss in older adults (Crews & Campbell, 2004; Heinemann et al., 1988; Kelly, 1995; Lin et al., 2004; McGrath et al., 2016; Owsley et al., 1981; Sekuler & Hutman, 1980; West et al., 2002). Yet, there is a lack of understanding about the mobility and visual capabilities of older adults while performing shopping tasks in a grocery store, an essential IADL. This research created simulations of grocery store environments and employed performance-based measures to study mobility capability, reach capability and visual capability of older adults while performing grocery store shopping tasks. If community retail stores are geared toward the physical limitations of older adults, this could increase the independence and quality of life for the aging population as well as boost retailers' profitability. Therefore, this research fills the gap in the literature regarding the difficulties that older adults face while completing shopping tasks inside a grocery store due to their mobility and visual impairments.

Table 2.

Summary of literature review

Findings from past research	Issues that need further exploration
• The need and benefit of successful aging. • Shopping has been recognized as an important IADL for independent living. • Reduced mobility limitations due to age in older adults. • Reduced visual limitations due to age in older adults. • Current retail environment is not age-friendly.	• Functional reach of older adults on existing shelf heights in national grocery store. • Walking capability of older adults with and without shopping cart. • Relationship between visual acuity and walking capability and reach capability and its effects on older adults' performance while shopping. • Relationship between arthritis self-efficacy, walking capability and reach capability and its effects on older adults' performance while shopping. • Relationship between fall self-efficacy and reach capability and its effects on older adults' performance while shopping. • Print type and size preference for ease of reading, appropriateness of size and clearness of type on labels and tags in retail stores.

CHAPTER III

RESEARCH METHODS

Introduction

Making the built environment age-friendly is an essential determinant to active aging. As discussed in the literature review, there is a paucity of current research about how retail stores may be made friendlier to older adults. Hence, the purpose of this study was to investigate the influence of reduced mobility capability and visual capability in older individuals on shopping for their daily needs, and then to provide suggestions to retailers about how to accommodate older adults. This chapter begins with describing the conceptual framework for the study, followed by the research approach. Then, the flow of activities for this research is described, including sample and recruitment process as well as data collection methods. This chapter concludes with a description of data analysis methods.

Conceptual Framework

The conceptual framework is based on demand-capability theoretical model of this study. Disability occurs when there is a mismatch between the person's capability and the demands of the environment (Verbrugge & Jette, 1994). This creates a demand-capability competence gap that ultimately makes daily tasks like shopping difficult for older adults. The conceptual framework (Figure 4) presents person (older adults) capabilities on left hand side and environment demands on right hand side. The middle part of the framework describes the competence gap due to mismatch between person capabilities and environment demands.

This study explores this demand-capability gap by measuring the mobility capabilities and visual capabilities of older adults while performing the shopping tasks in a grocery store environment simulation (Figure 4). Grocery store simulations were created in a laboratory according to measurements of a national grocery store and according to universal design recommendations for older adults (Farage et al., 2012). Universal design advocates for thoughtfully designing products, communication material and physical environment to meet needs of all ages. According to the universal design principle of accessibility, products should be accessible for expected range of body size, posture and mobility; whereas the universal design principle of low effort states that the product or environment should be usable comfortably with minimal strain or fatigue (Farage et al., 2012). The outcome of this research is the recommendations for retailers, giving them suggestions for accommodating older adult

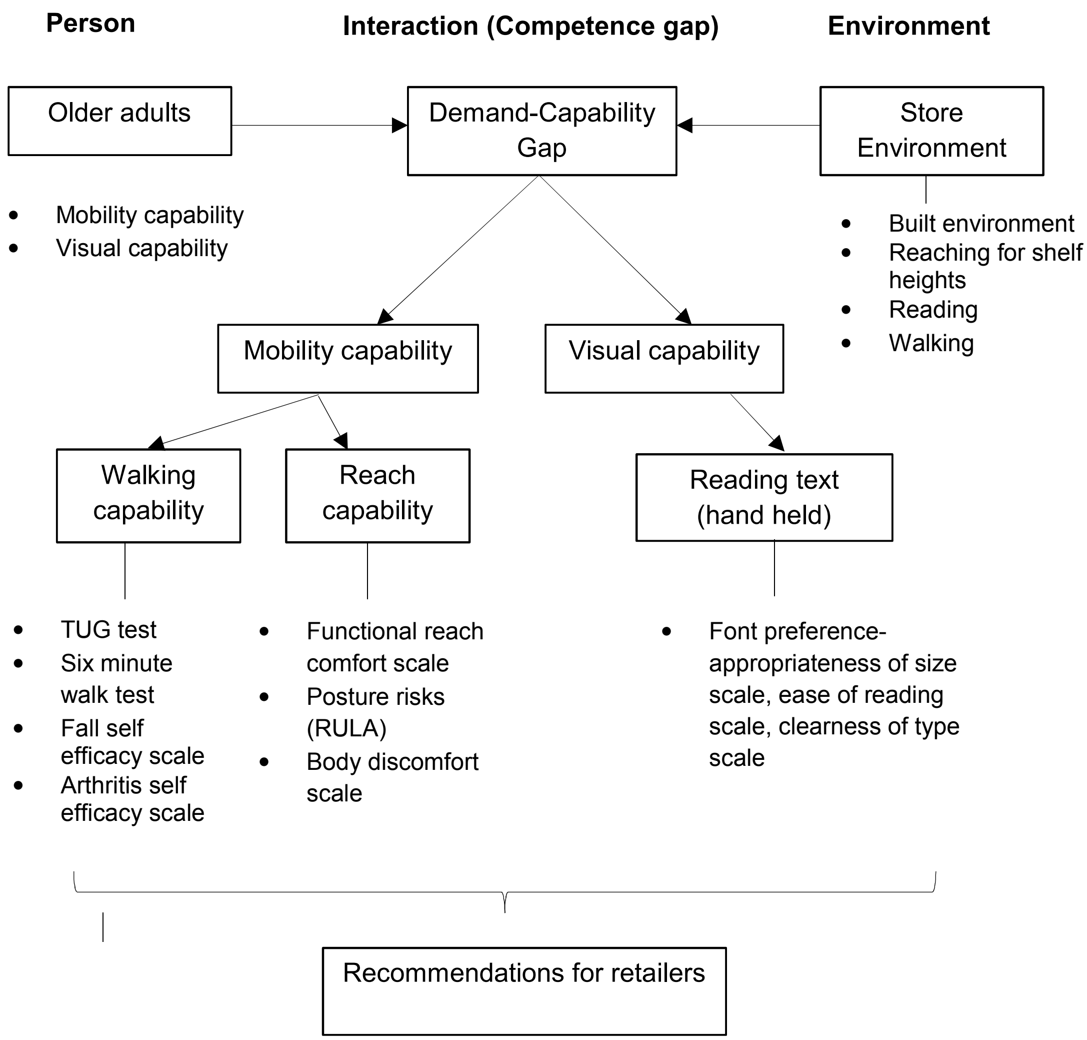

Figure 4. Conceptual Framework

Quasi-experimental research design was used in this study to measure mobility capability and visual capability of older adults. Experimental design enables the researcher to control other factors that may affect the result (Kirk, 2007). In this case, setting up mobility capability and visual capability measures in a laboratory allowed for control of external factors that may be present in an actual grocery store. IRB approval was obtained before beginning this study. Member checking was conducted after collecting and analyzing the data. Study participants were asked to either confirm or explain a reflection about their experience in light of the results (Goldblatt et al., 2011), thus supporting or challenging the research findings. Member checking is known to improve the credibility of the qualitative research (Creswell, 2000). In this research this method was used to gain contextual information about the mobility capability and visual capability of older adults while performing shopping tasks in actual grocery store.

Participant characteristics, recruitment, and screening

The study participants were female adults age 60-79 with OA, control groups being female older adults age 60-79 without OA, and female young adults age 20-30. Female participants were chosen as women have more common prevalence of OA than men, and the intensity increases with age (Cross et al., 2014; Y. Hu et al., 2017). And, research also indicates that women do majority of grocery shopping (Krishnamurti & Gupta, 2017; Morganosky & Cude, 2000; Raskind et al., 2017; Roy Dholakia, 1999). Older participants ranged in age from 61-79 with a mean age of 69 years. Young participants ranged in age from 21-30 with a mean age of 22 years. Older adults had a mean height of 5.2 inches and young adults had a mean height of 5.4 inches. The older subjects were very much like U.S female older adults whose mean height was reported to be 5.25mm and the young female subjects were also very similar to U.S. female young adults whose mean height has been reported to be 5.33 inches by National health and Nutrition Survey in 2011-2014 ("Anthropometric Reference Data," 2009). Majority of participants (90.2%) were Caucasian, 6.6% were African American, less than 1.6% were Native

Americans.

The older participants were recruited from local communities and churches, as well as grocery stores. The younger participants in age group of 20-30 years were recruited from the university campus. The criterion for selection was individuals who are able to conduct their shopping activities on their own in a grocery store. A request to participate in the study was posted via fliers in grocery stores, churches and the university campus in a Midwestern US state. Snowball sampling method played a major role in recruiting the participants. The researcher went to older adults' recreation centers, mid-day meal centers, and grocery stores to recruit the subjects for the study. Each older adult participant was offered $10 as compensation to participate in the study. Younger participants were recruited from a Midwestern University campus and received an extra credit in their course to participate. Recruitment verbiage requested the older and young adults to participate in a research project concerned with aging and independent living and also mentioned that they can deny or stop to participate in any of the performance-based tests at any time during the data collection process.

Subjects were divided according to age and mobility or vision capability. The first group was the mobility group with three subgroups: older adults with OA, older adults without OA and young adults without OA. The second group was categorized for vision in three subgroups: older adults with good vision, older adults with not so good vision and young adults with good vision. Vision was screened by Snellen near vision chart and older adults with vision 1.0 and 0.8 were included in this study. Older adults with vision lower than 0.8 were excluded to control for the effect of poor vision on readability of the font type and font size. Older adults were in the age group of 60-79 years, because OA conditions peak at this age and cause mobility limitations (Cushnaghan & Dieppe, 1991) and young adults were in age group 20-30 years. The participant groups with no OA and good vision were recruited to provide contrast in reach and reading capabilities of older adults (Table 3 and table 4). The total sample was 60 participants, with 40 older adults and 20 young adults. The sample size was chosen to be 20 for each group, as the literature on older adults with performance-based mobility and visual measures have used sample sizes of 10 and above and have indicated valid and reliable results (Dean, Richards, & Malouin, 2000; Ng & Hui-Chan, 2005; van Hedel, Wirz, & Dietz, 2005; Wirz et al., 2005). All groups were administered self-reported perceived mobility measures and performance-based measures in a laboratory setting.

Table 3.

Participant groups for mobility capability and visual capability measures

Groups	Older adults with OA	Older adults without OA	Young adults without OA
Older adults with good vision (Snellen 1.0)	10	10	
Older adults with not so good vision (Snellen 0.8)	10	10	
Young adults with good vision (Snellen 1.0)			20
Total participants	20	20	20

Table 4.

Participant groups mean and standard deviation

	Older adults	**Young adults**
Mean Age (years), standard deviation	70 +/- 2.9	21 +/- 0.97
Height (feet)	5.2 +/-1.2	5.4 +/-1.9
Standard error	0.06	0.11
Average US women height (feet)	5.2	5.3
Standard error	0.40	0.50

The research subjects were screened for OA and vision for this research and were divided into three groups. Group 1: older adults with OA (age 60 -79 years), Group 2: older adults without OA (age 60-79 years), and Group 3: young adults (age 20-30 years). Group 1: were older adults with OA. They had previous diagnosis of OA of hip or knee by a medical specialist, should be of age 60 years until 79 years of age. Participants should be community dwellers and able to shop for their needs in the grocery store. In addition to this they should sign the informed consent. Group 2 and 3 comprised of participants in age group of 60-79 years and 20-30 years without OA. They should also be independent community dwelling individuals with no active health problems and should be shopping for their groceries in grocery store. In addition to this, they signed the informed consent. The exclusion criterion was anyone not matching the required age criterion. Older adults using an assistive device, in a wheel chair or those who could not walk independently were excluded.

Data Collection Protocol

Data collection took place in a laboratory at a Midwestern University where simulations of a grocery store were created. The protocols for measuring capability of older adults in a grocery store environment were designed according to task-based research that was used to assess these difficulties while performing different tasks (Clark et al., 1990b; Morganosky & Cude, 2000). Task-based research has been supported in the literature to study the difficulties in performing the specific tasks in a given environment and then redesigning the environment to support the task performance (Clark et al., 1990b; Morganosky & Cude, 2000). In the current study, specific tasks related to grocery store shopping were created to measure mobility and visual capability of older adults. Several simulations were created for the following grocery store tasks: 1) reaching for products on shelves, 2) reading product labels, and 3) mobility capability while shopping in the store were created.

To understand the demand and capability gap while performing these tasks, two simulations were created (A and B) in the laboratory. Simulation A was created according to measurements of a national grocery store and simulation B was according to universal design recommendations for older adults (Farage et al., 2012). To set up simulation A, a national grocery store was chosen as it has uniform display fixtures, like shelves, all over U.S. The grocery store was visited and measurements for shelf heights were recorded. Simulated shelves with heights as per the national grocery store measurements were created in the laboratory. Various tests were conducted to measure reach capability of older adults to these shelves. Similarly, visual simulations of font type and font sizes were created from fonts on product labels and wash care labels of national brands. Simulation B was created in accordance with universal design principles suggested in the literature for older adults (Gassmann & Reepmeyer, 2011) and functional reach measures of older adults from the literature (Duncan et al., 1992; M. R. Lin et al., 2004; Newton, 2001). Universal design advocates for thoughtfully designing products, communication material and physical environment to meet needs of all ages. In this study, universal design principles of accessibility and low effort were used. According to the universal design principle of accessibility, products should be accessible for expected range of body size, posture, and mobility; whereas the universal design principle of low effort states that the product or environment should be usable comfortably with minimal strain or fatigue (Farage et al., 2012). Unfortunately, to the best of researcher's knowledge there is no literature on suitable shelf heights for older adults. So, the heights of shelves were set as per measurements of functional reach from the literature. Visual capability was assessed by reading text in font size and font types chosen as per the guidelines in literature about visual presentation for older adults (Farage et al., 2012).

The choice of a laboratory environment to create these grocery store tasks led the researcher to control for other factors like distraction from other shoppers while measuring the performance-based tasks, privacy issue for the participants, etc. in the actual grocery store. The protocol for data collection is described in Figure 5. Subjects were divided into groups after screening for OA and vision. Snellen near vision scale was used for vision screening. Participants with Snellen near vision rating of 1.0 and 0.8 were considered for this study. Older adults with vision lower than 0.8 were excluded to control for the effect of poor vision on readability. The participants signed an informed consent to participate in the study and then completed a survey with demographic questions (Newton, 2001; Stamm, Pieber, Crevenna, & Dorner, 2016) and health status (WOMAC, SF-36, arthritis self-efficacy and fall self-efficacy scales). After completing these questions all groups proceeded with performance-based tests.

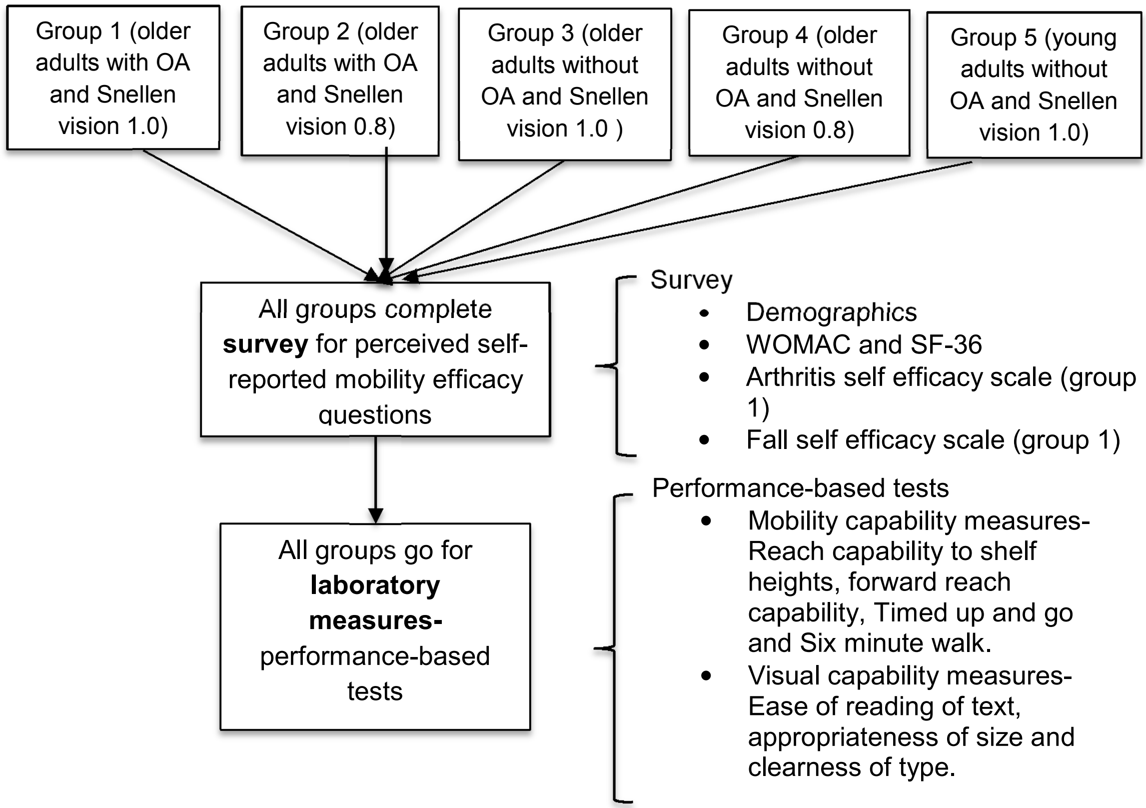

Figure 5. Protocol for data collection

Survey

The survey was designed to measure demographic variables and perceived mobility efficacy measures. Demographic variables measured were- age, gender, education level, race, household size, and language spoken in the family. In addition to these, participants were asked about if they were ever diagnosed with arthritis, or heart problems, number of medications they take, if they use any assistive device to walk, if they have tripped or fallen in the past six months, and where and with whom they like to shop for their groceries. Further to demographics were questions about perceived mobility efficacy. Perceived mobility is an individual's recognition of their ability to perform a behavioral task (Peel, Baker, Roth, & Brown, 2005; Webber et al., 2010a). Walking and climbing stairs are the major difficulties reported by older adults age 65 years and older with OA (Shunway-Cook, Patla, Stewart, & Ferrucci, 2002). Perceived mobility was assessed with the *Western Ontario and McMaster Universities Osteoarthritis Index WOMAC* and *Short form SF-36* health survey questions (Bombardier et al., 1995; Hawker, Melfi, Paul, Green, & Bombardier, 1995). WOMAC has been found to better measure knee problems in older adults with OA (Hawker et al., 1995), and SF-36 questions measure generic functional status. WOMAC and SF-36 scales together have been found to provide a comprehensive assessment of functional outcomes (Bombardier et al., 1995; Hawker et al., 1995).

The WOMAC (Appendix B) was used for OA patients to measure pain, stiffness and physical functioning. WOMAC consists of 24 questions in subscales of pain (5 questions), stiffness (2 questions) and physical functioning (17 questions) (N Bellamy, Buchanan, & Goldsmith, 1988; Nicholas Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988). Perceived mobility was assessed using WOMAC - physical functioning subscale. The reliability and validity of WOMAC is well established by previous studies (N Bellamy, 1989, 1997; N Bellamy & Buchanan, 1986; N Bellamy et al., 1988; Nicholas Bellamy et al., 1988; N Bellamy et al., 1997; Ehrich et al., 2000; Lequesne, 1991).

SF-36 is a 36-item scale that measures eight parameters of health: physical functioning, social functioning, bodily pain, role limitations due to emotional problems or physical problems, mental health, vitality and general health perceptions. WOMAC and SF-36 together have been known to be effective measures of functional, social and health status of older adults with OA (Hawker et al., 1995; McHorney, Ware, Lu, & Sherbourne, 1994). SF-36 scale has been shown to have good construct validity, test and retest reliability (Brazier et al., 1992; Hawker et al., 1995; McHorney, Ware Jr, Lu, & Sherbourne, 1994; McHorney, Ware Jr, & Raczek, 1993). In addition to this, since each older adult is different and has different health conditions, using SF-36 to measure the eight parameters of health enabled the researcher to control other health factors and study the influence on mobility limitations of older adults.

Self-efficacy is the belief in one's capacity to organize the cognitive resources and execute actions required to achieve goals (Bandura, 1991; Rejeski et al., 1996). *The arthritis self-efficacy scale* (Lorig, Chastain, et al., 1989) was used to measure self-efficacy of older adults for managing mobility and pain. This measurement has three subscales: The pain self-efficacy (PSE) subscale that consists of 5 questions, the function efficacy subscale (FSE) that consists of 9 questions and other efficacy subscale consisting of questions on managing fatigue, frustration and activity levels that consists of six questions. Test-retest reliability and validity has been established for this scale (Bandura, 1990; Lorig, Chastain, et al., 1989; Nicholas, 2007). The *modified fall efficacy scale* (MFES) (Hill, Schwarz, Kalogeropoulos, & Gibson, 1996) was used to measure self-efficacy of maintaining balance while walking. MFES has been found to be a reliable and valid measure of self-efficacy, and it could be used for comprehensive assessment of older adults with balance disturbance and mobility capability (Hill et al., 1996).

Laboratory Measures

Mobility capability. To understand the mobility capability holistically, the performance-based measures and self-reported perceived mobility measures (Figure 6) were studied together. Self-reported perceived mobility measures were measured using survey and are described in above section. A range of performance-based tests including 1) reach capability to various shelf heights, 2) forward reach capability, 3) walking capability were administered in laboratory.

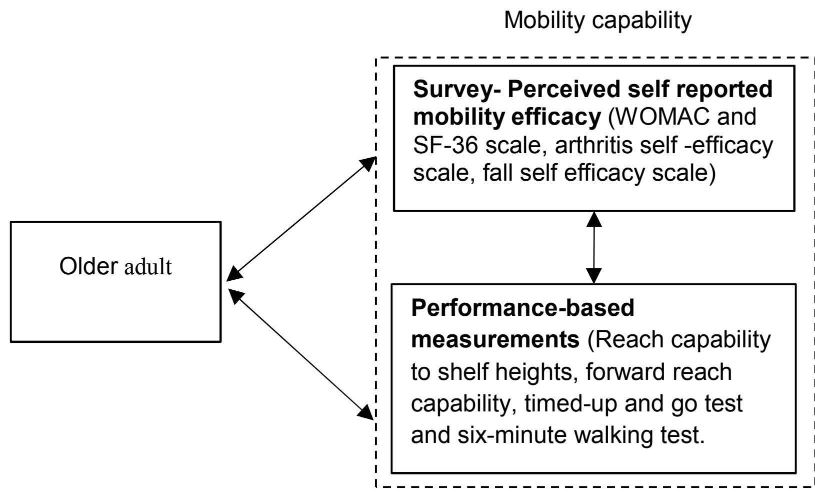

Figure 6. Measures used to identify mobility limitations of older adults with OA

While shopping inside the grocery store, there are various places like packaged goods on shelves where the shopper has to bend, pull forward or stretch the body to grab the product. Previous studies qualitatively indicate that older adults face difficulty in reaching for products on the higher shelves and in deep freezers (Pettigrew, Mizerski, & Donovan, 2005). Yet, there are no studies that test the functional reach capability of older adults to various shelf heights to find those that are most comfortable for them. Older people tend to lose height and weight with age; hence decreasing their functional reach (Duncan et al., 1992). So, this measure was designed to test the reach capability of older adults to various shelf heights.

Nine experimental shelf height conditions were set up in the laboratory. Shelves numbered 1-6 (73 inches, 57 inches, 42 inches, 30 inches, 15 inches, 4 inches from floor) were set up according to shelf heights in a national grocery store and shelves numbered A-C (57 inches, 37 inches, 23 inches from floor) were set up according to heights specified in universal design literature for older adults. Influence of reduced functional reach on picking up products from different shelf heights was measured by triangulated measures to increase the validity of the results (Figure 7) including: 1) comfort scores for shelves in simulation A and B and 2) body discomfort for shelves in simulation A and B and 3) Assessing postural load while reaching for products on various shelf heights using rapid upper limb assessment (RULA) method.

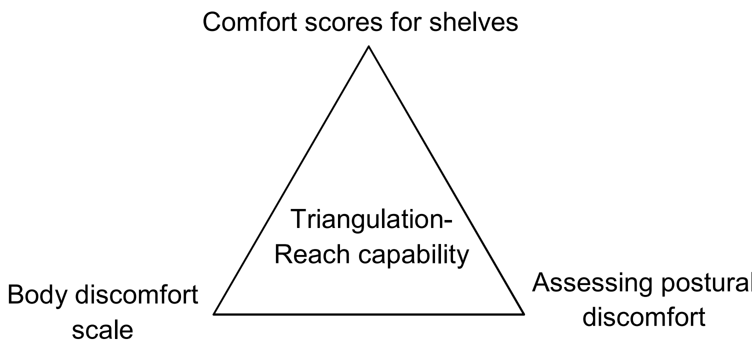

Figure 7. Triangulation for measuring reach capability

Materials for this test included an adjustable metal shelf unit and nine different shelf heights were adjusted according to the requirement. A random grocery product was kept on each shelf height. Wal-Mart donated a shopping cart for this study. Participants used this cart to keep products picked from the shelf while performing functional reach tasks. Positions for taking pictures for posture angles were marked on floor using masking tape.

During this test participants were shown all shelf height arrangements and were explained that, "the purpose of this setup is to find out optimum shelf heights that would be comfortable for you to reach." They were then briefed about the three measures being used for this study, a) assessing postural discomfort b) comfort scale for each shelf height c) posture angles for each shelf height and then were randomly allocated to a shelf height to start. Each participant picked up a grocery item from each shelf height and placed it in the shopping cart beside them. They then marked their postural discomfort on a body part diagram and rated each shelf height on a seven-point comfort scale. While they were reaching out for products the researcher stood on the pre-marked position and clicked pictures of their posture.

Human body part diagram was used to measure discomfort experienced by participants while reaching out to pick products from all nine-shelf heights. Human body diagram (Corlett and Bishop, 1976) with numbered body part was presented to participants and they were asked, "Imagine you are shopping in a grocery store. Now you should reach to each shelf, pick up one grocery item, keep in the shopping cart, and indicate on the diagram the body area or areas where you experienced discomfort while reaching out for products." There was an option to check mark for no discomfort (Figure 8a and 8b).

Figures 8a. Participant performing reach capability measure to lower shelf height

Figure 8b. Participant performing reach capability measure to higher shelf height

After completing body part discomfort scale participants were instructed to rate their comfort level to reach each shelf height on a scale of 1-7 where 1 being extremely comfortable and 7 being extremely uncomfortable. Functional reaches were randomly assorted for all nine-shelf heights and each older adult performed functional reach for all nine shelves but in randomly assorted height sequences (Figures 9 and 10). Height of participants was also recorded and was taken as control variable while looking at observations of comfort levels.

Postural angles can be used to quantify posture. Comparison values of posture angles for different participants will yield significant information regarding their posture. RULA assessment was used to determine risky postures while performing reach to various shelf heights. This gave information about exposure of older adults to risk of fall and developing upper extremity MSD.

The forward front functional reach test (Newton, 2001) measured the reach of older adults in forward directions. Participants were asked to stand against the wall and use their arm for measuring the maximum reach. A yardstick or a measuring stick one-yard long was used and it was placed at subjects' acromion or highest shoulder point level. Before the test process, the yardstick was leveled so that it was horizontal to the floor. Older adults lifted and outstretched their arm to their shoulder height. At this point, an initial reading was taken at the starting point of index finger. Then, instructions were given: "without moving your feet or taking a step, reach as far as possible and keep your hand along the yardstick." The measurement of the end point of the index figure was recorded. The difference between start and end point of the index finger of the out stretched arm represented the total reach in forward direction. The feet should be flat at the floor and if feet moved, the trail will be discarded. The participants could use their typical strategy to accomplish the task, using their arm of choice, for the forward task. This test was taken from a study by Newton (2001), who measured the limits of stability in older adults.

Walking ability of older adults plays an important role while completing shopping for daily needs. Walking ability was measured by the timed-up-and-go (TUG) test, and six-minute walk test. SMW test and TUG test are validated measure used in research to measure walking ability of older adults (Camarri, Eastwood, Cecins, Thompson, & Jenkins, 2006; Ko et al., 2013; Podsiadlo & Richardson, 1991; Stone et al., 2015; Webber et al., 2010a).

TUG test is a measure of mobility and balance in older adults (Salaffi et al., 1991) It measures older adults independence in performing the daily activities that require mobility (Podsiadlo & Richardson, 1991) (see appendix A). The participants were asked to stand up from a chair with arm rests, walk 3 meters, turn, walk back and sit down quickly and safely. The validity and reliability of TUG test has been established (Salaffi et al., 1991; Schaubert & Bohannon, 2005; van Hedel et al., 2005). The test was recorded in a well-lit, low traffic indoor area with distances clearly marked. The total score was the time required to complete the whole task. The instruction to the participants was given as, " on the word 'go' stand up and walk three meters up to the marked line, turn, walk back to the chair and sit as quickly and safely as you can". Each participant practiced the activity one time before the test score was recorded.

Six minute walk test (Camarri et al., 2006; Enright & Sherrill, 1998; Steffen et al., 2002) was performed with a shopping cart and without a shopping cart to find walking capability of older adults. Wal-Mart donated shopping cart for this study. The researcher visited Wal-Mart stores two times and observed five older adults to get an approximate amount of weight they were carrying in their shopping cart. These weights were then averaged to find the amount of weight to be put in the shopping cart during the six-minute walk test with the cart. The participants were instructed to " walk as quickly and safely as you would walk in a grocery store for 6 minutes". The participants were provided with a shopping cart and they walked with and without holding the shopping cart with their hands. The hallway used for this test was well lit. Total distance travelled during 6 minutes was recorded as score for each participant.

Visual capability. Reading the labels of packaged goods is an important shopping task in a grocery store. Visual capability of older adults is known to diminish with age-related visual impairments (Lin et al., 2004; McGrath et al., 2016; Owsley et al., 1981; Sekuler & Hutman, 1980). Age related vision changes in older adults like age related muscular degeneration (AMD) and cataract cause central vision loss, blurring and clouding of views. These result in reduced visual capability while performing instrumental activities of daily living like shopping. Initial interviews with older adults revealed that they had difficulty in reading product labels, tags on garments. It is important to know the optimum size and type of font that is easily readable by older adults on product labels and other hand held reading situations while shopping. The Table 5 shows options of font size and font type that this research tested to identify which font types and font sizes are better legible to older adults. The contrast of black text on white background was used, based on universal design guidelines for older adults. The font type and size information was presented in a form of information found on a garment label and wash care label, as these are often important for a consumer to read before buying a product. This research did not focus on label design, rather the focus was to find which font size and font type has better legibility among older adults.

Table 5.

Twelve font size and font type combinations studied in this study

6	12	14	18
Brush Script MT	Brush Script MT	Brush Script MT	Brush Script MT
Helvetica	Helvetica	Helvetica	Helvetica
Century Gothic	Century Gothic	Century Gothic	Century Gothic

The 12 experimental label conditions were developed using 3 (font: Brush script MT, Helvetica, Century Gothic) X 4 (font sizes: 6, 12, 14, 18). The selection of font type and font size was based on universal design guidelines that suggest font size suitable for older adults should be 12 point and up. Size 6 font was chosen after review of product labels and wash care labels on garments. The factorial combinations of font size and type result in 12 label conditions. These conditions were made using five different set of label information- name of the brand, garment description, size, price, and wash-care instructions. The text of each label comprised of font from one of the twelve font type/size conditions. All labels discussed similar material (all had wash care label information). All text conditions were of approximately same length (an average of 28 words per label condition). The text was arranged to look like wash care label (Figure 9). The information on each label condition was equated for content. Few words were changed for each label condition to prevent the carry over effect.

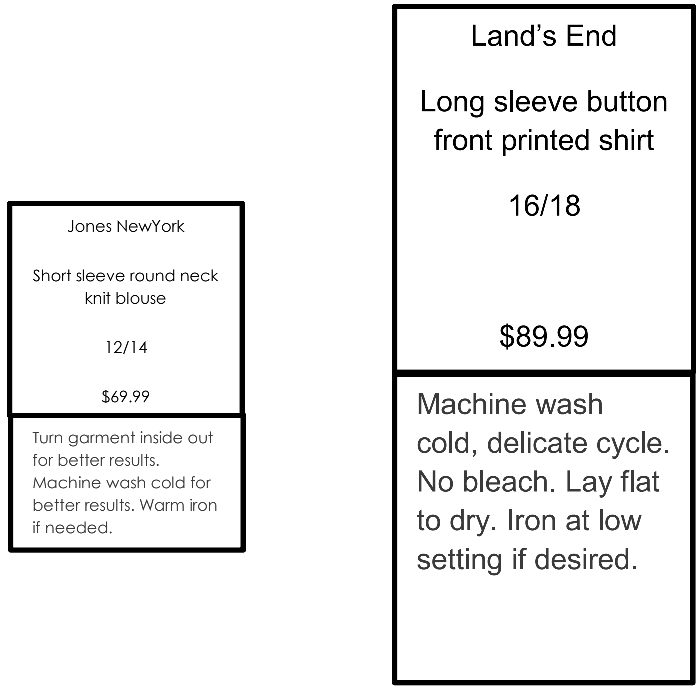

Figure 9. Examples of label conditions created for the study

Twelve experimental font type/ size conditions were printed on white letter size paper. Participants were seated in a room with light levels 50 foot-candles. This was chosen according to recommended light levels by Illuminating Engineering Society (IES) for retail to ensure adequate illumination and safety for occupants.

All participants were first screened for reading ability, cognitive function and visual acuity. Subjects should have completed minimum 8th grade, Digit symbol test of WAIS-R test should fall within normal range for their age group, and visual acuity by near vision Snellen chart should be at least 0.8 with correction glasses (if applicable). Participants were instructed to look at each label again and judge on a 7-point scale: ease of reading (very easy- very difficult), clearness of type (very sharp- not at all sharp), and appropriateness of size (too small- too large) for each font type/size combination.

Member Checking

Member checking was done after completing data collection and analysis of the results. The goal was to share the findings with the participants and give them opportunity to critically analyze the findings and comment on them. Two older adult female 69 years with OA and Snellen vision of 1.0 and 72 years old with OA and Snellen vision of 0.8 were taken to a national grocery store separately. This national grocery store was chosen as the measurements of shelf heights were taken from this store for this research. The researcher contacted the participants and requested them to meet at the national grocery store to discuss the findings. During the meeting at the national grocery store, the researcher explained the findings one by one about shelf heights, freezer depth, walking capability, font type and size. Following sequential protocol was followed for member checking: 1) Older participants were contacted and separate meeting was scheduled at the national grocery store at a Mid-Western city, 2) Researcher met each participant inside the national grocery store and accompanied her to the aisle with breakfast cereals, 3) The research findings of most comfortable shelf heights was explained to the participant by visually indicating the shelf heights 4) Then participant was accompanied to the freezer section and was presented the findings of maximum forward reach, 5) During this process, the participant walked with shopping cart filled with around 20 pounds of weight, 6) Lastly, participant was presented label conditions that were rated most preferred for ease of reading, appropriateness of size and clearness of type, 7) Study participants was asked to either confirm or deny that the findings reflect their feelings or experiences (Goldblatt et al., 2011), thus supporting or challenging the research findings. Member checking are known to improve the credibility of the qualitative research (Creswell, 2000). In this research this method was used to gain contextual information about the mobility capability and visual capability of older adults while performing shopping tasks in actual grocery store.

Data Analysis

This section describes data analysis methods used for each measure used in this study. There were two main types of measures- survey and performance based measures used in laboratory.

The survey data measured demographic variables and perceived self-efficacy measures. The collected data was imported into SPSS. Data preparation was conducted to check the data for missing values and perform necessary editing and coding. Each question was assigned specific labels. Preliminary descriptive analysis was performed using SPSS 20.0, to find out descriptive statistics and frequency distribution analysis. The data was further checked for normality and other assumptions of statistical tests like ANOVA. Next, a number of in-depth statistical analyses was applied: 1) analysis of variance (ANOVA) was used to assess between groups and within groups variation for hypothesis 1, 2, 3 and 10, 2) ANCOVA was used to measure statistically significant difference between groups – older adults with OA, older adults without OA, young adults and shelf heights on comfort scores while controlling for height of participants for hypothesis 9. 3) Correlation analysis was conducted to see any relationships between perceived efficacy measures and performance based measures for hypothesis 4, 5, 7, 8, 11, 12, 4) Interaction effects between the groups (older adults with OA, older adults without OA and young adults without OA) and visual acuity were analyzed to find interactions if any.

The laboratory data was collected and imported in SPSS. Data preparation was conducted to check the data for missing values and necessary editing and coding was done. Preliminary analysis was performed that included descriptive analysis and frequency distribution analysis. Further statistical appropriate statistical analysis (Table 5) was applied to test each hypothesis. Pictures of postures of participants were taken while they performed reach to various shelf heights. These postures were rated using validated Rapid upper limb assessment (RULA) technique. After ranking posture for each shelf height the data was imported into SPSS and then was prepared with necessary coding. Further descriptive statistics and frequency distribution analysis was conducted to analyze risky postures associated with reach performed to each shelf height. Non-parametric Friedman test was used in case normality was violated. Significance level of < 0.05 was used. Post hoc analysis was done using Tukey Honestly Significant Difference (HSD). Specifically, the analysis was employed to each hypothesis as given in Table 6

Table 6.

Analysis method for each hypothesis

Hypotheses	Analysis method
H1: Walking capability of older adults without OA and young adults will be better as compared to older adults with OA. IV: Older adults with OA, without OA and young adults DV: Walking Capability	One-way ANOVA was used to find differences in means of walking capability across groups- older adults with OA, older adults without OA and young adults without OA.
H2: Low visual acuity scores will affect the walking capability of older adults with OA more than older adults without OA and young adults. IV: Visual acuity and groups- older adults with OA, without OA and young adults DV: Walking Capability	ANOVA interaction effects between visual acuity and groups older adults with OA, without OA and young adults on walking capability.
H3: Walking capability of older adults with OA will be better with shopping cart than without shopping cart. IV: Conditions- with shopping cart and without shopping cart DV: Walking Capability	Paired t-test was used to see the variation of walking ability of older adults with OA in both conditions.
H4: Low arthritis self-efficacy scores of older adults with OA will have negative relationship with walking capability of older adults in a grocery store. Variable 1: Arthritis Self efficacy	Correlation was used to find out relationship between self-efficacy scores and walking capability of older adults with OA.

Variable 2: Walking capability	
H5: Low fall efficacy scores of older adults with OA will have negative relationship with walking ability of older adults in a grocery store. Variable 1: Fall Self efficacy Variable 2: Walking capability	Correlation was used to find out relationship between fall efficacy scores and walking capability of older adults with OA.
H6: Functional reach of older adults without OA and young adults will be better than older adults with OA IV: Older adults with OA, without OA and young adults DV: Functional reach	ANOVA was used to find differences in means of forward reach scores across groups- older adults with OA, older adults without OA and young adults without OA.
H7: Low arthritis self-efficacy scores of older adults with OA will have positive relationship with reach capability in a grocery store. Variable 1: Arthritis Self efficacy Variable 2: Reach capability	Correlation was used to find out relationship between self-efficacy scores and reach capability of older adults with OA.
H8: Low fall efficacy scores of older adults with OA will have positive relationship with reach capability inside the grocery store. Variable 1: Fall Self efficacy Variable 2: Reach capability	Correlation was used to find out relationship between fall efficacy scores and walking capability of older adults with OA.

H9: Functional reach capability of older adults with OA will be better in simulation B as compared to simulation A. IV: Simulations A, B and groups- older adults with OA, without OA and young adults DV: Functional reach Covariate: Height	ANCOVA was applied to examine reach capability variations with in older adults with OA with height as covariate.
H10: Print characteristics investigated will be significantly different for ease of reading, appropriateness of size, and clearness of type scores for older adults. IV: Print characteristics and older adults DV: Ease of reading, appropriateness of size and clearness of type	Friedman χ^2 was applied to examine variation of scores for ease of reading, appropriateness of size, and clearness of type across all print conditions.
H11: Low visual acuity of older adults will have positive relationship with forward reach scores of older adults. Variable 1: Visual acuity Variable 2: Forward reach	Correlation was used to find out relationship between visual acuity scores and forward reach scores
H12: Low visual acuity of older adults will have negative relationship with walking capability scores of older adults. Variable 1: Visual acuity Variable 2: Walking capability	Correlation was used to find out relationship between visual acuity scores and walking capability of older adults with OA.

Independent variables: The independent variables used in this study as it relates to each hypothesis can be found in Table 5. They include age (older adults with OA, older adults without OA and young adults without OA), simulation A, B, print characteristics, were independent variables for this study. Age acted as independent variable to identify differences in performance based mobility capability and visual capability measures between older adults and young adults with and without OA.

Dependent variables: Walking capability, functional reach, perceived self-efficacy, visual acuity reading preferences (ease of reading, appropriateness of size, clearness of type) were dependent variables for this study. All dependent variables with the instrument to measure are listed in Table 7. The definition of dependent variables is provided below:

- **Walking ability**: the ability to walk functionally in the community (Mudge & Stott, 2007).
- **Functional reach:** the maximal distance one can reach forward beyond arm's length, while maintaining a fixed base of support (Duncan et al., 1992).
- **Functional status:** is the ability to perform mobility tasks, instrumental activities of daily living that are essential to maintain independent living in society (Cress et al., 1995; Guralnik & Simonsick, 1993).
- **Perceived self-efficacy:** is one's belief that one can perform a specific behavior or task in future (Banciura, 1977; Lorig, Chastain, et al., 1989).
- **Visual acuity:** the clarity or sharpness of vision. (I. Bailey & Lovie, 1976; Ferris et al., 1982).
- **Reading text:** the ability to clearly read the package instructions with minor reading errors like misread a word or initially read other information (Owsley et al., 2001).

Table 7.

Dependent variables and measures

Dependent variables	Measures
Walking capability	Timed up-and-go (TUG)
Reach capability	Reach test (Newton, 2001), Likert scale for Comfort level, posture angles and assessing postural discomfort
Perceived functional status	WOMAC
Perceived self-efficacy	Arthritis self-efficacy scale (Lorig, Chastain, Ung, Shoor, & Holman, 1989) and Modified fall efficacy scale (Tinetti et al., 1990)
Perceived functional status	SF-36 (Brazier et al., 1992; Hawker et al., 1995)
Visual acuity	Snellen near vision visual acuity
Readability	Timed reading test, ease of reading scale, clearness of type and appropriateness of size scale.

Threats to validity and responsive action

There were few threats to validity that could raise questions about the experimenters' ability to conclude intervention affects the outcome and not some other factor (Creswell, 2013). The Table 8 provides a list of internal and external threats and responsive action that were taken to overcome them in this research.

Table 8

Threats to validity

Types of threat to internal validity	**Description of threat**	**In response, the actions taken to overcome the threats**
History	As the time passes during an experiment, events can occur that can unduly influence the outcome	The groups of participants experience both simulation A and simulation B
Diffusion of treatment	Participants in the control and experiment groups communicate with each other. This communication can influence how both groups score on the outcomes	The three groups were kept separate as possible as they visit tests for Simulation A and simulation B
Compensatory/ resentful demoralization	The benefits of an experiment may be unequal or resented when only the experimenters group receive the treatment	All three groups participate in tests for simulation A and simulation B
Testing	Participants become familiar with the outcome measures and modify the responses	Participants were not told exact outcome measures of the research to restrict the modification of the answers to suit the outcome. They were informed that the research was about encouraging independent living of older adults by solving the problems they might face in a grocery store
Instrumentation	The instrument change tests, thus impacting the score outcome	Same type of instruments like chairs, the walking path reading packages will be used for all the participants
Threats to external validity		
Interaction of selection and treatment	Because of narrow characteristics of participants in the experiment, the researcher cannot generalize to individuals that do not possess the characteristics of the participants	The claims from the research will be restricted to older adults with OA. Also the younger groups without OA will provide better contrast to the results for older adults with OA

Chapter Summary

This chapter presented the conceptual framework for this study followed by methods of data collection. The purpose of this research was to identify the mobility capability and visual capability of older adults while shopping to reduce the competence gap between older adults capabilities and grocery store environment. The outcome of this research was the plan for design and training intervention (DTI) module that will give guidelines to retailers on how to accommodate for mobility and visual limitations of older adults. DTI is in the form of an educational module. The following steps were taken to make a plan for DTI- 1) collecting and analyzing survey and performance-based measures data, 2) developing recommendations for retailers to accommodate for mobility and visual limitations of older adults 3) planning learning objectives and structure of module, 4) finalizing the methods of implementing the training.

CHAPTER IV

FINDINGS

Introduction

The framework of this study was inspired by the demand-capability theoretical model that suggests that disability occurs when there is a mismatch between the person's capability and the demands of the environment (Verbrugge & Jette, 1994). The purpose of this study was to assess the mobility capability and visual capability in older adults as they complete shopping for their daily needs, and then to provide suggestions to retailers about older adults' capabilities and limitations while shopping. This chapter presents findings about the demand-capability gap between demands between the retail store environment and older adults' capability. The chapter is organized in accordance with the conceptual framework of the study and contains the following sections:

- Demographics and descriptive statistics
- Walking capability of older adults and performance of shopping tasks
- Functional reach capability of older adults and performance of shopping tasks
- Visual capability of older adults and performance of shopping tasks

Demographics and descriptive statistics

Total study sample was 60 participants (Table 9 and Table 10) including older adults with OA (N=20), and older adults without OA (N=20) and young individuals without OA (N=20). The sample size was chosen to be 20, as the literature on older adults with performance-based mobility and visual measures have used sample sizes of 10 and above (Dean et al., 2000; Ng & Hui-Chan, 2005; van Hedel et al., 2005; Wirz et al., 2005). All participants were female. The study was restricted to female participants as females are major grocery shoppers and also females have higher risk of getting mobility disability with diseases like OA (Bijlsma & Knahr, 2007). In addition to this, women have more common prevalence of OA than men, and the intensity increases with age (Cross et al., 2014). All participants were screened for vision using the Snellen near vision chart and older adults (N=20) belonged to good vision category with Snellen vision of 1.0 and older adults belonged to not so good vision (N=20) category of Snellen vision of 0.8. It is important to note that older adults were allowed to wear their correction lenses as applicable. Older adults with lower than 0.8 vision were not included in this study. All young adults belonged to the good vision category of 1.0.

Older participants ranged in age from 61-79 with a mean age of 69 years. Young participants ranged in age from 21-30 with a mean age of 22 years. Older adults had a mean height of 5.2 inches and young adults had a mean height of 5.4 inches. The older subjects were very much like U.S female older adults whose mean height was reported to be 5.25 inches and the young female subjects were also very similar to U.S. female young adults whose mean height has been reported to be 5.33 inches by National health and Nutrition Survey in 2011-2014 (“Anthropometric Reference Data,” 2009). Majority of participants (90.2%) were Caucasian, 6.6% were African American, less than 1.6% were Native Americans. All participants had English as their first language. The majority of them (59%) had completed some college study, 24.6% had a bachelor’s degree and 13.1% had a master’s degree or higher. Also, a majority of participants (73.8.1%) had at least a two-person household while only 6.6% lived alone. The majority of participants liked to shop with their spouse or family member (52.5%), followed by those who preferred to shop alone (34.4%) and those who shopped with a friend (13.1%). Most of older adult participants had a preference to shop at a small grocery store (60.7%) followed by others who preferred a large department store (36.1%).

Table 9

Demographic profiles of the participants

	DEMOGRAPHIC CHARACTERISTICS	FREQUENCY (N)	PERCENT (%)	FREQUENCY (N)	PERCENT (%)	FREQUENCY (N)	PERCENT (%)
		Older adults with OA		Older adults without OA		Young adults (19-24)	
AGE							
	60- 64 years	1	5	7	35		
	65- 69 years	4	20	7	35		
	70- 74 years	8	40	4	20		
	75- 79 years	7	35	2	10		
	19-20 years					8	4
	21-24 years					12	6
ETHNICITY							
	White/ Caucasian	19	95	18	90	17	85
	Native American	0		1	5	1	5
	Black/ African American	1	5	1	5	2	10
HOUSEHOLD SIZE							
	One person	2	10	1	5	1	5
	Two people	15	75	14	70	4	20

	Three people	2	10	3	15	6	30
	Four and more people	1	51	2	10	9	45
EDUCATION							
	High school graduate	2	10	0			
	Some college credit	12	60	4	20	20	100
	Bachelor’s degree	5	25	9	45		
	Master’s degree	1	5	7	35		

Table 10

Health status of the participants

	DEMOGRAPHIC CHARACTERISTICS	FREQUENCY (N)	PERCENT (%)	FREQUENCY (N)	PERCENT (%)	FREQUENCY (N)	PERCENT (%)
		Older adults with OA		Older adults without OA		Young adults (19-24)	
HEALTH STATUS	Excellent	1	5	6	30	6	30
	Good	13	65	10	50	12	60
	Fair	5	25	4	20	2	10
	Poor	1	5	0	0		
FEAR OF FALLING							
	Yes, I am afraid	7	35	1	1		
	No, I am not afraid	13	65	19	95		
FALL							
	Yes	11	55	4	20		
	No	9	45	16	80		
SHOPPING							
	Alone	5	25	9	45	7	35
	With my spouse/ family member	15	75	11	55	4	20
	With friend	0	0	0	0	9	45

Mobility capability of older adults

To understand the mobility capability of older adults holistically, the self-reported perceived mobility measures and performance-based measures were studied together. Perceived mobility was assessed with the *Western Ontario and McMaster Universities Osteoarthritis Index WOMAC* and *Short form SF-36* health survey questions (Bombardier et al., 1995; Hawker et al., 1995). *The arthritis self-efficacy scale* (Lorig, Chastain, et al., 1989) was used to measure self-efficacy of older adults for managing mobility and pain. This measurement has three subscales: The pain self-efficacy (PSE) subscale that consists of 5 questions, the function efficacy subscale (FSE) that consists of 9 questions and other efficacy subscale consisting of questions on managing fatigue, frustration and activity levels that consists of six questions. The *modified fall efficacy scale* (MFES) (Hill et al., 1996) was used to measure self-efficacy of maintaining balance while walking.

It was hypothesized that walking capability of older adults without OA and young adults will be better as compared to older adults with OA in simulation B (Hypothesis 1). A one-way between subjects ANOVA was conducted to compare the effect of OA on walking ability (timed up-and-go scores) of older adults with OA, without OA, and young adults while completing shopping tasks. The assumptions for ANOVA including normality (p = 0.074) and homogeneity of variance (p = 0.156) were met and scores for one group were not dependent on another group. There was a significant effect of OA (Table 11) on walking ability at the p<.05 level for three groups [F (2, 57) = 57.75, p = 0.00]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for older adults with OA (M = 12.90, SD = 1.92) was significantly different (Table 10) than the older adults without OA (M = 10.57, SD = 0.96) and young adults without OA (M = 8.26, SD = 0.98). The hypothesis was supported. Seeing the significant difference in walking capability, it can be concluded that the differences between group means are not likely by chance and are probably due to OA. Older adults with OA had minimum score of 9.03 seconds and maximum of 15.52 seconds. Scores above 13.5 seconds for TUG test indicate high risk of fall. Older adults without OA had minimum of 9.05 and maximum of 12.60 seconds (Figure 10). This indicates that older adults with OA have increasing chances towards risk of fall. Taken together the results indicate that older adults with OA take a longer time to complete the walking tasks as compared to older adults without OA and young adults. Hence, shopping tasks requiring walking will pose difficulty to older adults with OA.

Table 11

ANOVA table for timed up-and-go scores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	215.15	2	107.58	57.75	.00
Within Groups	106.17	57	1.86		
Total	321.33	59			

Note: $p<0.05$

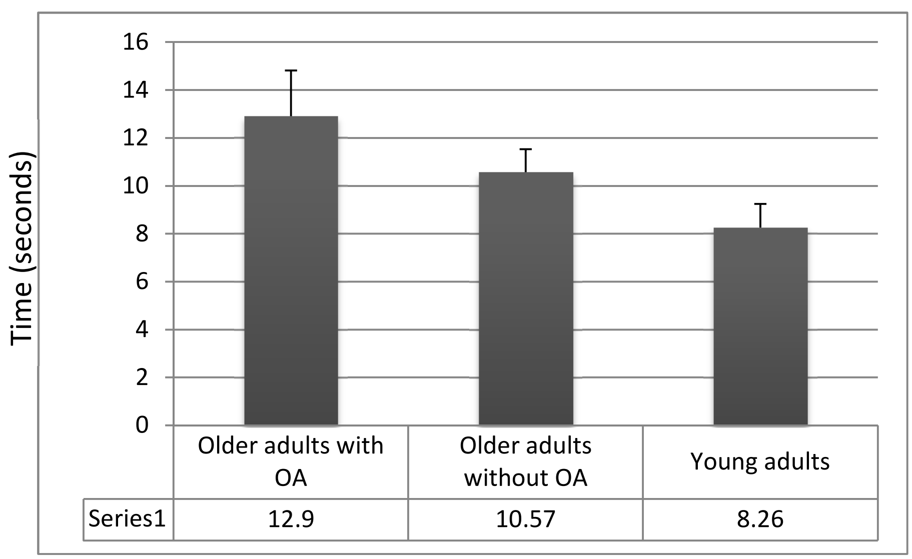

Figure 10 Timed up and go scores for groups- older adults with OA, without OA and young adults

Table 12
Descriptive statistics for TUG scores

	N	Mean	Std. Deviation	Minimum	Maximum
Older adult with OA	20	12.90	1.92	9.03	15.52
Older adult without OA	20	10.57	.96	9.05	12.60
Young adult without OA	20	8.26	.98	6.40	10.12
Total	60	10.57	2.33	6.40	15.52

Interaction effects were investigated between visual acuity scores and mobility capability of older adults. It was hypothesized that lower visual acuity scores will affect the walking capability of older adults with OA more than older adults without OA and young adults (Hypothesis 2). Visual acuity was screened for each participant using Snellen near vision test. Participants belonged to either 1.0 visual acuity or 0.8 visual acuity. Test of between subjects ANOVA was conducted to study interaction effects of visual acuity and groups-older adults with OA, older adults without OA and young adults on timed up-and-go scores. There was a significant interaction effect of visual acuity and groups on walking ability scores (Table 13) at the $p<.05$ level [F (1, 55) = 8.18, $p = 0.00$]. The hypothesis was supported in this case. Estimated marginal means for interaction between groups and visual acuity indicated that mean score of walking capability for older adults with OA and 0.8 visual acuity was higher (M=13.80) as compared to older adults without OA and visual acuity 1.0 (M= 11.55). This indicates that the group of older adults with OA and lower visual acuity took even longer to walk the distance. Hence this group might have more difficulties in walking while shopping in grocery store.

Table 13

*Interaction between Groups * Visual acuity*

Dependent Variable: TUG

				95% Confidence Interval	
Groups	Visual acuity	Mean	Std. Error	Lower Bound	Upper Bound
Older adult with OA	.8	13.80	.35	13.09	14.50
	1.0	11.56	.43	10.69	12.42
Older adult without OA	.8	10.58	.39	9.80	11.35
	1.0	10.57	.39	9.79	11.34
Young adult without	.8	.[a]	.	.	.
OA	1.0	8.26	.27	7.71	8.81

Note: a. This level combination of factors was not observed, thus the corresponding population marginal mean was not estimable.

Further, participants also performed a six-minute walk test with and without a shopping cart. The shopping cart was filled with 20 pounds of weight according to the average weight determined by observing older adults shopping in the grocery store. To do this, the researcher visited a national grocery store at three different times and observed the approximate amount of groceries bought by five different older adults. These scores were averaged to around 20 pounds of weight. It was hypothesized that walking capability of older adults with OA will be better with a shopping cart than without shopping cart (Hypothesis 3). Walking capability here was measured by shortness of breath and level of fatigue scores. Shortness of breath and level of fatigue was measured using the BORG scale before and after the six-minute walk without a shopping cart and then with the shopping cart. Paired sample T-test was conducted to compare shortness of breath in older adults with OA when walking without a shopping cart and with the shopping cart condition. Another paired sample T-test was conducted to compare level of fatigue in older adults with OA when walking without the shopping cart and with the shopping cart condition. There was no significant difference in the scores of shortness of breath in older adults with OA (Table 14) when walking without a shopping cart (M = 1.80, SD = 0.696) and when walking with a shopping cart (M = 2.05, SD = 0.68). Previous studies have found that shopping cart gives support while walking (Steenblock, 2010), so no difference in shortness of breath could be linked to the reason that shopping cart was giving a support to older individuals. Alternatively, there was a significant difference found in the scores of fatigue level in older adults with OA when walking without shopping cart (M = 1.45, SD = 0.68) and with a shopping cart (M = 2.55, SD = 0.68). Taken together the results indicate that older adults with OA felt more fatigue when walking with the shopping cart filled with weight. This fatigue could be related to getting tired by pushing a heavy object, in this case a shopping cart with weight of 20 pounds. Hence, the hypothesis in this case was not supported, as older adults with OA felt more fatigue when walking with a heavy shopping cart. Pushing heavy trolleys (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003), trolley lock not working properly, and the trolley being too deep (Yin et al., 2013) have previously been reported as problems by older adults in the literature.

Table 14

Paired sample test

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Shortness of breath without shopping cart	1.80	20	.70	.16
	Shortness of breath with shopping cart	2.05	20	.69	.15
Pair 2	Fatigue without shopping cart	1.45	20	.69	.15
	Fatigue level with shopping cart	2.55	20	.69	.15

To get a holistic view of walking capability of older adults perceived self-efficacy scores were also recorded with performance-based scores. It was hypothesized that low arthritis self-efficacy scores of older adults with OA will have negative influence on walking capability of older adults in a grocery store (Hypothesis 4). A Pearson product-moment correlation coefficient was computed to assess the relationship between the self-efficacy pain scores and timed up-and-go scores for older adults with OA. There was a negative correlation between self-efficacy pain scores and timed up-and-go scores for older adults with OA [r = -0.52, n = 20, p = 0.01]. The results (Table 15) suggest that self-efficacy affects walking capability of older adults. Hence, the hypothesis was supported. Specifically, the results suggest that when self-efficacy decreases, the older adults will have difficulty in walking and will take longer to complete the distance.

Table 15

Correlations between self-efficacy and timed up and go

		SE pain	TUG
SE pain	Pearson Correlation	1	-.52*
	Sig. (2-tailed)		.018
	N	20	20
TUG	Pearson Correlation	-.52*	1
	Sig. (2-tailed)	.018	
	N	20	20

Note. *. Correlation is significant at the 0.05 level (2-tailed).

TUG- Timed up-and-go, SE pain- Self efficacy pain score

It was hypothesized that lower fall efficacy scores in older adults with OA will have a negative relationship with walking capability scores (Hypothesis 5). A Pearson product-moment correlation coefficient was computed to assess the relationship between the fall self-efficacy scores and timed up-and-go scores for older adults with OA. There was a negative correlation between fall self-efficacy scores and timed up-and-go scores for older adults with OA [r = -0.70, n = 20, p = 0.001]. Hence, the hypothesis was supported. The results (Table 16) suggest that fall self-efficacy does have an effect on walking capability of older adults. Specifically, the results suggest that when fall self-efficacy scores decreases, older adults have more fear of falling and less confidence in walking, so the walking capability of older adults also decreases, and the older adults will take longer to complete the distance.

Table 16

Correlations between fall self-efficacy and TUG scores.

		Fall Self Efficacy OA	TUG
Fall Self Efficacy OA	Pearson Correlation	1	-.70**
	Sig. (2-tailed)		.001
	N	20	20
TUG	Pearson Correlation	-.70**	1
	Sig. (2-tailed)	.001	
	N	20	20

Note. **. Correlation is significant at the 0.01 level (2-tailed). TUG- Timed up-and-go scores.

Functional reach capability of older adults

Functional reach capability of older adults was measured with 1) maximum forward reach, 2) comfort scores for shelves in simulation A and B and 3) body discomfort for shelves in simulation A and B and 4) assessing postural load while reaching for products on various shelf heights. Shelf heights created for this experiment were – simulation A- shelf 1- 72", shelf 2- 56.5", shelf 3-42.5", shelf 4-29.5", shelf 5-15", shelf 6-4"; and simulation B- shelf A-57.5", shelf B-37.5", and shelf C-22.5". It is important to note that simulation A shelf heights were taken from measurements at grocery store and simulation B shelf heights were taken in accordance with universal design principles suggested in the literature for older adults (Gassmann & Reepmeyer, 2011) and functional reach measures of older adults from the literature (Duncan et al., 1992; M. R. Lin et al., 2004; Newton, 2001).

It was hypothesized that functional reach of older adults without OA and young adults will be better than older adults with OA (Hypothesis 6). Descriptive statistics for forward reach scores show mean score of 14.24 inches for young adults without OA, which was much higher than forward reach scores for older adults with OA (6.23 inches) and older adults without OA

(6.98 inches). A one-way between subjects ANOVA was conducted (Table 15) to compare the effect of OA on forward reach scores of older adults with OA, without OA and young adults while completing shopping tasks. The assumptions for ANOVA including normality (p = 0.061) and homogeneity of variance (p = 0.143) were met and scores for one group were not dependent on another group. There was a significant effect of OA on forward reach capability at the $p<.05$ level for three groups [F (2, 57) = 76.54, p = 0.00]. Post hoc comparisons (Table 17 and Table 18) using the Tukey HSD test indicated that the mean forward reach score for older adults with OA (M = 6.23, SD = 1.77) was significantly different than the young adults without OA (M = 14.24, SD = 2.74) but not significantly different from older adults without OA (M = 6.99, SD = 2.17). Hence, the hypothesis was supported. Taken together the results indicate that older adults with OA have the least forward reach capability (Figure 11) followed by older adults without OA. It is important to note here that young adults have higher scores of forward reach so they can reach various places in a grocery store where older adults might have difficulty.

Table 17

ANOVA table for forward reach scores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	755.200	2	377.600	72.609	.000
Within Groups	291.226	56	5.200		
Total	1046.426	58			

Note: $p< 0.05$

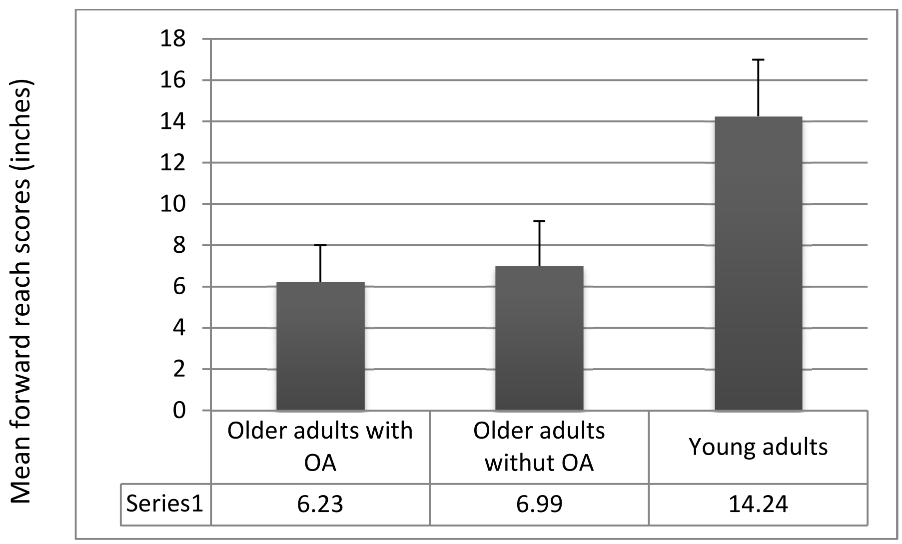

Figure. 11. Mean scores of forward reach across groups

Table 18

Tukey HSD for forward reach scores

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
Older adult with OA	Older adult without OA	-.7525	.7211	.553
	Young adult without OA	-8.0043*	.7306	.000
Older adult without OA	Older adult with OA	.7525	.7211	.553
	Young adult without OA	-7.2518*	.7306	.000
Young adult without OA	Older adult with OA	8.0043*	.7306	.000
	Older adult without OA	7.2518*	.7306	.000

Note. *. The mean difference is significant at the 0.05 level.

Forward reach scores when correlated with perceived self-efficacy scores resulted in a positive relationship between them. It was hypothesized that low arthritis self-efficacy scores of older adults with OA will have positive influence on reach capability in a grocery store (Hypothesis 7). A Pearson product-moment correlation coefficient was computed to assess the relationship between the arthritis self-efficacy pain scores and forward reach scores for older adults with OA. Forward reach scores were measured by conducting front forward reach test where participants bent forward to make maximum forward reach without losing their balance. There was a positive correlation (Table 19) between self-efficacy pain scores and forward reach scores for older adults with OA [$r = 0.923$, $n = 20$, $p = 0.000$]. The results suggest that self-efficacy does have effect on forward reach capability of older adults. Hence, the hypothesis was supported. Specifically, the results suggest that when self-efficacy decreases, the forward reach capability of older adults also decreases and they will have difficulty in reaching forward to pick up item from the shelves.

Table 19

Correlation between self-efficacy and forward reach scores

		SE pain	Forward reach
SE pain	Pearson Correlation	1	.923**
	Sig. (2-tailed)		.000
	N	20	20
Forward reach	Pearson Correlation	.923**	1
	Sig. (2-tailed)	.000	
	N	20	20

Note. **. Correlation is significant at the 0.01 level (2-tailed). SE pain- Self- efficacy pain scores

It was also hypothesized that lower fall efficacy scores in older adults with OA will have a positive relationship with forward reach scores (Hypothesis 8). A Pearson product-moment correlation coefficient was computed to assess the relationship between the fall self-efficacy scores and forward reach scores for older adults with OA. There was a positive correlation (Table 20) between fall self-efficacy scores and forward reach scores for older adults with OA [r = 0.673, n = 20, p = 0.001]. The results suggest that fall self-efficacy does have an effect on forward reach capability of older adults. Hence, the hypothesis was supported. Specifically, the results suggest that when fall self-efficacy scores decreases, older adults have more fear of falling and less confidence in walking and the forward reach capability of older adults also decreases and they will have difficulty in reaching forward to pick an item from a shelf.

Table 20

Correlations between fall self-efficacy and forward reach scores

		Fall Self Efficacy	Forward reach
Fall Self Efficacy	Pearson Correlation	1	.673**
	Sig. (2-tailed)		.001
	N	20	20
Forward reach	Pearson Correlation	.673**	1
	Sig. (2-tailed)	.001	
	N	20	20

Note. **. Correlation is significant at the 0.01 level (2-tailed).

As discussed in the methods section, simulations of grocery store shelf heights were set up in the laboratory. Simulation A was created with shelf height measurements (1-6) from a national grocery store and simulation B with shelf heights (A-C) were set up based on universal design requirements for older adults in literature. The shelf heights (Table 21) from the floor were- shelf 1- 72”, shelf 2-56.5”, shelf 3-42.5”, shelf 4-29.5”, shelf 5-15”, shelf 6-4”, shelf A-57.5”, shelf B-37.5”, and shelf C-22.5”. It was hypothesized that functional reach capability of older adults with OA will be better in simulation B as compared to simulation A (Hypothesis 9). Comfort scores for each shelf heights (1-6 and A-C) were recorded using a seven-point Likert scale. A repeated measure ANCOVA was conducted to detect statistically significant difference between older adults with OA; older adults without OA and young adults and shelf heights on comfort scores while controlling for height of participants. The results indicated that shelf heights had significantly different means for comfort scores, F (2.56) = 17.953, p = 0.00 and had high value for effect size, partial eta square of 0.391. Older adults with OA had higher estimated marginal mean score (M=3.3) indicating they found shelf heights more uncomfortable than older adult without OA (M= 2.9) and young adults (M=2.2) after controlling for height. The mean rank for comfort scales ranging from most uncomfortable to most comfortable were Shelf 6 (M=5.6), Shelf 1 (M=4.9), Shelf 5 (M=4.4), Shelf 2 (M=2.2), Shelf 4 (M=1.9), Shelf C (M=1.9), Shelf 3 (M=1.6), Shelf A (M=1.5), Shelf B (M=1.4) after controlling for height as a covariate.

Table 21

Shelf heights

Shelf numbers	**Shelf heights (inches from floor)**
Shelf 1	72”
Shelf 2	56.5”
Shelf 3	42.5”
Shelf 4	29.5”
Shelf 5	15”
Shelf 6	4”
Shelf A	57.5”
Shelf B	37.5”
Shelf C	22.5”

Note: Shelf height (1-6) were measurements from a national grocery store and shelf heights (A-C) were set up based on universal design requirements and functional reach of older adults in literature

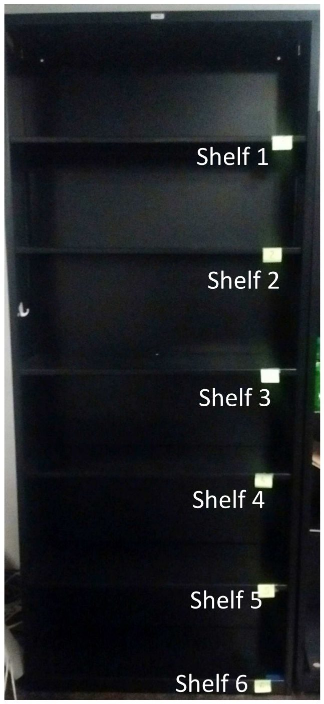

Figure 12a Shelf heights in simulation A

Figure 12b Shelf heights in simulation B

The posture adopted by older and young participants to reach various shelf heights was evaluated using RULA (McAtamney and Corlett, 1993). Photographs of participants were taken while performing the reach to all shelf heights. The posture in these photographs was evaluated by using RULA measure. Higher score of 6 and higher indicate very high risk and immediate change required, whereas score of 5-6 was a medium risk with change required soon and scores 3 and lower have low risk for musculoskeletal risk. The mean rank for RULA scores ranging from highest score to lowest score were Shelf 6 (M=7), Shelf 1 (M=7), Shelf 2 (M=6), Shelf 5 (M=5), Shelf 3 (M=4), Shelf 4 (M=3), Shelf A (M=2.55), Shelf B (M=2), Shelf C (M=2). It was interesting to note RULA scores had same mean scores for older adults with OA, older adults without OA and young adults. The highest and lowest shelf 1, shelf 2 and shelf 6 had very high musculoskeletal risk score that needed immediate change followed by shelf 3, and shelf 5 that had medium musculoskeletal risk. Shelf heights 4 and Shelf A, B, and C had very low risk posture.

In addition to comfort scores for each shelf height, participants marked areas in their body where they felt the most discomfort while reaching out to pick up items from each shelf. Frequency distribution for discomfort areas for each shelf height was made (Table 21). For shelf 1 and shelf 2 maximum participants reported discomfort on shoulders (shelf 1 (72”), 55%, shelf 2 (56.5”), 48.3%) followed by neck (shelf 1, 11.3%). For shelf 3 (42.5”) and 4 (29.5”) ‘no-discomfort’ was reported the most (shelf 3, 98.3% no-discomfort and shelf 4 76.7% no-discomfort). For shelf 5 lower back discomfort (60%) and shelf 6 lower back (45%) and knees discomfort (30%) was reported. Shelf A had no-discomfort (66.7%) followed by shoulder discomfort (25%), shelf B had no-discomfort (80%) of times and shelf C had no-discomfort (63.3%) followed by lower back and knees discomfort of (13.3%). To put it together, shelf 3 and 4 and shelf A and B were reported to have maximum no-discomfort on body parts to lift up items. In the contrary, shelf 1, 6, 2 5 had different areas of discomforts in participant’s body making it difficult to pick up items from these heights (Table 22). The shelves A, B belonged to simulation B and were found to be more comfortable than simulation A shelf heights. Hence, the hypothesis was supported.

Table 22

Shelf height versus discomfort experienced in body areas.

Shelf heights (inches from floor)	**Body areas of discomfort experienced**
Shelf 1 (72”)	Shoulder (55%) neck (11.3%)
Shelf 2 (56.5”)	No-discomfort (51.7%), Shoulder (48.3%)
Shelf 3 (42.5”)	No-discomfort (98.3%)
Shelf 4 (29.5”)	No-discomfort (76.7%)
Shelf 5 (15”)	Lower back (60%)
Shelf 6 (4”)	Lower back (45%), knees discomfort (30%)
Shelf A (57.5”)	No-discomfort (66.7%), shoulder discomfort (25%)
Shelf B (37.5”)	No-discomfort (80%)
Shelf C (22.5”)	No-discomfort (63.3%), lower back (13.3%)

Note: Shelf height (1-6) were measurements from a national grocery store and shelf heights (A-C) were set up based on universal design requirements for older adults in literature

Visual capability of older adults

Visual capability is one of the important skills to complete shopping tasks. Visual capability of older adults while shopping was measured by studying font preferences like ease of reading, appropriateness of size and clearness of type. This study used 3 x 4 (font type x font size) within- subjects design. The 12 experimental label conditions were developed using 3 (font: Brush script MT, Helvetica, Century Gothic) X 4 (font sizes: 6, 12, 14, 18). It was hypothesized that print characteristics investigated will be significantly different for ease of reading, appropriateness of size, and clearness of type scores for older adults (Hypothesis 10). Friedman χ^2 was used to measure preferences in terms ease of reading, appropriateness of size and clearness of type. Assumption of normality was violated for dependent variables ease of reading, appropriateness of size and clearness of type scores (p<0.05), so Friedman χ^2 was used to measure differences in mean of preference variables across all font conditions. The Friedman test indicated that label conditions had significantly different means for ease of reading scores, [χ^2 (11) = 546.73, p = 0.00], for appropriateness of size scores, [χ^2 (11) = 526.63, p = 0.00] and also for clearness of type scores, [χ^2 (11) = 476.93, p = 0.00] across twelve label conditions. Hence, the hypothesis was supported.

The Friedman test-ranking data revealed that most easily read label condition was label 12 (score 2.95) followed by label 11 (score 3.08), then label 7 (score 3.18) and label 8 (score 3.33). Label condition 1 (score 11.34), 5 (score 10.01) and 9 (score 9.88) were most difficult to read. Similarly, for appropriateness of size, label condition 12 (score 11.15), followed by label 8 (score 9.90), label 11 (score 9.38) were ranked higher. For clearness of type label condition 7 (score 2.99), 8 (score 3.33), 12 (score 3.38), and 11 (score 4.30) were ranked higher. To sum up the results, label condition 11, 12, 7, 8 in Helvetica and Century Gothic in size 14 and 18 were ranked higher for preferences of ease of reading, appropriateness of size and clearness of type. Table 23 describes the font and size combinations of these label condition.

Table 23.

Font type and size combinations

6	12	14	18
Brush Script MT Label 1	Brush Script MT Label 2	Brush Script MT Label 3	Brush Script MT Label 4
Helvetica Label 5	Helvetica Label 6	Helvetica Label 7	Helvetica Label 8
Century Gothic Label 9	Century Gothic Label 10	Century Gothic Label 11	Century Gothic Label 12

It was hypothesized that lower visual acuity scores in older adults with OA will have positive relationship with forward reach scores (Hypothesis 11). A Pearson product-moment correlation coefficient was computed to assess the relationship between the visual acuity scores and forward reach scores for older adults with OA. There was a positive correlation between visual acuity scores and forward reach scores for older adults with OA [$r = 0.488$, $n = 20$, $p = 0.029$]. The results (Table 24) suggest that visual acuity scores have a positive relationship with forward reach scores of older adults. Hence, the hypothesis was supported. Specifically, when visual acuity scores decreases, older adults have lower forward reach capability.

Table 24

Correlation between visual acuity and forward reach of older adults with OA

		Visual acuity	Forward reach
Visual acuity	Pearson Correlation	1	.488*
	Sig. (2-tailed)		.029
	N	20	20
Forward reach	Pearson Correlation	.488*	1
	Sig. (2-tailed)	.029	
	N	20	20

Note: *. Correlation is significant at the 0.05 level (2-tailed).

It was hypothesized that lower visual acuity scores in older adults with OA will have negative relationship with walking capability scores (Hypothesis 12). A Pearson product-moment correlation coefficient was computed to assess the relationship between the visual acuity scores and timed up-and-go scores for older adults with OA. There was a significant negative correlation with $p<0.01$ between visual acuity scores and timed up-and-go scores for older adults with OA [$r = -0.586$, $n = 20$, $p = 0.007$]. The results (Table 25) suggest that visual acuity scores have negative relationship with timed up-and-go scores of older adults. Hence, the hypothesis was supported. Specifically, when visual acuity scores decrease, older adults will have difficulty in walking; their walking time scores will increase and older will take longer time to walk the distance.

Table 25

Correlation between visual acuity and timed up and go scores

		Visual acuity	TUG
Visual acuity	Pearson Correlation	1	-.586**
	Sig. (2-tailed)		.007
	N	20	20
TUG	Pearson Correlation	-.586**	1
	Sig. (2-tailed)	.007	
	N	20	20

Note: **. Correlation is significant at the 0.01 level (2-tailed).

Member checking

Member checking was conducted after the data collection and data analysis to gain contextual knowledge about mobility and visual capability of older adults while performing shopping tasks. Member checking is known to improve the credibility of the qualitative research (Creswell, 2000). Two older adult females were randomly selected from the sample of the study and contacted for follow up study. First older women was aged 69 with OA and Snellen vision of 1.0 and another was aged 72 with OA and Snellen vision of 0.8. They accompanied the researcher to a national grocery store in Mid-western city separately. This national grocery store was chosen as the measurements of shelf heights were taken from this store for this research. The researcher contacted the participants and requested them to meet at the national grocery store to discuss the findings of the study. At the national grocery store participants were presented with findings from mobility capability tests and visual capability tests. First, the researcher accompanied her to an aisle of breakfast cereals. The research findings of most comfortable shelf heights in the range of 29.5” to 49.5” from floor were explained to the participant by visually indicating the shelf heights. The participant was accompanied to freezer section and was presented the findings of maximum forward reach of 6.23 inches. During this process, participants walked with shopping cart filled with around 20 pounds of weight. Lastly, participants were presented label conditions in Helvetica and Century Gothic in size 14 and 18 and were asked to rate the ease of reading, appropriateness of size and clearness of type. Study participants were also asked to either confirm or deny that the findings reflect their feelings or experiences (Goldblatt et al., 2011), thus supporting or challenging the research findings. The findings from member checking indicate rich contextual information and several implications (Table 26).

Table 26
Member checking results

Findings from research	Member checking results	Implications for stores
Shelf heights- most comfortable shelf heights in the range of 29.5” to 49.5” from floor	Both participants confirmed this finding and felt that this change was necessary. Some quotes, “I do not like to bend down at all, my back hurts. This shelf height range is very comfortable for me. I think this change is very much needed.”	It is necessary to adjust the shelf heights
Freezer section- maximum forward reach of 6.23 inches	Both participants confirmed this finding. Some quotes, “As you know my back hurts with bending, so this change will very good for me. I would say the product should be available without bending at all.”	Adjustment for freezer and produce section depth
Participant walked with shopping cart filled with around 20 pounds of weight. Older adults with OA felt more fatigue when walking with a heavy shopping cart	Both participants confirmed this finding and said pushing heavy trolleys was difficult for them and many times trolley wheels don’t function properly. Participant 2 preferred automated trolleys but she pointed that the freezer sections and higher aisles were difficult to reach	Adjustment for trolleys and placement of daily need products to reduce walking time
Font preference- Helvetica and Century Gothic in size 14 and 18 for ease of reading, appropriateness of size and clearness of type	Both participants rated both font conditions high on ease of reading and clearness of type. Participant 1 ranked size 14 higher for appropriateness of size as compared to size 18	Need to change the print font type and size to suit older eyes

Chapter Summary

This chapter presented results for mobility capability and visual capability of older adults while performing simulated grocery store tasks. Walking capability of older adults with OA was found to be better when walking without shopping cart, and higher fatigue levels were reported when walking with shopping cart with weight. Walking capability of older adults without OA and young adults was much better than older adults with OA. To get a holistic view of mobility capability of older adults, performance-based scores and perceived efficacy scores were considered together. It was interesting to note that when older adults had low-arthritis efficacy scores they took more time to complete the required walking task. Older adults with lower arthritis self-efficacy scores also had lower forward reach. Similarly low fall efficacy scores indicated higher fall risk and these older adults took longer to walk the distance and also had lower forward reach scores. In addition to walking, mobility capability was also assessed by functional reach capability. It was found that simulation B with shelf height measurements from functional reach literature had better comfort scores as compared to simulation A that was set up as per shelf height measurements from the national grocery store. It was worth noting that functional reach measurements of older adults were much lower than young adults, and these scores actually fell under future fall risk category. Table 27 shows a summary of results for each hypothesis.

Table 27. Result for each hypothesis

Hypotheses	Result
H1: Walking capability of older adults without OA and young adults will be better as compared to older adults with OA.	Supported
H2: Low visual acuity scores will affect the walking capability of older adults with OA more than older adults without OA and young adults.	Supported
H3: Walking capability of older adults with OA will be better with shopping cart than without shopping cart.	Not supported
H4: Low arthritis self-efficacy scores of older adults with OA will have negative relationship with walking capability of older adults in a grocery store.	Supported
H5: Low fall efficacy scores of older adults with OA will have negative relationship with walking ability of older adults in a grocery store.	Supported
H6: Functional reach of older adults without OA and young adults will be better than older adults with OA	Supported
H7: Low arthritis self-efficacy scores of older adults with OA will have positive relationship with reach capability in a grocery store.	Supported
H8: Low fall efficacy scores of older adults with OA will have positive relationship with reach capability inside the grocery store.	Supported
H9: Functional reach capability of older adults with OA will be better in simulation B as compared to simulation A.	Supported
H10: Print characteristics investigated will be significantly different for ease of reading, appropriateness of size, and clearness of type scores for older adults.	Supported
H11: Low visual acuity of older adults with OA will have positive relationship with forward reach scores.	Supported
H12: Low visual acuity of older adults with OA will have negative relationship with walking capability scores of older adults.	Supported

The test for visual capability of older adults revealed that print characteristics investigated were significantly different for ease of reading, appropriateness of size and clearness of type. Further, visual acuity scores had a positive relationship with forward reach scores of older adults. Specifically, when visual acuity scores decreased, older adults had lower forward reach capability. In addition to this, visual acuity scores had a negative relationship with timed up-and-go scores of older adults. Specifically, when visual acuity scores decreased, older adults had difficulty in walking; their walking time scores increased, and older adults took more time to walk the distance. Member checking was done with participants to confirm the validity of mobility capability and visual capability findings. The participants confirmed the findings and stressed that changes in shelf heights and print size and type were necessary in the grocery store.

CHAPTER V

DISCUSSION AND CONCLUSION

For the first time in US history, the older adult population is expected to grow to 78.0 million by 2035, exceeding children under the age of 18 by over two million (Nasser, 2018). Unfortunately, retailers are not ready to serve the older population even though shopping is an important IADL to sustain independent living. There is a need to match older adults' capabilities to the demand of the grocery store environment. With age, older adults start experiencing difficulty in walking, difficulty in moving body parts, and stretching or bending to pick up items due to musculoskeletal diseases like osteoarthritis (OA) (Costa, 2002; S. Z. Nagi, 1976; Steffen et al., 2002; Webber et al., 2010a). OA is related to age, and the most common joints affected in the body are knee, hip and hands (Helmick et al., 2008; Summers et al., 1988; Tubach et al., 2005). Knee and hip OA are leading causes of mobility disability among older adults (French et al., 2017; Litwic et al., 2013). Women have more common prevalence of OA than men, and the intensity increases with age (Cross et al., 2014; Y. Hu et al., 2017). Aging is also associated with decline in vision capability of older adults that affect their daily functions (Heesterbeek et al., 2017; West et al., 2002). When combined with vision impairment in older adults, OA is known to have exacerbating effects with further increase in difficulties in walking, personal care and other IADLs (Althomali & Leat, 2017; Fried et al., 1999; Verbrugge, 1995).

The tasks that were once easy to perform become difficult. This creates a capability gap between older adults' capabilities and demands of their environment. Research about this capability gap has been both general and sparse. If community retail stores were geared toward the physical limitations of older adults, it could increase the independence and quality of life for the growing aging population as well as boost retailers' profitability. Therefore, the current research study fills the gap in the literature regarding the accommodations that should be made in the retail store to accommodate for mobility and visual capabilities of older adults and make stores age-friendly. This chapter summarizes the study and discusses its results. Implications and limitations of the present study are presented, and recommendations for future research are discussed.

Summary of Research

The purpose of this study was to assess the mobility capability and visual capability in older adults as they perform the task of shopping for their daily needs. This study aims to provide suggestions to retailers about modifications that could be made to better accommodate older adults. The theoretical model for this study has its foundation in Nagi's disablement model and disability model by Verbrugee and Jette (1994) who describe disability as a gap between persons' capabilities and the physical environment. Disability occurs when there is a mismatch between individual capabilities and demand of the environment where the task is performed. OA is well known cause for mobility disability in older adults. This creates a demand-capability competence gap that ultimately makes the daily tasks like shopping difficult for older adults with OA. The current study explores this demand-capability gap by measuring the mobility capabilities and visual capabilities of older adults while performing shopping tasks in a grocery store environment simulation. Grocery store simulations were created in a laboratory according to measurements of a national grocery store and according to universal design recommendations for older adults (Farage et al., 2012). In addition to this, survey with demographic and perceived self-efficacy questions was also administered. The results from performance based measures at laboratory and perceived self-efficacy measures from survey were useful in examining mobility and visual capability of older adults.

Discussion of Results

Capability Gap due to Mobility Limitations. Mobility is important to active aging and is closely related to independent living and quality of life (Webber, Porter, & Menec, 2010b). Limitations in mobility can lead to limitations in performing IADLs. Walking is one of the most important activities to complete shopping tasks in a grocery store. The current research study found that older adults with OA and without OA had difficulty in completing shopping tasks, but older adults with OA had comparatively lower scores for walking capability and reach capability to the extent that they were falling under fall risk condition. Older adults with OA need more time to walk the same distance compared to their younger counterparts. If they have to walk long distances to find items (e.g., daily breakfast items and meat etc.) in the store, then this poses a challenge. Also, an interaction of visual and mobility limitations can compound challenges presented by the environment, making walking hazardous (e.g., walking long distances with heavy shopping basket in hand). As indicated by the results of this study, lower visual acuity scores affected the walking capability of older adults with OA more than older adults without mobility limitations. Also, it was found that the walking scores of older adults with OA and lower visual acuity scores were in the range of fall risk. Previous research indicates that musculoskeletal diseases like arthritis decrease the capability of older adults to move and complete the activities of daily living (Cross et al., 2014; Cushnaghan & Dieppe, 1991; Felson et al., 1987; Rejeski et al., 1996), and OA has been found to increase the difficulty in walking or climbing stairs (Guccione, Felson, & Anderson, 1990) and increase the risk of fall (Podsiadlo & Richardson, 1991; Shumway-Cook, Brauer, & Woollacott, 2000). Older adults with OA also had lower scores of perceived self-efficacy and fall self-efficacy, so this group was generally less confident in walking and has a greater fear of falling. Hence, walking long distances in large grocery stores to locate the products of need is difficult and tiring for older adults with OA and presents a potential fall hazard.

A shopping cart is an important tool to complete shopping tasks and is also expected to provide support to older adults (Fried & Guralnik, 1997). Interestingly, the current study found that older adults with OA experience more fatigue while pushing a cart. Older adults with OA reported more fatigue when walking with shopping cart filled with an average of twenty pounds of weight as compared to walking without shopping cart. Earlier research has shown that shopping carts might actually provide support to older adults because they tend to lean on it for stability (Fried & Guralnik, 1997), nevertheless, the weight of the groceries makes pushing the cart difficult, though no significant change in shortness of breath with or without the shopping cart was observed in the current study. Shopping cart problems indicated in the literature include pushing heavy carts with locks not working properly and carts being too deep (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003).

To summarize, older adults with OA have limited mobility capability to walk in the grocery store, and long walks can prove to be fall hazards. Recent research has also indicated that older adults who have lower scores of balance and fall efficacy report difficulty with grocery shopping (Johnson & McLeod, 2017). In addition to this, older adults with OA also indicated difficulty in pushing heavy shopping carts. Interestingly, young adults did not report any fatigue while pushing shopping cart with same weights. This clearly indicates the necessity to make changes in current retail store environments that are geared towards younger population (Lesakova, 2016; Moore & Conn, 1985).

Reaching for products. Body movements are required when reaching for products, and that can be difficult for older adults. In this study, mean scores for comfort levels to reach various shelf heights indicated that older adults with OA felt more discomfort to perform reach as compared to older adults without OA and young adults. In addition to this, older adults with OA indicated more discomfort in shoulder and neck for higher shelf heights and discomfort in knees and lower back for lower shelf heights where bending was required to lift an item from the shelf. It was also found in this research that older adults with lower arthritis self-efficacy scores and lower fall efficacy scores also had lower reach capability. Previous research has indicated high risk of falling in older adults while reaching up or down (Dargent-Molina, Favier, et al., 1996; Grisso et al., 1991; Li et al., 2006; Nevitt, Cummings, & Hudes, 1991). Other research has indicated that older adults have expressed fear of falling while reaching for items overhead or bending down, to the extent that they prefer not to perform this activity (Lachman et al., 1998). Hence, reaching for products kept on shelves over the head and shelves that require bending down is difficult for older adults and presents a fall hazard.

Specifically, shelf heights from 29.5 to 42.5 inches from the floor were reported to be most comfortable and also had low musculoskeletal risk posture score under RULA measure. The results also indicated fall risk for shelf heights higher than this range. Interestingly, these shelf heights are almost within an arm's length distance without raising the arm or bending the body of a persona of average height. These results also confirm with universal design guidelines for older adults that says that shelf heights should be within average human height adults (Farage et al., 2012; Gassmann & Reepmeyer, 2011). The results of this study affirm the observational research conducted by Underhill (2009) in retail environments that suggest that an "eyeball-to-knee" range is the most comfortable for older adults to reach. As discussed earlier, medical literature confirms that older adults with OA have stiff joints and have difficulty in moving their shoulders, knees and back. It is important to highlight here that large department stores like Wal-Mart have items that are often placed at heights that are both very high and very low for older adults to reach, which present areas of potential discomfort as well as a serious fall hazard. So, making older adults especially with OA conditions, reach high up or bend low is not a good proposition.

Another mobility issue for older adults relevant to grocery store shopping is forward reaching for products in a freezer or produce section. The results of this study indicate that maximum forward reach scores for older adults were much lower (6.23 inches) than young adults (14.24 inches). Literature has identified reduced functional reach as an important clinical measure that has predictive validity in identifying recurrent falls. It is noteworthy that forward reach from 6 inches to 10 inches represents a high risk of falling (Duncan et al., 1992). As indicated earlier, vision and mobility are interrelated, and the combination of limitations in these areas causes more limitations. This study found that older adults with OA has both lower visual acuity scores had lower scores for reach as compared to older adults without OA and young adults. Hence, it is important that grocery store environments not require tasks that test older adults' reach ability.

Capability Gap due to Visual Limitations

Reading package labels, medicine bottle labels, and brochures are important tasks that are usually performed in grocery stores to complete the task of shopping independently. This research examined font preference under hand-held reading conditions. The results of this study indicate that labels at a point size of 18 followed by 14 in Century gothic or Helvetica font types were ranked higher for preferences in regard to ease of reading, appropriateness of size, and clearness of type. These results confirm with universal design guidelines for older adults that says that font sizes for older adults should be minimum 12 size in Helvetica and Century Gothic (Farage et al., 2012; Gassmann & Reepmeyer, 2011). This research found that older adults better read higher font sizes 14 and 18. Interestingly, most product labels in stores, including wash care labels, were found to have a point size of 6. The results of this study show that older adults could not read the label condition in point size 6 regardless of font type. Many of them refused to read it, as they could not even see the text. Underhill (2009) has highlighted that print size in newspapers, medicine labels and many product packages range from 6 to 9 points, which make them readable by younger population but not by older population. The author further states that with a growing population of older adults, there is a dire necessity to improve the reading conditions for older adults. Previous research has also indicated that older adults performance is significantly better for medium to large font conditions than small print conditions in drug labels (Vigilante & Wogalter, 2003; Wogalter & Dietrich, 1995) and reading text on computers (Darroch et al., 2005; Kurniawan & Zaphiris, 2005). Another study on font legibility by older adults on computer screens revealed that 14-point font was more legible to read as compared to 12-point font size on computer screen (Bernard, Liao, & Mills, 2001). Even though design elements and space restrictions prompt the need for smaller font size, if the growing older adult population cannot read it, then it is not serving its purpose. This might lead to a risky situation when an older adult cannot read certain important guidelines. This calls for action from retailers and manufacturers to change the print characteristics to suit the older adults needs.

To summarize, the changes made in the retail environment to reduce the capability gap between older adults reduced capabilities and demands of the store environment will ultimately reduce dissatisfaction among older consumers. Satisfaction is an important factor in the retail environment that is often used as a measure to identify problems. Hare (2003) has done seminal work in studying satisfaction among customers in the U.K. and indicated that major areas of dissatisfaction among older consumers was in the way the stock was managed and displayed in the stores. In a similar study about older U.S. consumers, a majority of them felt food shopping was a problem for them and reported dissatisfaction of seeing labels and package sizes that were too large for older individuals. Handling shopping carts were also reported as problem, and that places to sit and rest while shopping were not available (Mason & Bearden, 1979). Further studies also report similar problems in reaching high and low shelves, reading price displays, and pushing trolleys by older adults (Celeski et al., 2017; Leighton & Seaman, 1997; George P Moschis, 2003). The current study conducted task analysis to identify solutions to reduce the capability gap between older adults' capabilities and the store environment. The implications are discussed further.

Implications

The results of this study offer contributions with a goal of decreasing the capability gap between older adults' capabilities and demands of grocery store environment. Both theoretical and managerial implications are discussed in the following.

Implications for Theory

This study makes four major contributions. First, this study broadens the theoretical research about person-environment fit in grocery store environments. Grocery shopping is vital for independent living of older adults (IADL) (Clark, Czaja, & Weber, 1990a; Fried & Guralnik, 1997), and not being able to shop for their groceries is one of the most important reasons for older adults to choose assisted care living options (Golant, 2004; Roe, Whattam, Young, & Dimond, 2001). Prior research has examined mobility in older adults from the perspective of mobility in community living (Baker et al., 2003; Fobker & Grotz, 2006), functional mobility and daily walking (Peel et al., 2005; Podsiadlo & Richardson, 1991; Shunway-Cook et al., 2002; Stone et al., 2015; Webber et al., 2010a), and functional reach and its measures (Duncan et al., 1992; Duncan et al., 1990; Newton, 2001). The present research extends this understanding of mobility capability of older adults by focusing on assessing capability of older adults while performing grocery-shopping tasks. This dissertation further examines the differences in mobility and visual capabilities of older adults with OA, older adults without OA and young adults to give in-depth understanding of differences in capabilities while performing grocery store tasks. There is a lack of research that evaluates older adults' mobility and visual capabilities with respect to the demands of a grocery store. Grocery shopping being an essential IADL, this research demonstrates that older adults' capabilities do not match the current grocery store environment, and changes should be made to reduce this gap. Researchers could further develop this research to improve other IADL conditions for older adults; like managing medications, using a phone and looking up numbers, laundry, and driving or public transport to improve independent living conditions for a fast-growing population of older adults.

Secondly this research applied demand-capability theoretical model (Verbrugge & Jette, 1994) and developed a specific older adults capability gap framework with respect to grocery store environments that could assist researchers in analyzing other areas of a grocery store for this capability gap. This will further advance the existing literature. Hence, this research has theoretical implications for the fields of consumer behavior, retailing, and gerontology by providing a theoretical basis for understanding capability gap between consumer capabilities and retail store environment.

Third, this research contributes to universal design and user-centered design based on person-environment fit theories with a goal to create environments that are suitable for greater human function. The current research on universal design for older adults (Farage et al., 2012; Gassmann & Reepmeyer, 2011) suggests general guidelines to adjust for lower trunk heights and restricted stretch capability of older adults but does not go deep into various heights that are comfortable for older adults. This dissertation applies the findings of universal design and advances the literature to specifically suggest which heights are most comfortable for older adults. Specifically, this dissertation also takes into account OA, which is the major reason for causing mobility disability in older adults.

Finally, this research has methodology implications. This research used a laboratory research methodology that is rare in merchandising research. Previous research has either used the observational method to identify issues that older adults face in retail stores (Underhill, 2009), surveys to study approach and avoidance behaviors and other issues faced by older adults in retail stores (Morganosky & Cude, 2000; Moye & Giddings, 2002; Oates, Shufeldt, & Vaught, 1996), or interviews to study older adults' perceptions of retail stores (George P. Moschis et al., 2011; Pettigrew et al., 2005). The drawback of these methodologies is that they qualitatively identify the observations in the retail store, but do not present the tested solutions to those problems. The present dissertation extends merchandising research to the laboratory, and measured mobility capability and visual capability of older adults to come up with tested solutions to the problem. The laboratory environment helped the researcher to control for many other variables that could influence the capability measure of older adults in actual retail store environments Proper care was taken while implementing the performance-based tests in the laboratory. This laboratory research methodology could be used in future merchandising task-based research to solve human problems.

Implications for Practice

The findings of this study have a number of managerial implications for retail practice. First, the results highlight the importance of understanding that older adults and young adults have different capabilities in the retail environment, and it is important to adjust the retail environment to accommodate for a growing population of older adults. Musculoskeletal conditions like osteoarthritis reduce mobility capability of older adults and put them at risk of possible fall or other injury (Boonen et al., 2004; G. Jones et al., 1994). Knee OA has been found to be independently associated with increased risk of injurious falls (Barbour et al., 2018) and fractures (Adachi et al., 2010). It is important that the shopping environment be safe to avoid any injury to fall- susceptible older population. The results of this study could be applicable to various types of retail environments where older adults have to reach different levels to acquire products or have to perform reading tasks. These could be grocery, apparel or furniture retail stores, hospitality and service industry serving older adults, airports, etc. These places could benefit by keeping products most used by older adults at heights ranging from 29.5 to 42.5 inches from the floor that were reported to be most comfortable by older adults and also had low musculoskeletal risk posture score under RULA measure. Older adults indicated in this study that many times they do not buy the items that are placed at heights requiring reaching high or bending low because of fear of falling. This result confirms previous research that has identified reaching high or bending down to reach low heights as one of the factors contributing to risk of falling (Dargent-Molina, Favier, et al., 1996; Grisso et al., 1991; Hill et al., 1996; Lachman et al., 1998; Nevitt et al., 1991; Rantz et al., 2013; Shumway-Cook et al., 2000). Hence, it is important that retail stores not require tasks that test older adults reach ability. This finding could benefit employees of the retail stores as well. The employees often perform tasks that require them to stretch high and bend low for re-shelving items in the shelves. Very high and very low shelf heights had high musculoskeletal risk scores for RULA measurement even for the young population, putting them at risk for musculoskeletal injury. Hence, adjusting the retail store environment according to the older adult population will also benefit the younger employees of the store who are performing variety of tasks in that environment.

Secondly, older adults with OA took a longer time to walk and also had walking scores falling under the risk of future fall. In addition to this, many older adults expressed that pushing the shopping cart with groceries is a difficult task for them, especially in large department stores. To avoid this, they shop in small amounts but then they have to make more trips. During performance-based tests, older adults indicated higher levels of fatigue when walking with a shopping cart filled with weight as compared to walking without shopping cart. Large department stores have sprawling stores, and daily food items like milk and dairy products are often stored at the back of the store. Looking at the results of this study and the supporting evidence from the literature, it is evident that retails stores need to rethink the placement of items of daily need. To accommodate for this reduced mobility capability of older adults, retailers should also take steps to reduce the walking distance in the store to acquire basic products. Products like dairy products, produce, breakfast, and lunch items should be kept within closer proximity to the door. This will make it easier for older adults to shop for products required for daily living. The results also indicate the need to change or possibly modify the shopping cart design. This research used a metal shopping cart from Wal-Mart. The shopping cart was reported to be heavy, and older adults found it difficult to push it with groceries. The shopping carts should maintain good steering condition, and lighter weight carts would be easier to push. This implies the need for future research on shopping carts (motorized or non-motorized), as they are an important tool to complete the shopping successfully by older adults.

Third, another area that requires utmost attention by retailers and manufacturers of products is the print characteristics on products. Previous studies have indicated better reading performance of older adults with medium and larger font sizes as compared to smaller font sizes on drug bottles (Vigilante & Wogalter, 2003; Wogalter & Dietrich, 1995) and text on computers

(Darroch et al., 2005; Kurniawan & Zaphiris, 2005). The results of the current study affirm the necessity of a change in print characteristics across all hand-held reading conditions in the retail stores like product labels, wash care labels, brochures, billing receipts, etc. that use font sizes as lower as 6 point. This study tested print characteristics on product labels and wash care labels, and the results indicate that labels at a point size of 18 followed by 14 in Century gothic or Helvetica font types were ranked higher for preferences of ease of reading, appropriateness of size, and clearness of type by older adults. The current study calls for action from retailers and manufactures to accommodate for this reduced visual capability of older adults and make changes in the print characteristics of their products to suit older eyes of this growing segment. American Foundation for Blind (AFB) guidelines for people with vision loss or impairment recommend that medicine bottles should have minimum 18 point type and they recognize that all information cannot be accommodated in large font on the bottles so to accommodate all information, duplicate labels printed on paper stock or printed pictograms are recommended. In addition to this, duplicate labels should match the medicine container by using large-print number or colored sticker on both the duplicate label and the medicine bottle (Summary of Recommendations for Pharmacists, n.d.). Similar duplicate labels could be provided inside food packages describing important content and usage information in 18 point in Century gothic or Helvetica font types to accommodate for older adults reduced vision capabilities.

Plan for DTI. The older adult population is one of the fastest growing populations in United States and in the world. Understanding needs and preferences of this population and accommodating them will give significant competitive advantage to retailers that respond proactively. This study proposes guidelines to accommodate for mobility and visual capabilities of older adults. These include comparison of older adults' and young adults' capabilities while shopping for products in a grocery store. The current grocery store environment is not older-adults friendly, and earlier researchers have also identified that there is a need of environmental change in the grocery store to suit the older adults (Pettigrew et al., 2005; Steenblock, 2010).

This research linked older adults' capabilities to an existing retail environment, and a key outcome was a plan for design training intervention module (DTI) that will aid retailers in accommodating for older adults. A design guideline suggested in this research is expected to assist retailers in designing their in-store environments to suit the needs of older adult population. The guidelines suggested are in the form of a training module (Table 28) that will have following topics: 1) description of mobility capability and visual capability of older adults, 2) comparison of capabilities of young adults and older adults while shopping, 3) proposed accommodations for mobility limitations of older adults, 4) proposed accommodations for visual limitations of older adults, and 5) post occupancy evaluation (POE) plan, that will evaluate the store environment after it has been in use to learn about effective design features (Menezes, Cripps, Bouchlaghem, & Buswell, 2012). POE is the structured process of evaluating the performance of changes made in the environment. This will be done by set of survey questions administered to the older consumers after they have experienced the changed shopping environment. The goal will be to provide store managers with valuable information regarding the in-use performance of the design changes made in the store environment. With these guidelines retail managers can aim to achieve higher levels of satisfaction among the older adult consumer segment. These changes in grocery store environments will help reduce the capability gap between older adults' capabilities and grocery store environments.

Table 28.

Training module for retailers

Module: Design training intervention for retailers	
Content	Guidelines to accommodate for mobility and visual capabilities of older adults
Objective	Acquisition of professional competency, theoretical knowledge and practical skills necessary for successful execution of changes in the store environment.
Learning results	• Increase knowledge about difficulties that older adults face due to their mobility and visual limitations. • Understand essential concepts of person- environment fit and capability gap of older adults. • Understand and compare capability differences of older adults and younger adults while shopping. • Plan and organize changes in the retail store.
Participants	Small and large grocery retailers
Method of training	Lecture/ presentations, training video
Training material	Training module syllabus, module presentation

DTI module will be disseminated through lectures and workshops organized for retailers. The first step towards this is to spread awareness about the dire necessity to change the retail store environment to suit older adult population through a call to action brochure that has been developed as an outcome of this study. This brochure will be distributed to local retail stores, kept for information in county extension offices, and shared in retail conferences.

In summary, the DTI module has an aim to ultimately make positive changes in the retail environment to reduce the capability gap between older adults' capabilities and demands of store environment. Retail managers will need to identify the areas in their stores to implement these guidelines and assess its impact upon business endeavors. The brochure was developed with a purpose to spread awareness in retail sector about the need to accommodate for older adults needs. It is expected that these recommendations will better ensure the health and independence of older adults by making shopping easier, an important IADL for independent living. Also, marketing these changes will draw attention and interest within this consumer segment. These recommendations could also be used by community-based organizations like the service industry, including sales and hospitality, to help older adults remain healthy, independent, and productively engaged by shopping for healthy food and living in their own homes and communities. Thoughtful application of the design changes will promote public health by minimizing hazards and promoting independent living of older adults.

Limitations and Future Research

This study was designed to capture mobility and visual capabilities of older adults while shopping for their needs. The researcher took into consideration walking and reaching to different shelf heights; freezer and produce section, but there could be other tasks where mobility limitations might affect one's ability to shop for groceries. The results of this study might not be applicable to all situations in a grocery store and future research is required to apply the results of this study to diverse situations in the grocery store and assess the pre- and post-impact of these changes in reducing the difficulties of older adults.

The results of this study indicated that older adults felt fatigue when pushing the heavy metal cart with their grocery weight. There is a need for further research about shopping carts design changes like lighter weight, and possibility of giving body support to older adults. Since the results also showed that older adults with OA and lower visual acuity had scores of TUG test that showed higher risk of fall, so future research could be done to explore the light and color contrast options in retail stores that work best for older adults with OA and lower visual acuity scores.

This study examined reduced mobility and visual capability of older adults. Examining effects of reduced cognitive capability in shopping environment and providing solutions to accommodate for it in retail environment would also be beneficial for the older population.

Further this study was limited to female participants, as they are an important segment of grocery shoppers and have higher rate of OA than men (Cross et al., 2014; Y. Hu et al., 2017) yet the results may be different for males, and this comparison could be interesting to look at in future studies. This research was limited to one city; thus, future research should be carried out to further validate the results of this study at different geographic locations. Lastly, the participants were classified as per their chronological age (60-79 years and 20-30 years of age). This could be a limitation as some participants might have better mobility even though they are older chronologically. Thus, future research could be done with grouping of people with biological age with similar balance, gait, strength etc.

Use of technology like a motion capture system for gait analysis, along with electromyography (EMG) to study muscle activity as individuals carry out shopping tasks could be another future research direction to pursue. Motion capture technology can be used to track human body movements in 3-dimensional space and the kinematic data could be used to calculate joint angles and velocities for different body segments as individuals carry out various shopping tasks. This data could be useful to better understand posture and mobility under different shopping scenarios.

Conclusion

The final chapter of this dissertation summarizes the main findings of this research and provides theoretical and practical implications followed by potential future research directions. The aim of this research was to examine the mobility capability and visual capability of older adults to assess the capability gap while performing shopping tasks. A laboratory experiment was created to measure this mobility and visual capability in a controlled laboratory environment. Younger adult and older adults without OA were studied as control groups to provide comparisons of mobility and visual capabilities with older adults with OA. The outcome of this study is recommendations in the form of a DTI educational module for retailers that will provide them guidelines to accommodate for older adults' capabilities. With the long-term goal of making the retail environments suitable for older adults, this research presented solutions to accommodate for reduced mobility and visual capability of older adults. Aging should not be viewed as a liability, rather it is a destiny of the fortunate (Farage et al., 2012). One of the important goals of this study was to support independent living of older adults by providing them better environment to shop for their daily food, thus, ultimately promoting public health.

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APPENDIX A

TIMED UP-AND-GO TEST

Measure a 10-foot distance from a chair and mark the point. Show this point to the individual before beginning the test.

2. If the individual wears eyeglasses or uses an assistive device such as a cane, walker, etc., they should do so while performing the test.

3. Instruct the individual to rise from a chair that has a straight back without using their arms.

4. Ask the individual to rise from the chair by stating ‘ready, set, go’ and begin timing.

5. Observe the patient as he/she walks to the mark, turns and walks back to the chair.

6. Stop timing when the patient sits back down in the chair.

7. Record the time it took the patient to complete this exercise. This is the patient’s score.

Time/Score ___________

Completion of the test in 20 seconds or less indicates that the patient is independent in activities of daily living; Time greater than 30 seconds indicates that the patient may be more dependent in activities of daily living and requires assistive devices

APPENDIX B

The Western Ontario and McMaster Universities Osteoarthritis Index

(WOMAC)

The license agreement for the WOMAC does not allow publication. More information about the WOMAC can be found at the following web address:

www.womac.org/womac/

APPENDIX C

Health Survey (SF-36)

About: The SF-36 is an indicator of overall health status. Items: 10

Reliability: Most of these studies that examined the reliability of the SF_36 have exceeded 0.80 (McHorney et al., 1994; Ware et al., 1993). Estimates of reliability in the physical and mental sections are typically above 0.90.

Validity: The SF-36 is also well validated.

Scoring:

The SF-36 has eight scaled scores; the scores are weighted sums of the questions in each section.
Scores range from 0 - 100
Lower scores = more disability, higher scores = less disability
Sections:

- Vitality
- Physical functioning
- Bodily pain
- General health perceptions
- Physical role functioning
- Emotional role functioning
- Social role functioning
- Mental health

APPENDIX D

Arthritis Self-Efficacy

For each of the following questions, please circle the number that corresponds to how certain you are that you can do the following tasks regularly at the present time.

Self-Efficacy Pain Scale (may be combined with Other Symptoms Scale)

How certain are you that you can decrease your pain quite a bit?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can continue most of your daily activities?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can keep arthritis pain from interfering with your sleep?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can that you can make a small-to- moderate reduction in your arthritis pain by using methods other than taking extra medication?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can make a large reduction in your arthritis pain by using methods other than taking extra medication?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain

Self-Efficacy Function Scale

How certain are you that you can walk 100 feet on flat ground in 20 seconds?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can that you can walk 10 steps downstairs in 7 seconds?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can get out of an armless chair quickly, without using your hands for support?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can button and unbutton 3 medium-size buttons in a row in 12 seconds?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain

can cut 2 bite-size pieces of meat with a knife and fork in 8 seconds?	
How certain are you that you can turn an outdoor faucet all the way on and all the way off?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can scratch your upper back with both your right and left hands?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can get in and out of the passenger side of a car without assistance from another person and without physical aids?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can put on a long-sleeve front-opening shirt or blouse (without buttoning) in 8 seconds?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can cut 2 bite-size pieces of meat with a knife and fork in 8 seconds?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain

Self-Efficacy Other Symptoms Scale (may be combined with Pain Scale)

How certain are you that you can control your fatigue?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can regulate your activity so as to be active without aggravating your arthritis?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can do something to help yourself feel better if you are feeling blue?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
As compared with other people with arthritis like yours, how certain are you that you can manage arthritis pain during your daily activities?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can manage your arthritis symptoms so that you can do the things you enjoy doing?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain
How certain are you that you can deal with the frustration of arthritis?	Very uncertain (1 2 3 4 5 6 7 8 9 10) Very certain

Scoring

The score for each item is the number circled. If two consecutive numbers are circled, code the lower number (less self-efficacy). If the numbers are not consecutive, do not score the item. The score for the scale is the mean of the items. If more than 25% of the items are missing, do not score the scale.

VITA

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