GUIDELINES FOR DESIGNING KITCHEN APPLIANCES

FOR THE ELDERLY

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GUIDELINES FOR DESIGNING KITCHEN APPLIANCES FOR THE ELDERLY

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FOR THE ELDERLY

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Susan Raven, daughter of Richard and Eleanor Raven, was born on October 22, 1981, in Lansing, Michigan. She graduated from Shaw High School in Columbus, Georgia in 1999. In the same year, she entered Auburn University and received a Bachelor of Mechanical Engineering in August 2003. In May 2005, she graduated with a Bachelor of Science in Environmental Design from Auburn University. She started her graduate career in May 2005 at Auburn University pursuing a Masters in Industrial Design.

THESIS ABSTRACT

GUIDELINES FOR DESIGNING KITCHEN APPLIANCES

FOR THE ELDERLY

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The number of elderly people in the United States is growing due to the baby boom. The life span of kitchen appliances is also growing due to new technologies that are developed. Since the elderly will be using their kitchen appliances longer than before, their appliances should be designed with their needs in mind.

The guidelines created in this study give specific dimensions and shapes for features such as knobs, buttons, switches, and handles. The luminance level of lights, frequency and decibel of sounds, and color and size of graphics are also given. To create these guidelines, existing control standards and the aging process of humans were analyzed.

The guidelines were applied to the design of a microwave oven.

Style manual or journal used American Psychological Association

Computer software used Microsoft Word, Adobe Illustrator, Adobe Photoshop

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I. INTRODUCTION

a. Problem Statement

Along with the growing number of elderly people in the United States, due to the baby boom, the life span of kitchen appliances is also improving because of advances in technology. Therefore, people will have the same appliances for several years. As people grow older it will be more difficult for them to use their current appliances because they were not designed with the aging process of people in mind.

Since most kitchens have several different brands of appliances, there are many inconsistencies when it comes to their features. With the creation of guidelines, the inconsistency in the kitchen is eliminated. The guidelines provide specific criteria to consider when designing, such as type of handle, size of knobs, buttons, graphics, and colors that are adaptable to aging users.

b. Need for Study

By the year 2030, there will be approximately 70 million people in the United States over the age 65 (Saxon & Etten, 2002). Due to the increase in the elderly population and the longer lives of kitchen appliances, newly designed products need to adapt to their user as they age. The guidelines show designers the existing specifications on appliances along with the modification needed for the elderly.

On July 1, 2004 the annual estimate of housing units in the United States was 122,671,734 (United States Census Bureau, 2004). There are numerous kitchen appliance manufacturers in the United States that produce several types of appliances, and they each have their own design style. Since most kitchens contain several different brands of appliances their features are inconsistent. The guidelines, when used, allow kitchen appliances to be compatible with each other and are appropriate for the targeted user. The guidelines also save designers time as they do not have to do much research to determine what is functional for the targeted user.

c. Literature Review

The number of elderly people in the United States is growing rapidly. The United States Census Bureau projected that the older population, 65 and over, will double from 36 million in 2003 to 72 million in 2030. By 2050, the older population is estimated to be 86.7 million. American Housing Survey (AHS) stated, in 2001, there were 21.8 million homes in the United States where the householder was 65 or older. According to Census 2000, 27.8% of people 65 and over live alone in the United States. Because there is such a large number of elderly couples and elderly people living alone, products in their homes should be designed with their needs in mind.

As a person ages, there are many physical changes that occur. Saxon and Etten (2002) discuss several physical and physiological changes in their book. As people grow older all of their senses become affected; these changes begin in the middle of their lives and grow gradually with age. There is an inconsistency in the rate at which people age; each person is different.

Saxon and Etten (2002) state that with age the lens of the eye becomes thicker, denser, and less elastic, therefore they become more yellow. The "yellowing filter effect" alters a person's color vision, which makes is difficult to differentiate between darker colors, such as green and blue. Cataracts, which are a common age related disorder, cause visual loss due to the gradual increase of opacity in the lens. To compensate for the changes in the eye, products designed for the elderly should use bright colors and larger print.

Hearing loss can begin in the fourth decade and it gradually worsens with age. Over half of the people over 65 and 90% of people over 80 have some hearing loss. Hearing loss usually begins with high frequencies, and then later can affect the middle and low frequencies. Because many elderly people can not hear high frequencies, alarms and timers on products should use a low frequency.

Osteoporosis, which affects many older adults, causes the bones to become porous, fragile, and brittle. Arthritis is the deterioration of articular cartilage, which exposes the ends of the bones at the joints and results in pain and stiffness. This type of pain restricts range of motion and worsens with the movement of joints. Products designed for the elderly should pay close attention to the size of handles and twisting controls.

Elderly people need stronger stimuli to activate their sensory receptors. Since the elderly are slower in receiving information through sensory receptors, they need more time to perform simple tasks, to process sensory information, and to respond.

Isle, Denno, and Metz (1992) discuss the changes that the eye goes through as it ages. The lenses of the eyes become less able to change shape and bend light passing

through them, which is reduced by as much as one-third. It also becomes more difficult to shift focus from far to near objects. The elderly become incapable of focusing on an object at a close distance. Because of the aging eye, light should be increased along with the size of graphics and lettering.

Tilley (2002) states things to consider when designing products for the elderly. Larger visual details should be used for the elderly. The eye's reaction time and disability glare doubles with age. Lights need to be brighter and illumination should be increased 20% for the elderly. An elderly person's hand strength is reduced by 16-40%. All of these criteria should be considered when designing any product for the elderly.

Burdman (1986) discusses the three major psychological concerns among the older population which are depression, dementia, and alcohol and drug related disorders. Depression can be caused by a physical illness or sensory deprivation. People with dementia are deprived the use of part of the brain that is associated with intellectual skills and activities. Alcoholism is a progressive illness which can develop over several years. Designers should consider these disorders to ensure their product has simple functions and is safe to use.

Historically, manufacturers of consumer products have made product design decisions without considering the needs, wants and expectations of the full range of consumers (DellaContrada, 2006). Since physical and psychological changes occur as a person ages, products should be designed to compensate for those changes.

There are a few products that have been designed with consideration to the elderly. Designers have developed cooking utensils especially for elderly people with arthritis, for example a knife with thicker handle so it is easier for the user to grip (Jayson

& Dixon, 1974). A wide variety of tools with "easy grip" handles are available to meet the needs of individuals who are affected by arthritis (Kelsheimer & Hawkins, 2000). Oxo's Good Grip produces kitchen utensils that have chunky, comfortable handles (Jeavans, 2005). The idea came about when Sam Farber noticed his wife, who suffered from arthritis, was struggling with her metal potato peeler (Jeavans, 2005).

TKO manufactures a turning knob operator, which is a turning device for people with hand disabilities or arthritis. The knob operator fits over existing knobs, faucets, valves, and keys and has a T-shaped handle for easy grip. Comfortable spoon and fork holders are available for people with arthritis. The plastic holder slips onto existing silverware to give a larger handle which is easier to grip.

The Rehabilitation Engineering Research Center on Technology Transfer at the University at Buffalo helps corporations produce consumer products that are more usable and accessible to all, including persons with disabilities and the elderly, such as automatic jar openers and a remote control for washers and dryers (DellaContrada, 2006). Black & Decker produces the Automatic Lids off jar opener and Whirlpool will introduce a new interactive device for washers and dryers that will enable remote operation and interaction of those appliances (DellaContrada, 2006).

Several products have been created for the kitchen specifically for the elderly, which makes it easier for them to accomplish necessary tasks. However, kitchen appliances designed with the elderly in mind were not mentioned. They are a major part of the kitchen and their design should be changed to accommodate the changes that occur in the aging process.

Other things are done in the kitchen to help the elderly work efficiently; for example, raising the oven and dishwasher six inches off the floor can make it easier to transfer food or dishes to the countertop and cuts down on bending (Winfield, 1999). Non-glare, matte finish countertops with contrasting color edging can help people with diminishing eyesight distinguish where the counter ends (Winfield, 1999). Counter heights can be varied and the installation of pull-out work spaces can provide easier access for the elderly (Hardwood Manufacturers Association, 2001).

Although there are tips for how a kitchen should be designed, several different kinds of utensils, and gadgets to accommodate the elderly, there are no kitchen appliances designed specifically for them. Since kitchen appliances are the most used thing in the kitchen, they should be designed with consider for the elderly. It is as if kitchen designers are using existing products and adapting them to the elderly, when they should be designing the products specifically for the elderly from the beginning.

The Human Factors Design Handbook by Woodson (1992) discusses a wide range of controls including resistance needed to activate along with visual and auditory displays. The criterion given is general and can be used for any product; it is not specifically for kitchen appliances. Basic dimensions of the body of males and females 70 and over in the 5^{th}, 50^{th}, and 95^{th} percentile are given. The only dimensions that are relevant to determine control specifications are the tables containing information about the hands. These dimensions alone are not enough to determine control specifications for the elderly; more specific information is needed. Even though Woodson has given this information about males and females over 70, it is not at all mentioned in the control specifications.

Woodson also discusses the strength of humans in relation to control operation. Many forces are listed for different types of movements and controls. However, nothing is said about what the force should be if the operator is elderly. Some of the forces are classified by 5^{th}, 50^{th}, and 95^{th} percentile, with this type of table it is not known who or what age group is in which percentile.

The Human Factors Design Handbook (Woodson, 1992) suggests when beginning the design process, the designer should find out who will be using the product, how they feel about its adequacy and ease with which the job can be done. This is contradictory of the information discussed above; Woodson gives human factors criteria that only focus on the "average" user, the information does not include the elderly.

Honeywell Inc. (1992) has produced Human Factors Guidelines for the Elderly and People with Disabilities. In arriving at the guidelines, specific changes that occur in the aging process are discussed, along with a wide range of physical, perceptual, and cognitive impairments, including blindness, paralysis, complete hearing loss, and severe mental retardation. Specific percentages of loss are given, which aid in arriving at the appropriate specification for the elderly. Many types of controls are given with appropriate specifications for the elderly; however, no development of the guidelines could be found. They are just listed without reason supporting those specifications. Reasoning or existing specifications should be given along with the guidelines so one can see the need for the change. It is very difficult to make guidelines that include everyone from the blind to the mentally retarded because they have completely different needs. The guidelines should focus on the normal aging process of a human to satisfy the majority of the population.

Design guidelines for kitchen appliances for the elderly need to be developed; they would be based on the aging process of humans and existing feature specifications. Generally, when products are made more accessible to people with limitations, they are usually easier for more able-bodied people to use. Some benefits include lower fatique, increased speed, and lower error rates (Vanderheiden, 1990).

d. Definition of Terms

1. alcoholism – a diseased condition caused by the excessive or continuous use of alcoholic liquors.
2. arthritis – inflammation or degenerative changes in body joints.
3. audition – the sense of hearing.
4. cataract – is a cloudy or opaque lens severe enough to interfere with light rays passing through the lenses and causing impaired vision.
5. cerumen – the wax or yellow matter secreted by the glands of the external ear.
6. compression – pressed together, make more compact by or as by pressure.
7. concave – hollow and curved like a section of the inner surface of a spherical body.
8. dementia - a syndrome of progressive and global decline in cognitive capabilities, severe enough to substantially interfere with the individual's well being and social function (age related disorder).
9. depression – low spirits, gloominess, dejection, sadness.
10. electroencephalogram (EEG) – records brainwave patterns from the continuous tiny electrical signals coming from the brain. The EEG machine then magnifies the size of

these signals, without affecting the brain, so that the information can be recorded on paper or computer.

11. gustation – the sense of taste.
12. kinesthetic – the sensation of position, movement, tension, etc. of parts of the body, perceived through nerve end organs in muscles, tendons, and joints.
13. olfaction – the sense of smell.
14. ossicle – a small bone or bonelike structure; especially, any of the three small bones in the tympanic cavity of the ear.
15. osteoporosis – gradual progressive change causing a rate of bone resorption greater than bone formation with the result that bone mass is reduced; bones become porous and more fragile but the chemical composition of the bone remains normal.
16. pinna - in anatomy, the external ear; auricle.
17. presbycusis – the gradual loss of acute hearing with advancing age.
18. pupil – the contractile circular opening, apparently black, in the center of the iris of the eye.
19. purchase – grip.
20. shear – shearing stress
21. suicide – the act of killing oneself intentionally.
22. tactile – having the sense of touch.
23. vestibular – balance.
24. yellow filter effect – yellowing of the lenses.

e. Assumptions

- Kitchen appliances are not designed to adapt to people as they age.
- Existing specifications of kitchen appliance features are not adequate for elderly users.
- Kitchen appliance features are inconsistent from brand to brand.
- Adults and elderly people have multiple appliances of multiple brands in their kitchens.
- Elderly people are only affected by the “normal aging process”.
- Overhead lighting of elderly peoples’ kitchens has not been enhanced; it is the same amount as adults’ kitchen.

f. Scope and Limits

Scope

- Aging process of humans: physically, psychologically, and acceptance of technology.
- Existing control, handle, display, and form specifications on kitchen appliances.
- Define new control, handle, display, and form specifications for the elderly using the changes that occur as a person ages.

Limits

- People in United States
- Adults age: 16-64 years old
- Elderly age: 65-79 years old

g. Anticipated Outcomes

Guidelines will be created for elderly users using existing feature specifics along with the aging process of humans. Research findings will be used to determine specifics for features such as handles, knobs, buttons, text, color, and graphics. The guidelines will outline the cross section, diameter, and length of handles. Knobs will be defined by their shape, diameter, and depth. Buttons will be specified by their shape and size. The height and color of text will be given along with the size and color of graphics.

It is expected that although features will be similar for the adult and elderly users adaptations will be needed for the elderly user such as larger graphics, brighter lights, louder sound, more color contrast, and less resistance.

II. CHARACTERISTICS OF ELDERLY

a. Physical Changes

As people age, their sensory systems are affected: vision, hearing, taste, smell, touch, balance, and muscle sense (Saxon and Etten, 2002). Sensory changes begin in the fourth and fifth decade with a gradual reduction in sharpness, but they do not appreciably limit behavior until about the seventh and eighth decade (Saxon and Etten, 2002). The measurement of the decrease in functionality of a given sensory system cannot enable one to predict an older person's unique behavior capabilities or limitations associated with the particular sensory loss (Saxon and Etten, 2002). There is significant variation among individuals in the rate of aging. The amount of loss is highly variable from one organ system to another within a given individual (Saxon and Etten, 2002). Humans can adapt and compensate for gradual changes (Saxon and Etten, 2002). Some sensory systems are more important in everyday functioning than others, for example, vision is more important than the sense of smell (Saxon and Etten, 2002). As a person ages it takes stronger stimuli to activate their sensory receptors; lights need to be brighter, sounds louder, and smells stronger (Saxon and Etten, 2002).

Eyes

The lenses of the eyes have two important functions in vision, refraction and accommodation, both of which are affected by aging (Saxon and Etten, 2002). Refraction requires crystalline clear lenses, while accommodation requires the lenses to

be elastic and able to change shape (Saxon and Etten, 2002). The lens of the eye becomes less able to change its shape and bend the light rays passing through it (Caldwell and Hegner, 1986). The decrease in the refractive power of the lens in shifting focus from far to near objects reduces from a peak of 14 diopters at 8 years old to less than 2 diopters at age 50 (Isle, Denno, and Metz, 1992). When a person reaches 60 years old their lens is incapable of focusing on an object at close distance (Isle et al, 1992). The pupil size increases as a person ages, which reduces the amount of light that enters by as much as one-third; therefore, this reduces the abilitly to detect details (Isle et al, 1992). The lenses grow with age by adding layers (Saxon and Etten, 2002). Between the ages of 20 and 80 the width of the lenses increases by 50% (Saxon and Etten, 2002). As a result, they become thicker, denser, and less elastic (Saxon and Etten, 2002). As the lenses become denser, they also become more yellow, impairing their refractive ability (Saxon and Etten, 2002). Yellowing of the lenses or the "yellow filter effect" produces changes in color vision, although many older adults remain unaware that color discrimination has altered (Saxon and Etten, 2002). Older people with distorted color perception are often able to differentiate between bright colors such as reds and yellows better than between darker colors such as blues and greens (Saxon and Etten, 2002). Color blindness tends to increase, especially among men (Caldwell and Hegner, 1986). Peripheral vision is reduced, especially in dim light (Caldwell and Hegner, 1986). Additionally, the eye's reaction time and disability glare doubles with aging (Tilley, 2002). Cataracts, the most common age related disorder of the eye, affect approximately 90% of those people over 70 and are the single most important cause of blindness in old age (Saxon and Etten, 2002). A cataract is a cloudy or opaque lens that interferes with light rays passing though

the lens and causes impaired vision (Saxon and Etten, 2002). Visual loss is due to a gradually increasing opacity of the lens (Caldwell and Hegner, 1986). The lens is originally a clear crystalline body enclosed in a capsule which changes its shape in order to bend the light rays to focus on the retina (Caldwell and Hegner, 1986). If the lens is opaque, light cannot pass through it; therefore, vision is lost (Caldwell and Hegner, 1986). For older adults, lights need to be brighter and illumination should be increased 20% (Tilley, 2002).

Hearing

Changes in a person's hearing usually begin in their fourth decade and progress gradually with age (Saxon and Etten, 2002). Approximately 60% of people over 65 and perhaps as many as 90% of people over age 80 have some hearing impairment (Saxon and Etten, 2002). Presbycusis is the most common cause of hearing loss in the older population and is caused by physiologic aging. It usually results in high frequency hearing loss and should not be diagnosed until all other possibilities are eliminated. Hearing loss often goes undetected and untreated in older adults. In our culture, men tend to have hearing loss earlier than women, partly because men generally have been exposed to more prolonged occupational noise than women (Saxon and Etten, 2002). As a person ages there are specific changes that occur in their ears. The pinna in the outer ear loses some flexibility and becomes longer and wider (Saxon and Etten, 2002). Hairs in the external ear canal become stiffer and the drying and thinning of tissues in the external ear canal contribute to a likelihood of cerumen accumulation with age (Saxon and Etten, 2002). Cerumen is ear wax that is produced in the later years and is of thicker consistency and is not always easily removed (Saxon and Etten, 2002). Cerumen in the

external ear canal is responsible for a substantial amount of hearing impairment (Saxon and Etten, 2002). Changes in the membranes of the middle ear and the ossicles impair transmission of sound vibrations but do not impair hearing significantly (Saxon and Etten, 2002). With age, auditory loss generally affects perception of high frequencies first. Later, age related changes may involve middle and low frequency ranges as well (Saxon and Etten, 2002).

Bones and Joints

Osteoporosis is the most common metabolic bone disease in older adults (Saxon and Etten, 2002). It is a gradual, progressive change causing a rate of bone resorption greater than bone formation with the result that bone mass is reduced (Saxon and Etten, 2002). The bone becomes porous and more fragile, but the chemical composition of the bone remains normal (Saxon and Etten, 2002). The porous bones eventually become fragile and brittle (Saxon and Etten, 2002).

Arthritis is an inflammation or degenerative change in body joints (Saxon and Etten, 2002). Three common types of arthritis are osteoarthritis, rheumatoid, and gout (Saxon and Etten, 2002). Osteoarthritis is the most common and leading cause of disability in those over 65 (Saxon and Etten, 2002). 85% of people over 65 have osteoarthritis (Steven, 1987). Osteoarthritis involves the progressive loss of articular cartilage, exposing the ends of the bones at the joints and resulting in pain and stiffness (Saxon and Etten, 2002). This pain restricts range of motion in the fingers and worsens with movement of the joints. To help relieve the pain, people with arthritis will often keep their fingers bent. While this temporarily relieves discomfort, holding a joint in the

same position for too long can cause permanent loss of mobility and hinder daily activities.

In a normal adult, range of motion for the distal interphalangeal joint (DIP), the outer most joint on the finger, is extension = 0 degrees and flexion = 80 degrees (Eaton, 1997). The range of motion for the proximal interphalangeal joint (PIP), the middle joint on the finger, is extension = 0 degrees and flexion = 100 degrees (Eaton, 1997). The range of motion for the metacarpophalangeal joint (MCP), the knuckle joint, is hypertension = 0 to -45 degrees and flexion = 90 degrees (Eaton, 1997). The range of motion in the fingers of someone with arthritis is severely limited; it ranges from 17 to 40 degrees for each joint (Bieber, Weiland, and Volenec-Dowling, 1986). The extension deficit average in people with arthritis is about 47 degrees (Swanson, 2005).

People with arthritis have difficulty performing every day tasks, such as opening jars, buttoning shirts, and tying shoes. An elderly person's hand strength is reduced by 16-40%. The loss of strength, manual dexterity and decrease of range of motion due to bone disease should be taken into account when designing any product.

b. Psychological Changes

With age, nervous system activities are slowed (Saxon and Etten, 2002). Older adults are usually slower in receiving information through sensory receptors, slower in transmitting, processing, and interpreting information and somewhat slower in acting upon it (Saxon and Etten, 2002). Increased time is needed for an older person to perform simple tasks and to process sensory information and to respond (Saxon and Etten, 2002). Action does not respond as rapidly to the will, and it requires greater motor impulse to

perform the act while greater mental concentration is required to obtain and hold sensory impressions (Nascher, 1979). Responding to multiple or complicated stimuli is more difficult (Saxon and Etten, 2002). It is slightly more difficult for older adults to learn new motor skills than younger people. Elderly people also need more trials to achieve the same degree of learning as a younger person (Stokes, 1992). Learning still occurs at an old age, it is just slower and more difficult. There is no serious decline in sensory information until after 70 (Caldwell and Hegner, 1986). After this time many elderly need more time to process sensory information and to respond (Caldwell and Hegner, 1986). Sensory receptors, in general, are less reactive, and stronger stimulation is needed to elicit a response.

Sleep patterns change with age (Saxon and Etten, 2002). Although older adults spend more time in bed trying to sleep, their total sleep time is less than in younger years, and the time it takes to fall asleep increases (Saxon and Etten, 2002). Frequent rest periods are mandatory (Caldwell and Hegner, 1986). They tire more easily and have little vitality (Caldwell and Hegner, 1986). Sleep deprivation and decreased nervous system response result in a decrease of cognitive function in the elderly which can limit their ability to use appliances.

Depression, dementia, and alcohol and drug related disorders are three major concerns among the older population (Burdman, 1986). Women ages 65-84 are more likely than men to have severe depression symptoms. Among people 85 and older, men and women have a similar prevalence of severe depressive symptoms, accounting for as high as 23%. The rate of depression increases with age.

Depression may be caused by a variety of factors that often represent a loss of some type to the individual (Burdman, 1986). Physical illnesses such as strokes, respiratory infections, cancers, heart disease, and arthritis are among many disorders that can induce depression (Burdman, 1986). Another source of depression in older people is sensory deprivation (Burdman, 1986). Hearing or visual loss may cause older people to withdraw from interaction with others (Burdman, 1986). Closely related to depression is a high risk for alcoholism which is known to increase with age (Burdman, 1986).

Alcoholism is usually a progressive illness developed over a period of five to twenty years (Burdman, 1986). Alcohol and other drug related problems among the elderly are increasing as the number of older people multiplies (Burdman, 1986).

Dementia is an age related disease of the brain that results in the progressive loss of mental faculties, beginning with the memory, learning, attention, and judgment (Burdman, 1986). People affected by dementia are deprived of the use of parts of the brain associated with a range of intellectual skills and activities (Burdman, 1986). It is estimated that 5% of the United States population age 65 and over is severely demented, 10% may be mildly to moderately impaired, and 85% is without the illness (Burdman, 1986). Older people with moderate or severe memory impairment ranged from about 4% among the 65-74 year olds to 36% among people 85 and older (Tepper and Cassidy, 2004). When designing appliances, consideration needs to be given to simple function and safety.

c. Reaction Towards Technology

Many older people are less exposed to new technology than a younger generation, which can make them feel intimidated (Eisma et al, 2003). As elderly grow closer to the end of their lives, they begin to have no desire to try new things (Day). They also feel that they have no need for new technologies around the house. People who are accustomed to older technologies may not be aware of the new technologies available (Eisma et al, 2003). Older people's opinions about new technology are often based on a limited number of experiences or stories that they have heard from friends or relatives (Eisma et al, 2003).

III. DEVELOPMENT OF DESIGN GUIDELINES

There are many different interactive components on kitchen appliances that require different uses of the body, such as eyes sight, hearing, and gripping. As people age their senses and function ability reduces. Therefore, products for the elderly need to have larger text, louder sounds, and decreased resistance. This section reviews existing specifications for components found on kitchen appliances. Using this information and analyzing the aging process of humans, design guidelines for the elderly are created.

a. Controls

i. Layout

Controls should be placed so they are easy for the elderly to use. We are conditioned for a top to bottom and left to right scanning (Wildbur, 1989). Thus, the simplest way to group controls is in a continuous line either vertically or horizontally (Wildbur, 1989). Sequential operations should flow smoothly by placing controls in close proximity (Corlett and Clark, 1995). The grouping of five controls in a horizontal arrangement is ideal as the eye can easily make the choice between the one in the center, which acts as a datum, and those to the left and right (Wildbur, 1989). Beyond five controls, errors of selection increase rapidly (Wildbur, 1989). In terms of vertical stacking, two or three rows are the most that should be used, giving a matrix of 10-15 units (Wildbur, 1989). Arrange controls of similar function together (Wildbur, 1989).

Where there is no natural sequence of operations or where some of the controls will be used infrequently, group the controls into areas or zones designated by use or function or define them by color or background (Wildbur, 1989). Each control should have only one function and the number of controls must be kept to a minimum (Peterson, 1998). Controls should be easy to read and operate, with high contrast and redundant cuing or cues that are audible, tactile and visual (Peterson, 1998). Sufficient clearance should be provided between adjacent controls so that critical controls can be easily grasped and manipulated (Woodson, 1992). Arrange related controls in same area, sequence of use—left to right, top to bottom, most frequently used in the most convenient place, emergency controls—where the operator does not have to search or reach for control (Woodson, 1992). The size and shape of handles, knobs, and buttons should be compatible with the size of the operator's hand (Woodson, 1992). The shape of a control should also be compatible with the kind of grip or motion required to operate the control interface (Woodson, 1992). The control should be chosen as though it were an extension of the operator's limb (Woodson, 1992). Create displays that are easy to read and interpret, as opposed to displays that are merely attractive and/or startling to look at. Avoid decorative displays, it hurts readability and interpretation. The more complex the display, the more time it takes to read and interpret the information provided by the display, and the more apt the operator is to misinterpret the information or fail to use it correctly. Some key issues for labels are legibility, size in relation to viewing distance, illumination, clarity of meaning, and location.

ii. Force

Force is exerted more effectively when the hand and handle are in compression rather than shear (Pheasant, 1996). It is better to exert a force perpendicular to the axis of a cylindrical handle than along the axis (Pheasant, 1996). If controls are used for a short amount of time, their resistance should be high (Ivergard, 1989). If controls are used for a long period of time they should have a low resistance (Ivergard, 1989). The resistance should increase gradually and then disappear when the button is activated (Ivergard, 1989). Controls that require dual motion, such as pressing down and turning, are difficult for many people to use (Ivergard, 1989). Controls must have enough resistance to prevent their activation by mistake and be designed to handle misuse (Ivergard, 1989). In an emergency situation very high forces are often applied and the control must be able to withstand these (Ivergard, 1989).

iii. Round Knobs

Round knobs can be found on ovens and toasters. A circular knob implies that the knob turns continuously and makes it easier for the operator to reposition his or her fingers for multi-turn manipulation (Woodson, 1992). If knobs have to be very small in diameter, they should be deeper and have serrations (Woodson, 1992). If a precise knob rotation is required, the knob should be large enough so that all the user's fingers and the thumb can be placed on the knob rim and/or surround the knob edges if considerable torque is required (Woodson, 1992).

For adult users, the minimum dimensions of a round control knob are 0.25" diameter and 0.75" depth (Woodson, 1992). This size knob should include serrations and should have 2-4 in-oz of resistance (Woodson, 1992). The preferred minimum round knob diameter is 0.5" diameter and 0.5" deep with serrations (Woodson, 1992). Four in-oz of resistance is the maximum for this size knob (Woodson, 1992). As the diameter of the knob increases the resistance also increases because the knob will be easier to grip (Woodson, 1992).

Since most elderly people have arthritis, the range of motion in their hands becomes limited as well as their hand strength. Figures 1, 2, and 3 illustrate the difference in range of motion of the finger joints for normal adults and elderly adults.

Figure 1: DIP Range of Motion

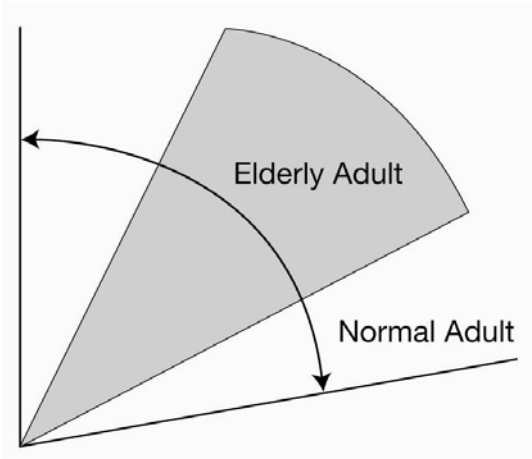


Figure 2: PIP Range of Motion

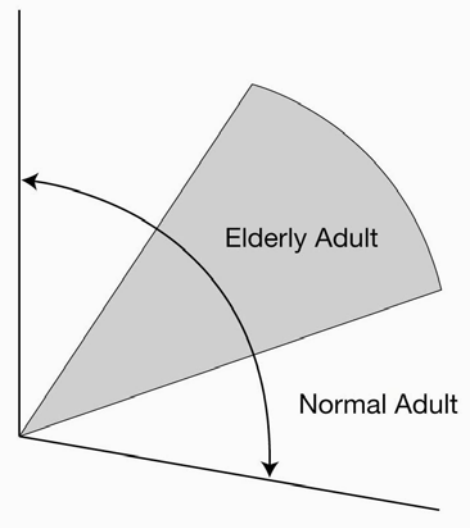


Figure 3: MCP Range of Motion

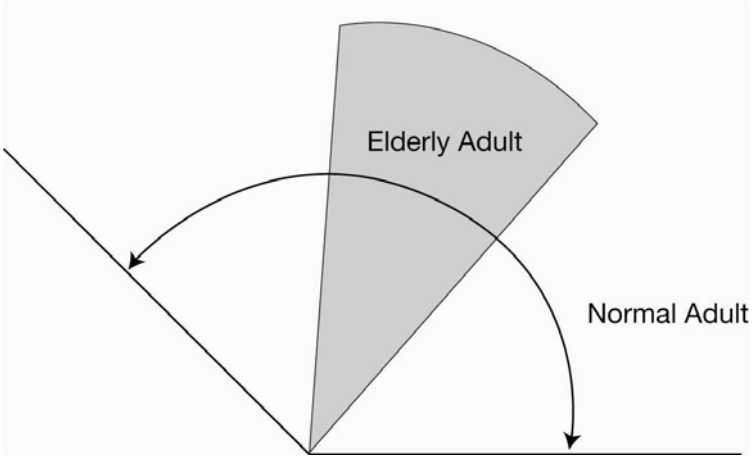
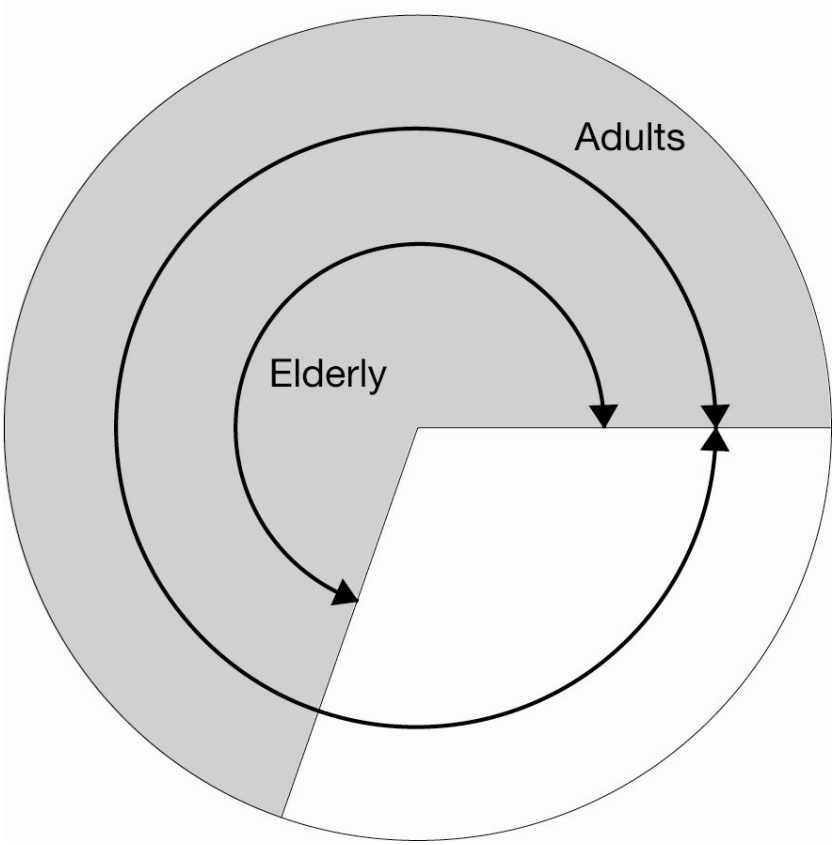


Figure 4: Hand Strength: Adults vs. Elderly

Figure 4 shows the difference in hand strength for adults and elderly.



Due to the limited range of motion and the hand strength of the elderly, the diameter of round knobs should be increased along with a decrease in resistance. Round knobs for the elderly should be serrated and have a diameter of 1”-2” and a depth of 0.5”-0.75”. Since hand strength of the elderly reduces 16-40% (Tilley, 2002), the resistance for these knobs should be no more than 3 to 6 in-oz.

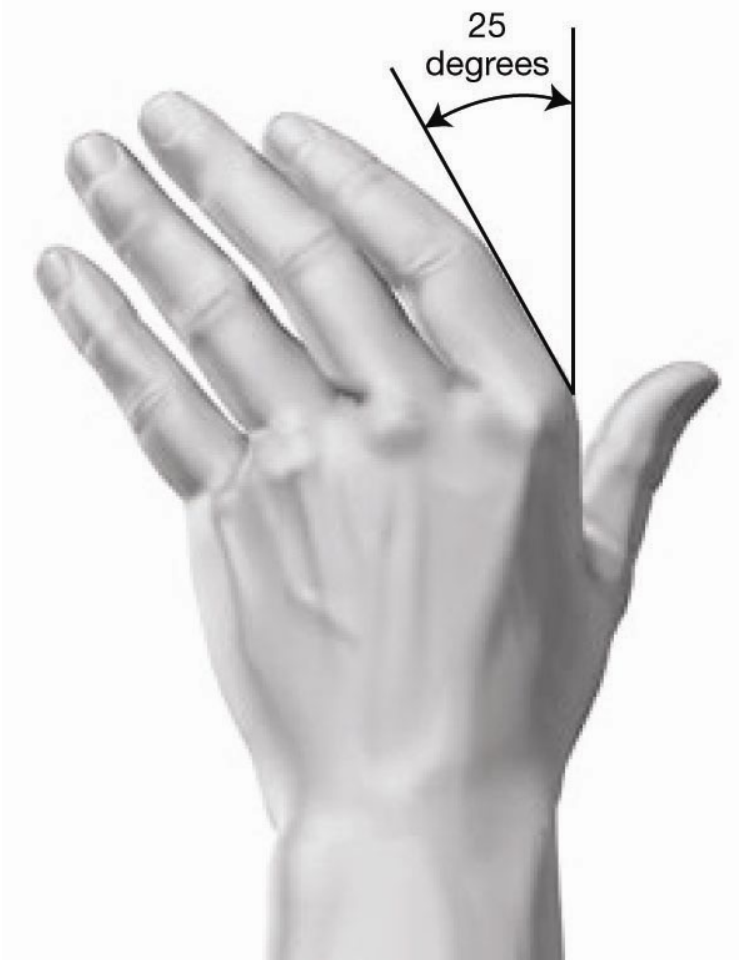
iv. Pointer Knobs

Pointer knobs can be found on ranges, ovens, coffee makers, and toaster ovens. A pointer knob implies that it is a positioning control that can be positioned in discrete increments (Woodson, 1992). Knobs with indents let the operator "feel" that the knob is properly positioned (Woodson, 1992). A pointer knob with a sloped point allows for a better view of the pointer tip, therefore fewer mistakes would be made (Woodson, 1992). Pointers should move right, up, or clockwise to indicate a value increase (Woodson, 1992). Knobs with moving pointers should be used over knobs with moving scales because they are easier to read (Ivergard, 1989).

For adult users, the length of the pointer knob is between 1"-2". The width is between 0.25" and 0.5" and the height is 0.5" (Woodson, 1992). The torque required to turn a pointer knob is 10 to 45 in-oz (Woodson, 1992).

Figures 1 through 3, which show joint range of motion, Figure 4, which illustrates hand strength of adults and elderly, and Figure 5, which illustrates the average ulnar drift for an elderly person with arthritis, are considered in the development of the new specifications for pointer knobs. Having an ulnar drift and limited range of motion makes it difficult to grip a pointer knob; therefore, the width of the pointer should be enlarged to 0.5"-0.75". The length of the pointer should be between 2"-3"; this length allows more fingers to grip the knob. The height of the knob should be 0.75" to ensure enough contact with the control. The resistance needed to turn this size pointer knob should be between 6 in-oz and 27 in-oz.

Figure 5: Ulnar Drift



Bieber, Weiland, Volenec-Dowling, 1986.

v. Press buttons

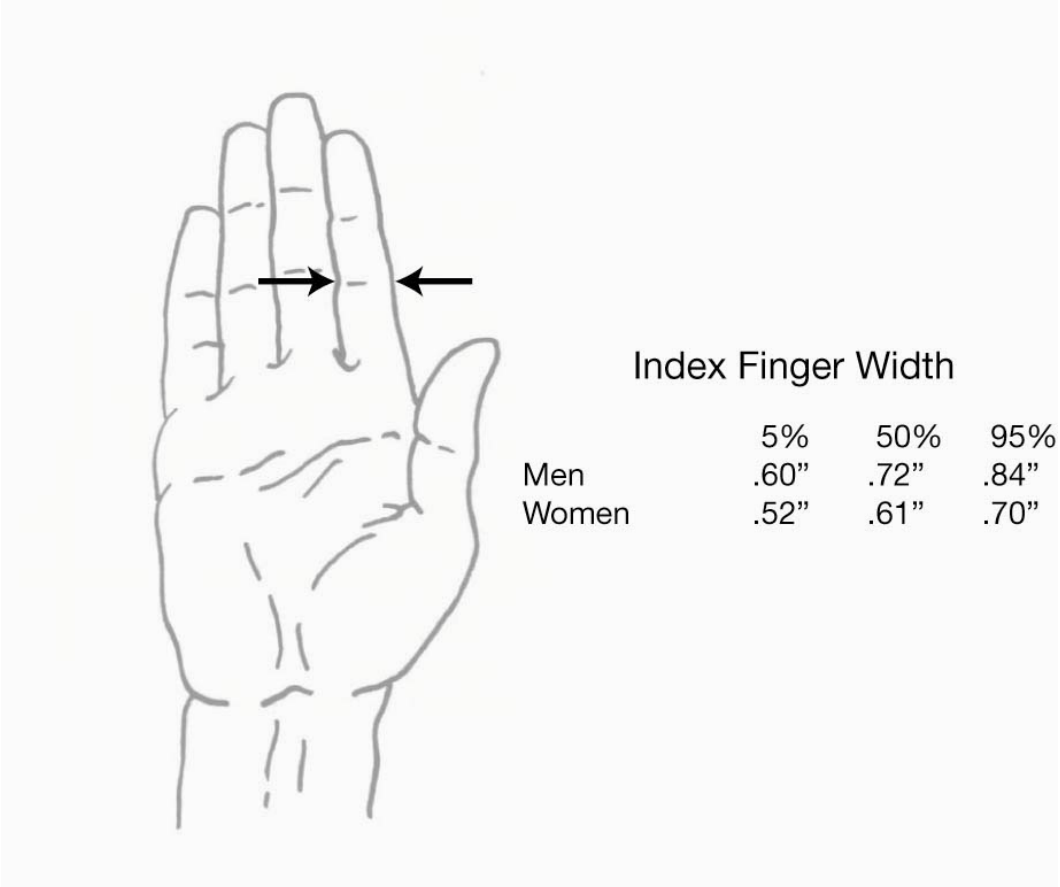
Press buttons are suitable for starting and stopping or for switching on or off and are found on ovens, blenders, and coffee makers (Ivergard, 1989). In order to indicate

the button has been activated, some kind of feedback should be emitted, either a sound or light (Ivergard, 1989). Press buttons should be designed so that the fingers will not slide off them (Ivergard, 1989). The surface should be made concave or have some form of increased friction (Ivergard, 1989). A press buttons is an effective emergency control device for shutting off machines in a hurry (Woodson, 1992). In this type of application the button should be larger so the operator does not have to very accurate when pressing the button (Woodson, 1992).

For normal users, the smallest diameter for a press button should be no less than 0.25" (Woodson, 1992). If the press button is 0.75" or larger in diameter, it should have a concave top (Woodson, 1992). When press buttons are placed in a row horizontally or vertically, the distance between them should be 0.1875" (Woodson, 1992). The average resistance for a press button is between 10 and 20 in-oz (Woodson, 1992).

Table 1, which displays the index finger width for men and women in the 5^{th}, 50^{th}, and 95^{th} percentile, is considered when arriving at the correct press button diameter for the elderly. The diameter should be between 0.5" and 0.75" for elderly users because the majority of the users' index finger will fit on the button. This size press button should be concave, so the user's finger will not slide off. The distance between press buttons should be increased to 0.25" to ensure the correct placement of the finger on the button. Since the hand strength of an elderly person is reduced, the resistance needed to activate a press button should be between 6 and 12 in-oz.

Table 1: Index Finger Width



Index Finger Width

	5%	50%	95%
Men	.60”	.72”	.84”
Women	.52”	.61”	.70”

Tilley, 2002.

vi. Toggle Switches

Toggle switches make good controls as they provide feedback of the movements made. A two position toggle switch is better than one with three positions because of the limited distance between positions (Woodson, 1992). The maximum range of movement for a toggle switch is 60 degrees. There are different types of toggle switches; the most common has a spherical end and tapers down as it gets closer to the product (Woodson, 1992). One has a skinny cylindrical rod to toggle; another has a round ball on the end and a cylindrical rod connecting it to the product (Woodson, 1992). The last toggle switch has a flat top and bottom, which allows for better grip on the switch (Woodson, 1992). If a number of toggle switches are used they should be placed in a horizontal row (Woodson, 1992). Toggle switches can become dangerous if they are too long (Woodson, 1992).

For normal users, the most common type of toggle switch is used. The minimum length of the switch is 0.5" while the maximum is 2" (Woodson, 1992). The tip of the switch can range from 0.125" to 1" in diameter (Woodson, 1992). If toggle switches are lined up horizontally, the minimum distance between them is 0.75" while 2" is optimum (Woodson, 1992). The resistance required to control a switch is 10 in-oz for a small switch and 40 in-oz for a large switch (Woodson, 1992).

A toggle switch that has a flat top and bottom should be used for elderly users because their fingers will be less likely to slip off the switch. To determine the length of the switch, Table 2 was used, which shows the hand length for elderly men and women in the 5^{th}, 50^{th}, and 95^{th}.

Table 2: Hand Length of Elderly

Hand Length of Elderly

	5th%	50th%	95th%
Men	6.29”	7.08”	7.67”
Women	5.71”	6.49”	7.08”

Tilley, 2002.

The index distal phalanx is 8.6% of the hand length in men and women (Davidoff and Freivalds, 1993). Using that and the hand lengths shown above, the average index distal phalanx is between 0.49” and 0.65”. Therefore, the flat end of the toggle switch should be 0.5” to 0.625” long and 0.375” wide. The width of the toggle switch is more than half the index finger width in all but one percentile from Table 1. Since it is not necessary to grip the toggle switch to operate it, the height of the flat switch should be 0.125”. Toggle switches lined up horizontally should be separated by at least 1” to ensure the wrong switch is not hit by mistake. Toggle switches designed for the elderly should have 9 to 12 in-oz of resistance.

vii. Contact Switches

Contact switches, which are used on microwaves, dishwashers and ovens, give no 3-dimensional feedback (Woodson, 1992). This type of switch should not be used for critical functions (Woodson, 1992). If this type of switch is used, clear visual or auditory feedback should be provided (Woodson, 1992). Clear graphic delineation of switch boundaries and graphic distinction between switches and purely visual displays should be used (Woodson, 1992). Contact switches are very useful where frequent cleaning is necessary (Woodson, 1992).

For normal users, the standard size of a rectangular contact switch ranges from 0.5” x 0.5” to 0.625” x 0.75”. A rectangular contact switch that ranges from 0.5” x 1” to 0.75” x 1.25” is used for “Start” and “Cancel” buttons. Circular contact switches are also used, which are 0.5” in diameter. These types of switches require 1 to 5 in-oz of force to operate (Woodson, 1992).

The index distal phalanx length calculated above and the index finger width from Table 1 are used in obtaining the size of the contact switches for the elderly. The height of the switch should be 0.625", and the width should be 0.875". This size will accommodate the length and width of the index distal phalanx. The size of the "Start" and "Cancel" buttons should be at least 0.625" in height, and the length should be between 1" and 1.25". If a circular contact switch is used, the minimum diameter should be 0.625", which accommodates the length of the index distal phalanx. The resistance needed to operate these types of switches should be reduced to 3 in-oz. Because there is no 3-dimensional feedback with this type of switch, a light or sound should be associated with the activation of a switch.

viii. Rocker Switches

Rocker switches can be found on coffee makers, ovens, blenders, and mixers. They are a good substitute for toggle switches because they provide a good physical indication of the switch position (Woodson, 1992). Since toggle switches protrude out, things can easily be snagged on them (Woodson, 1992). 30 degrees of travel by the switch is recommended (Isle, 1992). Rocker switches should snap into position with an audible click (Woodson, 1992).

The majority of rocker switches found on kitchen appliances are oval, and their height ranges from 0.5" to 1"while their width ranges from 0.625" to 1.5". The circular switches ranged from 0.5" to 0.625" in diameter. The square shaped rocker switches found were 0.375" x 0.5". Some rocker switches had red of green lights to indicate when

the switch had been activated. The force needed to activate a rocker switch is 10-40 in-oz (Isle, 1992).

An oval shaped rocker switch should be used for the elderly. A circular rocker switch does not give enough room for the user's finger to fit on the switch. The square rocker switch has hot spots on the corners of the switch, which are not comfortable to its users. Table 1, which gives the finger width of men and women, was used to determine the size of oval rocker switches. Rocker switches for the elderly should range between 0.5" to 0.625" in height and 1" to 1.25" in length. To ensure the grip the surfaces should be concave. Having an activation light would cause less confusion during operation. A rocker switch designed for the elderly should have a resistance between 6 and 16 in-oz.

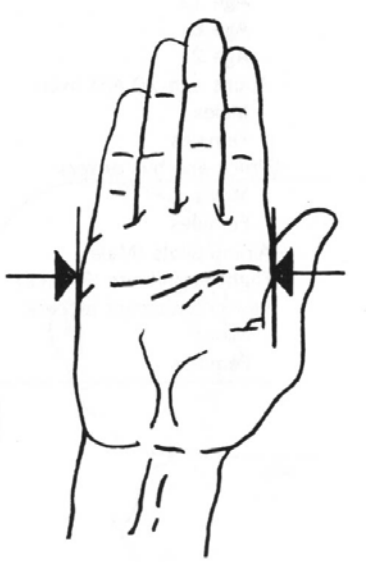
ix. Toaster Lever

Toaster levers are what the user pushes down to begin toasting. On existing toasters, the levers ranged from 0.875" to 3.125" wide and 0.75" to 1.25" deep.

Toaster levers designed for elderly should be large enough so that a couple of their fingers will fit on the lever. This will ensure control over the lever and will reduce slippage. To arrive at the proper width of the lever, Table 3, which shows the hand breadth for men, women, and elderly men, was used. Table 3 says that the hand breadth of a 95th% elderly man is 3.6". The lever does not need to accommodate all fingers; a lever that can fit two to three fingers is sufficient. The width of the lever should be at least 2" and get larger if desired. To arrive at the depth of the lever the index distal phalanx length was used, which was calculated from Table 2. The index distal phalanx ranges between 0.49" and 0.65"; therefore, the depth of the lever should be around 0.75".

This distance ensures that the 95th% elderly man's fingers will fit on the lever with extra room between the fingers and the toaster.

Table 3: Hand Breadth



Hand Breadth

		5th%	50th%	95th%
Adults				
	Men	3.1"	3.4"	3.8"
	Women	2.7"	3.0"	3.4"
Elderly				
	Men	3.1"	3.3"	3.6"
	Women	-	-	-

Tilley, 2002.

x. Feedback

Controls must give feedback, a light or sound, so that the operator knows when it has been activated, even when it has been done by mistake (Ivergard, 1989). The control

interface should provide feedback so the operator knows at all times what his or her input is accomplishing.

1. Lights

To determine the brightness of lights on appliances for elderly users, many things are considered, such as the deterioration of their eye sight and the luminance level needed in kitchens. For adult users, the luminance level of a light on an appliance should be at least 10% greater than the surrounding luminance (Woodson, 1992). The maintained average illumination level in a kitchen is 300 lux, while the food preparation areas have an average of 500 lux (Oregon). Since most appliances are on the counter in the food preparation area, 500 lux will be used as the surrounding luminance level. For adults the luminance level of a light on an appliance should be 550 lux. Since the illumination for the elderly should be increased 20%, the luminance level of a light on an appliance should be 650 lux. The majority of lights on appliances that are associated with a control movement are red; however, some are yellow and green. The light color should remain the same on appliances designed for the elderly; changing it may cause confusion. The majority of lights found on appliances are circular and have a diameter of 0.125". Some circular lights have a diameter as high as 0.25", but none went below 0.125" in diameter. Oval shaped lights are also used on appliances; they average 0.5" wide by 0.125" to 0.25" high. The diameter of circular lights for elderly users should be increased to at least 0.1875", to ensure visibility. The size of the oval shaped lights can remain the same as they are for adult users because they are already large enough.

2. Sounds

Sounds in a kitchen are found on microwaves, ranges, wall ovens and dishwashers. Audible tones are heard after buttons are activated and when a timer reaches zero. The loudness of sound is measured in decibels (dB). Table 4 shows the decibel level for various activities.

Table 4: Intensity Level of Sounds

Source	Intensity Level
Threshold of Hearing	0 dB
Rustling Leaves	10 dB
Whisper	20 dB
Normal Conversation	60 dB
Busy Street Traffic	70 dB
Vacuum Cleaner	80 dB
Large Orchestra	98 dB
Walkman at Max. Volume	100 dB
Front Row at Rock Concert	110 dB
Threshold of Pain	130 dB
Military Jet Takeoff	140 dB
Instant Perforation of Eardrum	160 dB

Henderson, 1996.

The normal range for an adult pure tone average is 0-25 dB (Marcincuk and Roland, 2002). Pure tone average is the average of the hearing thresholds for 500, 1000,

and 2000 Hz, which are the most important frequencies of speech (Marcincuk and Roland, 2002).

The frequency, the pitch of a sound, is measured in Hertz (Hz). A low frequency can be heard from a bass drum or tuba and ranges from 125-750 Hz (Burmark and Fournier, 2003). A high frequency can be heard in a bird chirping or a flute playing. A low frequency sound must have a higher decibel level in order to "sound" as loud as a higher frequency sound. A young person can hear frequencies in a range from 0-20,000 Hz (The Hyperacusis Network). By the time that person reaches forty years old, that range has been decreased to 0-12,000 Hz (The Hyperacusis Network). Many elderly people can only hear up to 8,000 Hz (The Hyperacusis Network). As people age it becomes harder for them to hear higher frequencies (Poulson, 1996). If an elderly person's hearing threshold shifts by 40 dB it does not mean that their suprathreshold also shifts (Isle, Denno, and Metz, 1992). The decibel level that they can hear comfortably is limited (Isle, Denno, and Metz, 1992). Table 5 shows classifications of hearing loss based on decibels (Davis, 1978). Table 6 shows the preferred listening level of speech for people ages 15 – 85 (Coren, 1994).

Table 5: Classifications of Hearing Impairment

< 20 dB loss	Considered normal
50 - 60 dB	Moderately hard of hearing
70 - 90 dB	Severly hard of hearing
> 92 dB loss	Deaf

Davis, 1978.

Table 6: Preferred Listening Level of Speech Sounds by Age

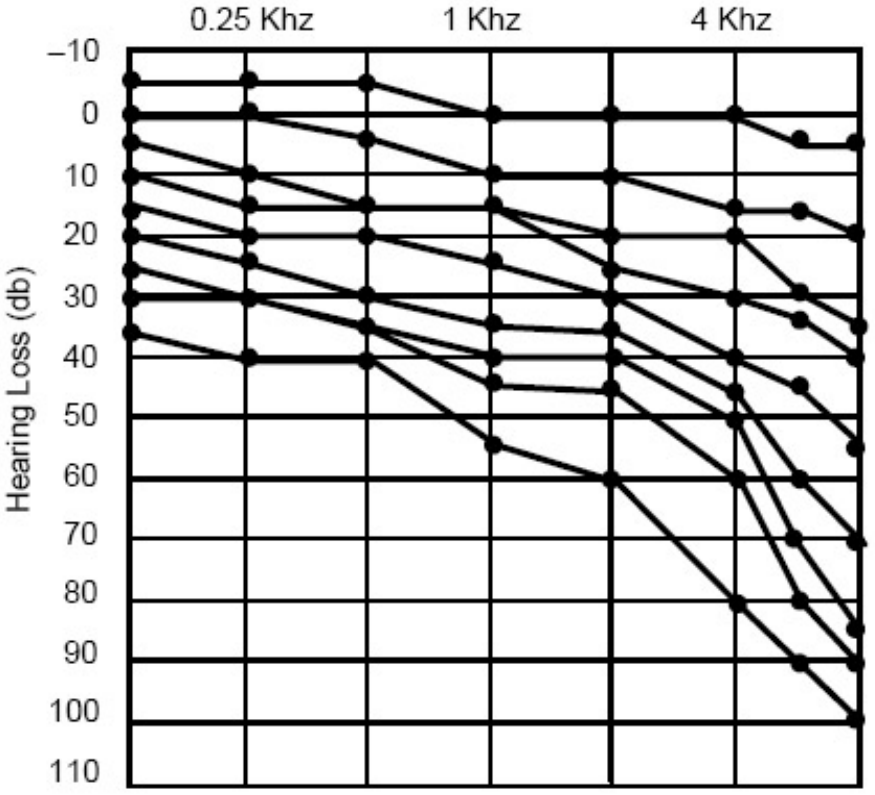
Age in Years	Sound Level (dB)
15	54
25	57
35	61
45	65
55	69
65	74
75	79
85	85

Coren, 1994.

For normal users, auditory tones have a frequency of 30-3,000 Hz; the ear is most sensitive at this range (Tiresias, 2006). This frequency of audible tone does not cause alarm, but attracts attention (Woodson, 1992). Standard auditory tones range from 62-80 dB. Using the sound level preferred for 15 year olds from Table 6, which is 54 dB, there is an 8 to 26 dB increase for auditory tones above the preferred listening level.

Studies were found giving an estimation of hearing loss for elderly people. A study was conducted by A. J. Duquesnoy (1983) with elderly people that had moderate, nearly symmetrical pure-tone hearing losses with an average loss at 500, 1000, and 2000 Hz of between 9 and 40 dB. Another study was conducted by S. Arlinger (1990) with elderly people with presbycusis and their pure-tone hearing loss ranged from 11 to 70 dB with an average of 40 dB. Table 7, illustrates the hearing loss in decibels and frequency in people 0 to 100 years old.

Table 7: Hearing Loss in a Population 0-100 years old



Each curve represents the following age group (from top to bottom):

0–20 years	60–70 years
20–30 years	70–80 years
30–40 years	80 –90 years
40–50 years	90 –100 years
50–60 years	

Isle, Denno, Metz, 1992.

Using the studies by Duquesnoy (1983) and Arlinger (1990) and Table 7, 40dB is used as the threshold of hearing for the elderly. Referring to Table 6, the preferred listening level for the elderly at the age of 85 is 85 dB. Using the same auditory tone increase for adults, the tone should be 8-26 dB above the preferred listening level, which would be 93-111 dB. Using Table 4, 111 dB would feel like the person was at a rock concert, which would be damaging to their ears. Therefore, the decibel range for auditory tones for the elderly should be between 93 and 98 dB. Since elderly people can not hear high frequencies as well as low ones, the frequency of auditory tones on kitchen appliances should be below 900 Hz (Poulson, 1996).

b. Handles

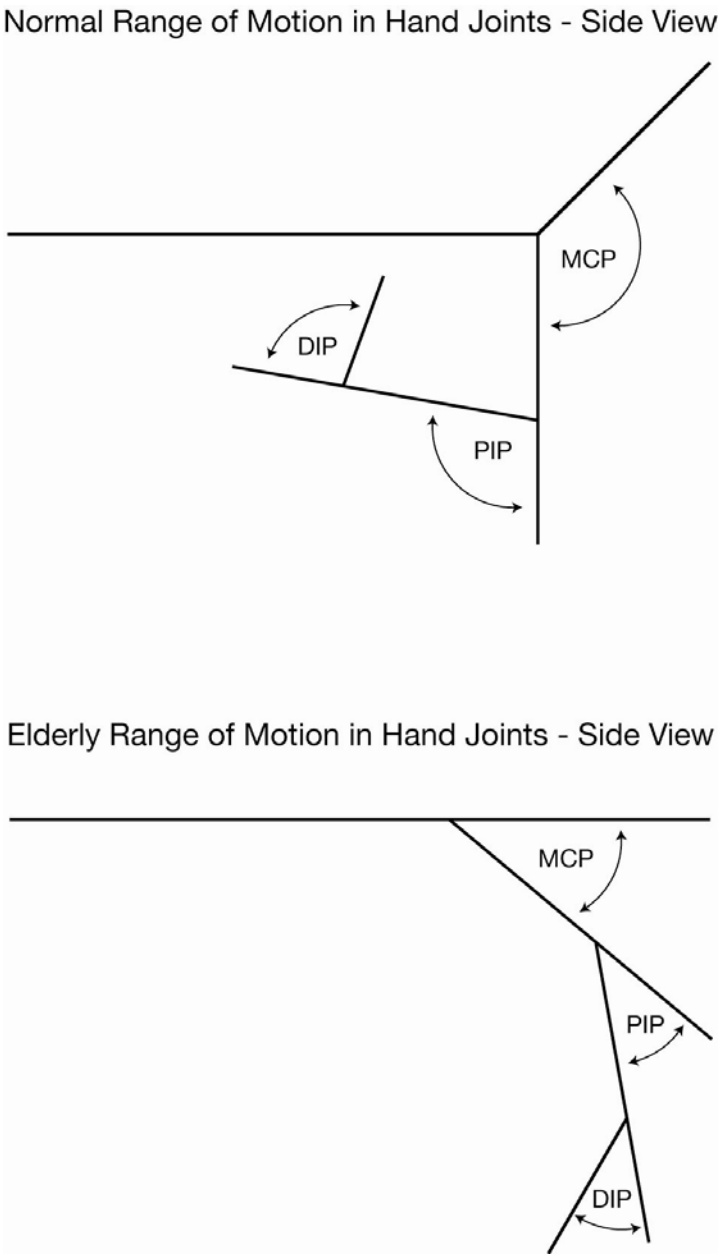
Handles should not include sharp edges or other surface features which cause pressure hot spots when gripped, such as finger shaping, edges of flat or raised surfaces for application of labels, and 'pinch points' between moving parts (Pheasant, 1996). A rectangular cross section will give greater purchase but will be less comfortable than a round or oval shaped handle (Pheasant, 1996). If a rectangular handle is used the edges should be rounded where the two planes meet to a minimum radius of 1"(Pheasant, 1996). In a circular handle the diameter must be large enough so that the user's hand and finger surface contact is maximized, but not so large that a firm grip cannot be maintained (Woodson, 1992).

For normal users, three types of handle cross sections were found on kitchen appliances: rectangular, oval, and round. The rectangular handles ranged from 1.125" to

1.5” in width, 0.5” to 1.125” in depth, and had a clearance, distance from handle to the product, of 1.125” to 1.5”. The oval shaped handles had a width of 1” to 1.5”, had a depth of 0.5” to 1”, and had a clearance of 1.125” to 1.5”. The round handles had a diameter of 1” to 1.25” and a clearance of 1” to 1.5”. The counter top appliances had a handle length that ranged from 3.25” to 4.25”.

Since elderly lose 16-40% of their hand strength (Tilley, 2002), a round or oval handle should be used because it provides maximum grip strength and greater flexibility for the operator if his or her orientation with respect to the handle must be changed (Woodson, 1992). Handles with a circular cross section will be comfortable to grip since there will be no possibility of hot spots, but they may not provide adequate purchase (Pheasant, 1996). For elderly users, an oval shaped handle should be used on kitchen appliances because they provide maximum grip strength, flexibility, no hot spots, and adequate purchase. To arrive at the appropriate size of oval handle, Figure 6 which illustrates the maximum finger joint movement in an elderly person is considered.

Figure 6: Normal and Elderly Range of Motion in Hand Joints



Due to the limited range of motion of finger joints in the elderly, handles should be larger. With handles being larger, the elderly users would not have to move their finger joints as much and would experience less pain than if the handle was smaller. Oval handles should be between 1.5” and 1.75” wide and between 1” and 1.25” deep. This size ensures maximum contact between the hand and handle. Due to the limited range of motion in the finger joints of the elderly seen in Figure 6, the clearance between the handle and the appliance needs to be increased as well. Since it is difficult for elderly people to open their hand all the way, the clearance should accommodate that. Therefore the clearance should be between 1.5” and 2”. Using the information in Table 3, which gives the hand breadth for men, women, and elderly men, the handle length for counter top appliances, should be between 4.125” and 4.625”. This length considers the hand breadth of the 95^{th} percentile elderly men and adds 0.25” to 0.5” to each side to ensure enough clearance for the hand.

c. Displays

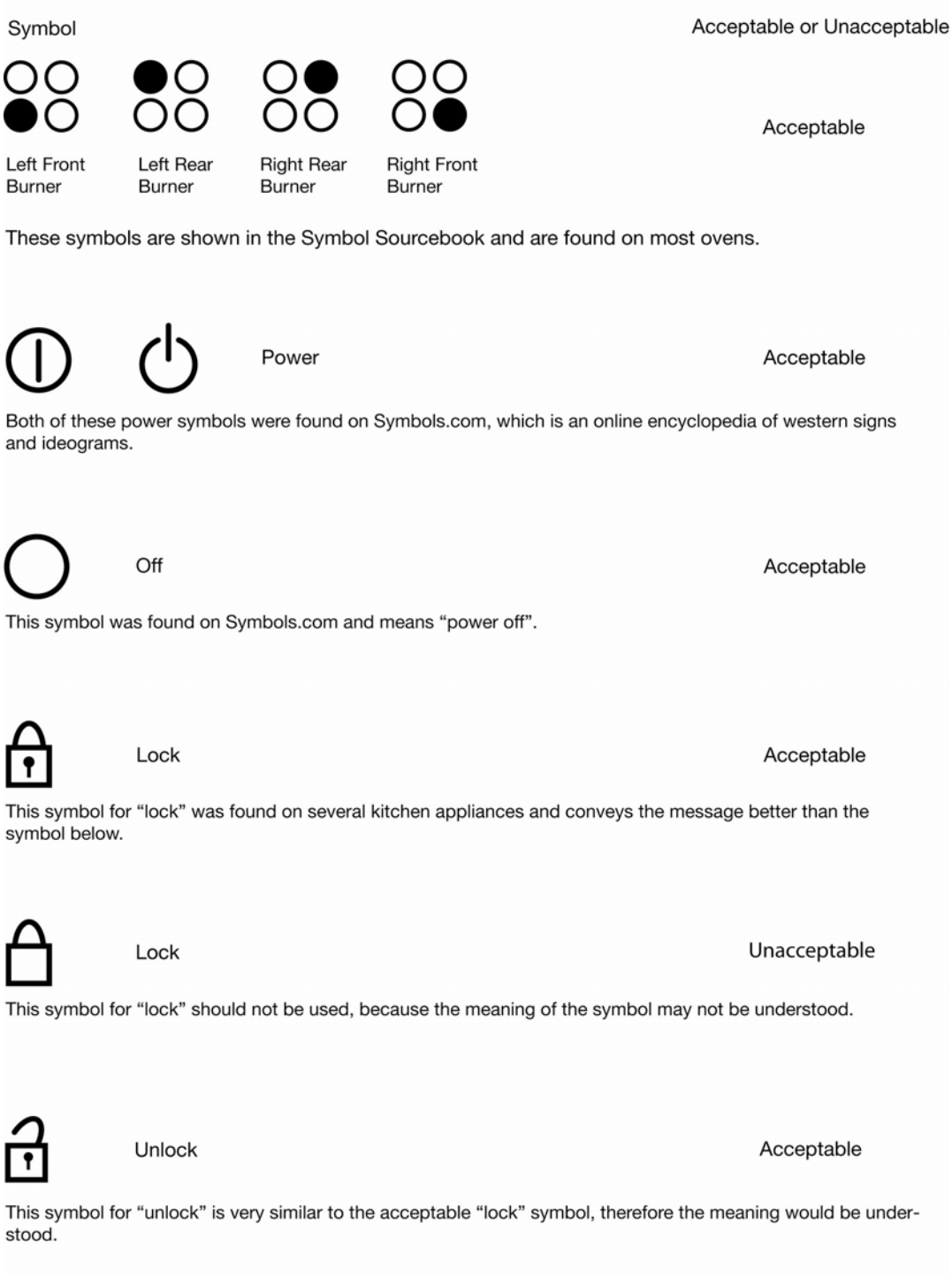
i. Graphics

When operating any appliance or machine, the graphics and controls are the basic interface with the user (Wildbur, 1989). The graphics identify, inform, and supply feedback about the state of the operation by means of a system of words and symbols (Wildbur, 1989). Interface graphics normally take three forms: verbal, symbolic, and pictogrammic (Wildbur, 1989). Both words and pictograms are used to identify controls and functions (Wildbur, 1989). Words are used to amplify directions and give warnings

and symbols such as arrows and arcs, to show direction of movement, increases or decreases and sequence of operations (Wildbur, 1989). Symbols can be designed to fit standard format such as a square or circle and therefore are more consistent in shape and proportion (Wildbur, 1989). Because symbols carry a heavy load of identity information, they are often reduced to the bare essentials of shape, line, tone, and other design structures (Crow, 1986). Graphics should be capable of lasting the estimated life of the product or appliance taking into account the working environment and frequency of use (Wildbur, 1989). There are products in which the graphics have peeled off or worn away leaving in doubt the function of the control settings and in some cases safety margins (Wildbur, 1989). Printing directly onto the product material by ink or foil is an option, while embossing or relief moulding, etching and anodizing are other common techniques (Wildbur, 1989).

Figure 7 illustrates existing graphics found on kitchen appliances. The graphics are either acceptable or unacceptable based on their design and amount of use on appliances.

Figure 7: Existing Graphics on Kitchen Appliances



Symbol		Acceptable or Unacceptable
	Unlock	Unacceptable
This “unlock” symbol is not as easy to understand without the keyhole.		
	Clock	Acceptable
The clock symbol was found on many kitchen appliances.		
	Water	Unacceptable
The glass is unnecessary to convey the meaning of water.		
	Water	Unacceptable
This symbol does not illustrate water as well as others that have been seen.		
	Water	Acceptable
This symbol conveys the meaning of water without unnessecary shapes.		
	Cubed Ice	Unacceptable
This symbol does not need to include the glass to be successful.		

Symbol		Acceptable or Unacceptable
	Cubed Ice	Acceptable

This symbol illustrates cubed ice well and can be found on many refrigerators.

	Crushed Ice	Unacceptable

This symbol does not resemble crushed ice.

	Crushed Ice	Unacceptable

This symbol does not need to include the glass to get the meaning across.

	Crushed Ice	Unacceptable

This symbol gives the feeling of snow, not crushed ice.

	Crushed Ice	Acceptable

This symbol illustrates crushed ice without having extra graphics.

	Ice	Unacceptable

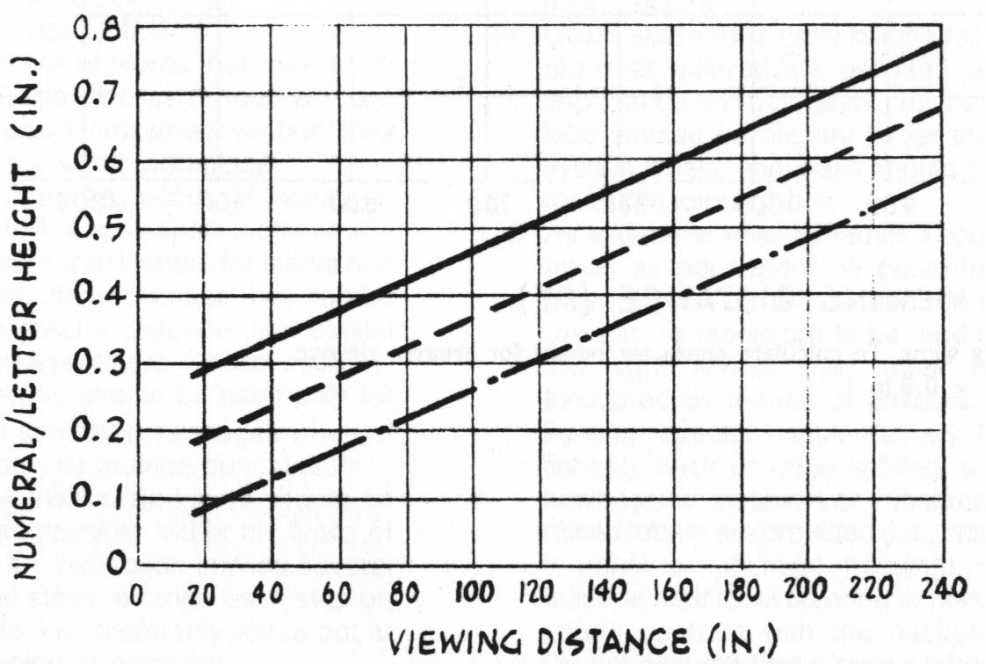
The symbol for cubed or crushed ice should be used in place of this one. This symbol does not resemble an ice cube.

Symbols		Acceptable or Unacceptable
	Light	Acceptable
This symbol is very easy to understand and can be found on several types of appliances.		
	Toast (Light, Medium, and Dark)	Acceptable
Either one or all toast symbols were found on most toasters.		
	Eject Toast	Acceptable
This symbol is easy to understand and can be found on most toasters.		
	Mixer Whisk	Acceptable
Most mixers have a whisk symbol to illustrate which button ejects the whisks.		
	Popcorn	Acceptable
The popcorn symbol is found on microwaves and is easy to understand.		

Since elderly people can not detect details as well as normal adults (Isle et al, 1992), the acceptable graphics are simple and do not have extra or unnecessary shapes. The acceptable graphics are commonly used on appliances and easy to understand. The acceptable graphics should be used for both normal and elderly people; the only difference should the size of the graphic.

For normal users the height of graphics on appliances range from 0.1875” to 0.25”. Table 8 illustrates the increase of numeral and letter height along with the increase of the viewing distance. Using Table 8, graphics at a height of 0.1875” to 0.25” can be viewed from a distance of 15” to 40”.

Table 8: Minimum Character Height When Viewed in Close Proximity

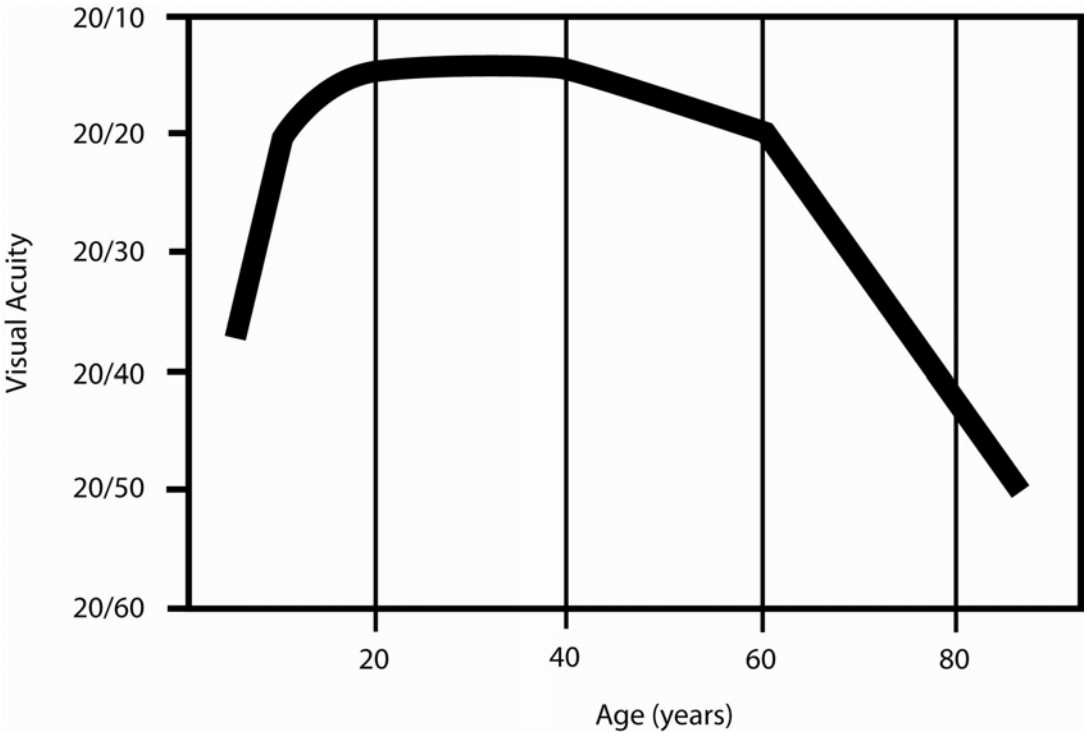


Letter height versus viewing distance and illumination level (minimum space between characters, one stroke width; between words, six stroke widths). (— For instruments where the position of the numerals may vary and the illumination is between 0.03 and 1.0 fL. --- For instruments where the position of the numerals is fixed and the illumination is 0.3–1.0 fL, or where position of the numerals may vary and the illumination exceeds 1.0 fL. –·– For instruments where the position of the numerals is fixed and the illumination is above 1.0 fL.)

Woodson, 1992.

A person with “normal” vision has a visual acuity of 20/20 (Montgomery, 1998). As the second number increases, the closer a person must stand to see the same object that the “normal” person saw (Montgomery, 1998). For instance, a person with 20/20 visual acuity can stand 30 feet away, while a person with 20/40 visual acuity must stand 15 feet away to see the same object (Montgomery, 1998). As shown in Table 9, the visual acuity of one’s eyes decreases with age. Approximately one-third of people over 80 have vision of 20/50 (Isle et al, 1992), which means they have to stand 12 feet away from the object (Montgomery, 1998). Using the distance of 30 feet for “normal” vision and 12 feet for elderly vision, there is a 60% loss in vision for the elderly. Applying that loss to the existing graphic size, the height of graphics for the elderly should be between 0.3” and 0.4”.

Table 9: Visual Acuity vs. Age



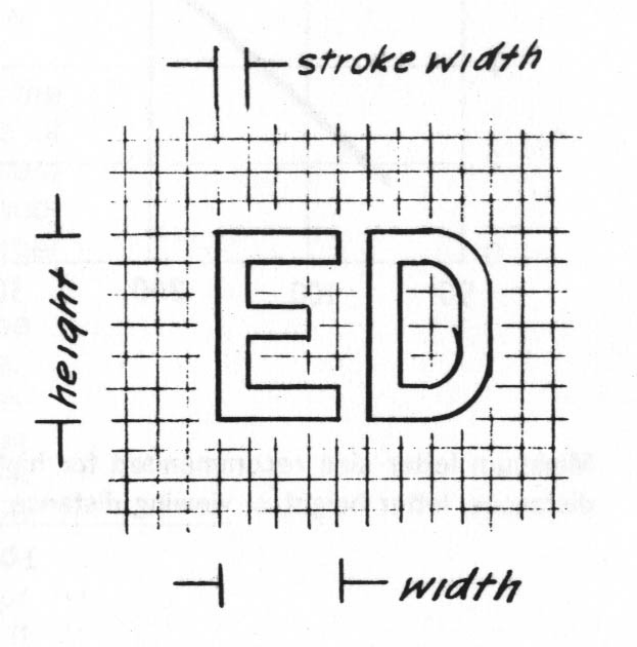
Timiras, 2003.

ii. Lettering

Two common types of fonts are serif and san serif. Serif types are defined by the presence of a finishing stroke at the end of major stem and hairline strokes (Crow, 1986). San serif types do not have serifs of any kind (Crow, 1986). Their variety comes from stroke thickness variation and weight differences (Crow, 1986). The kind of typefaces used for signs, labels, and other printed forms also make a difference in whether or not a message can be easily understood (Gay, 1986). Typefaces should be avoided if they have uneven stroke widths, extended serifs, include internal patterns or stripes, italics, stenciled, appear like handwritten script, shadowed or look 3D, old English script, and distorted to look tall, thin, wide or fat (Woodson, 1992). Some standard type styles that are acceptable include Folio Book, News Gothic, Trade Gothic, Futura Medium, and Spartan Medium (Woodson, 1992). Maximum contrast should be used for lettering (Woodson, 1992).

Avoid clutter and illegibility that result when characters are crowded together (Woodson, 1992). For individual letters, the optimum height to width ratio is 1:0.7 (Corlett and Clark, 1995). The stroke width to height ratio for black characters on a white background is 1:6 and for white characters on a black background is 1:8 (Corlett and Clark, 1995). This ratio is illustrated in Figure 8.

Figure 8: Stroke Width, Height, and Width



Corlett, Clark, 1995.

The spacing between lines of words should be the width of two strokes (Isle et al, 1992). The spacing between words should be the width of one character (Isle et al, 1992). The space between characters in a word should be the width of one stroke (Isle et al, 1992).

Word labels should use common terms and no abbreviations (Woodson, 1992). Control and display labels should be located consistently, either below or above the panel component (Woodson, 1992). Avoid putting labels where they will be blocked by equipment or the operator's hand (Woodson, 1992).

On existing kitchen appliances, the height of letters range from 0.09375” to 0.125”. Title case and uppercase was used approximately the same amount, while lowercase was used rarely. The exact fonts used is unknown, however they were all san serifs.

The size of characters should be increased for the elderly because of their loss of visual acuity. To find the height of the lettering, Table 9 was considered and a 60% loss of visual acuity in the elderly will be used, this percentage was calculated in the previous section. To make up for that loss, the letter height for the elderly should be increased to 0.15” to 0.2”. Helvetica should be used as the typeface (Isle et al, 1992). Woodson (1992) feels that all capital letters should be used for short labels and signs. While Wildbur (1989) thinks lower case lettering is the first choice because many descriptions giving the function of a control consist of a single word, and the use of all lower case will give a more harmonious look to the panel than starting each word with a capital letter. For elderly users, lettering on kitchen appliances should be in title case because it is easier to read than all capital letters and all lower case letters. Title case words provide a greater variety of shapes unlike capital letters which are a similar block shape (Bellevue, 2004).

iii. Colors

To ensure adequate legibility there must be adequate visual contrast between alphanumeric characters and the background against which they are viewed (Woodson, 1992). Saturated colors should be used as opposed to pale colors when colors have special significance (Woodson, 1992). If raised letters are used there must be additional

coloring to make the letters contrast with the background (Woodson, 1992). Do not assume that a raised letter that is the same color as the basic background will be readable just because it is raised (Woodson, 1992). Utilize size and/or color coding to help the observer differentiate between levels of importance on your panel (Gay, 1986). Color coding may also help put across clear visual messages; for example, red means stop; green means go or on, and yellow means caution (Woodson, 1992). No more than five colors should be used on a visual display (Galer, 1987).

On existing kitchen appliances most control panels are either white characters on a black background or black characters on a white background. Some appliances have a stainless steel background with black characters. Red, yellow, and green are usually found on kitchen appliances, to signify stop, caution, and start.

A high contrast control panel will simplify use for a person with visual impairments (Peterson, 1998). Instrument faces are more easily seen if the markings are black on a light colored face (Peterson, 1998). Applying this to the elderly, the control panel should have a white background with black lettering. Using black and white will create more contrast than using just a light color for the background. Due to the increase of glare in the elderly, a stainless steel background on a control panel should not be used. Bright colors, such as red and yellow, should be used over dark colors, such as blue and green, because as a person ages their color perception changes and they can not differentiate between dark colors as well as bright ones. Red and yellow can still be used on kitchen appliances for the elderly. If the color green is used it should be brighter than it is on existing appliances. A standard green is around C-80, M-0, Y-100, K-0. For the elderly, the green should be around C-50, M-0, Y-70, K-0. This CMYK is significantly

brighter than the standard green. The brighter the green, the easier it will be for an elderly person to see.

iv. Digital Displays

Electronically generated characters are formed with either a dot matrix or line segments. There are four sizes of dot matrixes, 5x7 matrix, which is the minimum size accepted, 7x9 matrix, which is preferred, 8x11 matrix, which is the minimum size preferred if the symbols are rotated, and 15x21 matrix, which is preferred if the symbols rotate (Woodson, 1992). Lowercase letters should not be used in a matrix, because they can be hard to distinguish from one another (Woodson, 1992). Dot matrixes are easier to read because they produce curved lines (Woodson, 1992). Segmented displays are found more on kitchen appliances than dot matrixes. Segmented displays either use a liquid crystal display (LCD) or light emitting diodes (LED). The color of an LED is determined by its wavelength (Marktech). For example the color green has a frequency of 560 – 569 nm, and red has a frequency of 628 – 639 nm (Marktech).

Most kitchen appliances feature digital displays with segmented characters; the majority of them are LED, but there are a few LCD. The LED digital displays can be found in red, yellow, and green. The average height of the characters is 0.5".

For the elderly, a dot matrix which is 7 x 9 should be used. The height of the characters should be 0.5" tall, which is the same as existing digital displays. There is no need to increase the height because the maximum letter height calculated above was 0.2". Since the elderly can differentiate between bright colors better than dark ones, the digital display characters should be red or yellow.

d. Technology and Form of appliances

New technologies that manufacturers are producing today help families save time in the kitchen. For instance, TMIO makes an oven that refrigerates food and will begin cooking when the user accesses the oven through the internet or by phone. Whirlpool also makes a refrigerated range, which keeps your food cool until it is time to start cooking. LG makes a refrigerator that has a television built into the door, which includes FM radio, stereo speakers, and cable-ready TV tuner. LG also has a refrigerator with a built in computer and barcode scanner that keeps track of the groceries and can send e-mails to the users letting them know if they are out of milk.

Since elderly people spend a lot more time at home and are not as busy as young families, kitchen appliances designed specifically for them should not include unnecessary new technologies. The technology used in appliances for the elderly should be similar to what they are used to; if something new and different is integrated into their appliances it may be rejected. The form and shape of appliances for the elderly should also be similar to what they are used to; all of the appliances should be recognizable. Figure 9 gives some examples of unacceptable and acceptable forms and shapes for several kitchen appliances.

Figure 9: Form of Appliances for Elderly

	Not Preferred	Preferred
Coffee Maker		
Microwave		

IV. GUIDELINES FOR DESIGNING KITCHEN APPLIANCES FOR ELDERLY

a. Controls

i. Round Knobs

Adults – Minimum diameter is 0.25” and depth is 0.75” with serrations, 2 - 4 in-oz resistance. Preferred diameter is 0.5” and depth is 0.5” with serrations, 4 in-oz resistance.

Elderly – Diameter 1” - 2” and depth of 0.5” – 0.75” with serrations, 3 - 6 in-oz resistance.

Figure 10: Round Knob Dimensions

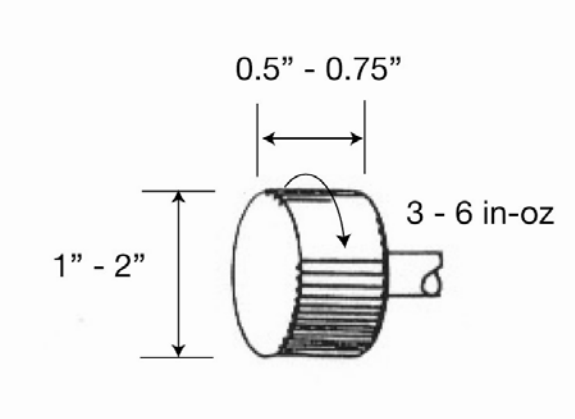


Image from Woodson, 1992

ii. Pointer Knobs

Adults – Length is 1”-2”, Width is 0.25” – 0.5”, Height is 0.5”, 10 - 45 in-oz resistance.

Elderly – Length is 2” - 3”, Width is 0.5” – 0.75”, Height is 0.75”, 6 – 27 in-oz resistance.

Figure 11: Pointer Knob Dimensions

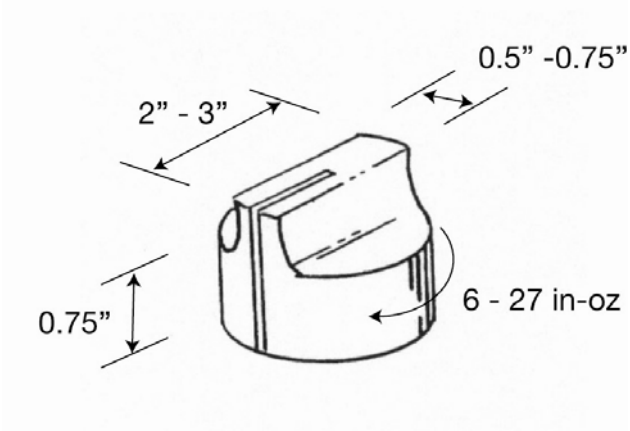


Image from Woodson, 1992

iii. Press Buttons

Adults – Minimum diameter is 0.25”, concave top if diameter is larger than 0.75”, 0.1875” between press buttons placed in rows horizontally or vertically, 10 – 20 in-oz resistance.

Elderly – Diameter is 0.5” – 0.75”, concave press button, 0.25” between press buttons placed in rows horizontally or vertically, 6 – 12 in-oz resistance.

Figure 12: Press Buttons Dimensions

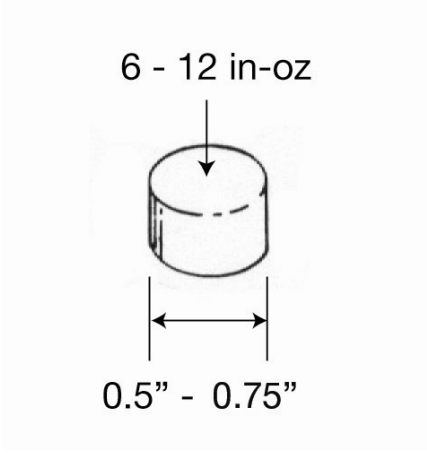


Image from Woodson, 1992

iv. Toggle Switches

Adults – Length is 0.5” – 2”, Tip diameter is 0.125” – 1”, Distance between switches when lined up horizontally is 0.75” – 2”, 10 – 40 in-oz resistance.

Elderly – Toggle switch that is flat on top and bottom, Length is 0.5” – 0.625”, Width is 0.375”, Height is 0.125”, Distance between switches when lined up horizontally is 1”, 9 – 12 in-oz resistance.

Figure 13: Toggle Switch Dimensions

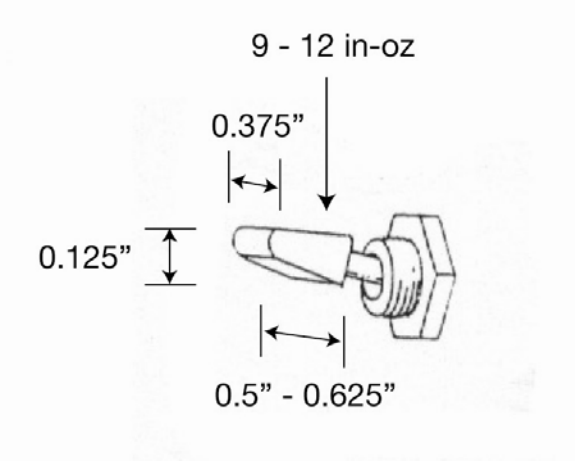


Image from Woodson, 1992

v. Contact Switches

Adults – Square or rectangular switches: Height is 0.5” – 0.625”, Width is 0.5” – 0.75”, Circular switches: 0.5” diameter, 1 – 5 in-oz resistance.

Elderly – Square or rectangular switches: Height is 0.625”, Width is 1” – 1.25”, Circular switches: 0.625” diameter, 3 in-oz resistance.

Figure 14: Contact Switch Dimensions

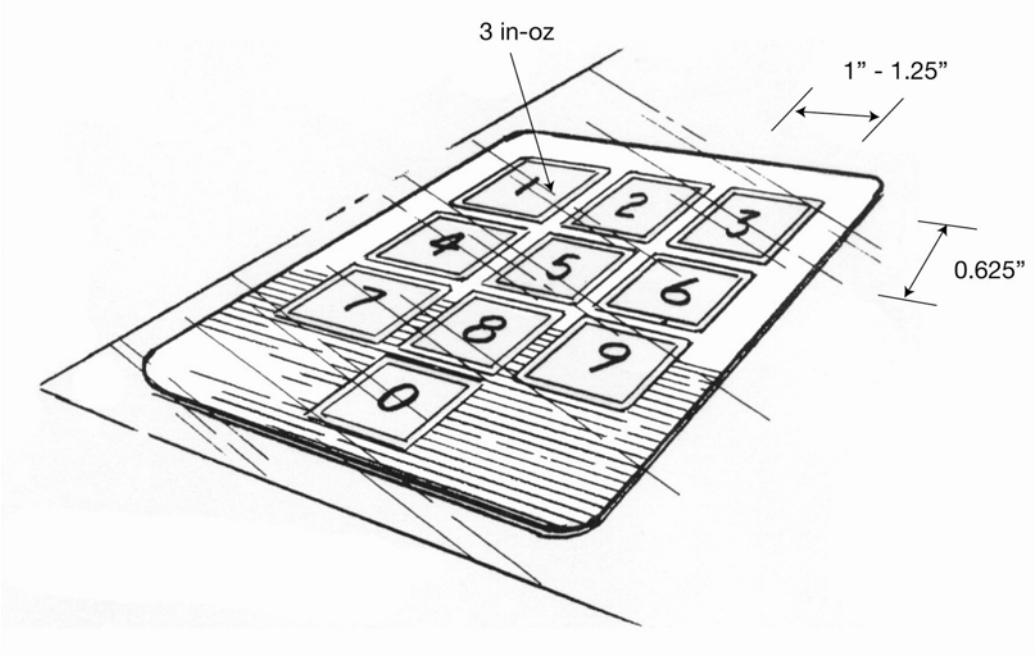


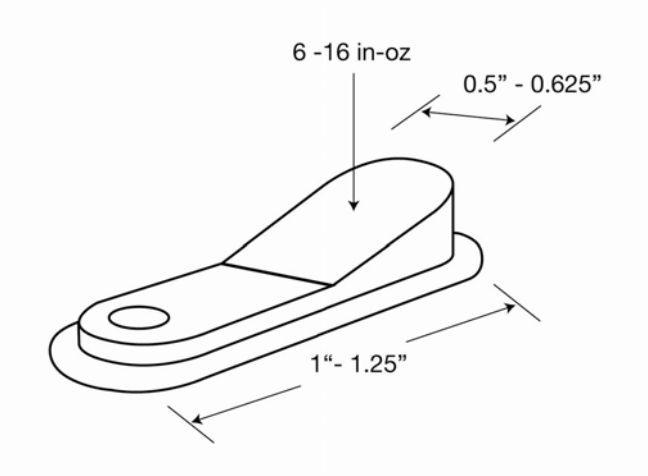
Image from Woodson, 1992

vi. Rocker Switches

Adults – Oval switches: height is 0.5” – 1, width is 0.625” – 1.5”, Circular switches: 0.5” – 0.625” diameter, Square switches: 0.375” x 0.5”, 10 – 40 in-oz resistance.

Elderly – Oval switch: height is 0.5” – 0.625”, width is 1” – 1.25”, concave surface and activation light, 6 – 16 in-oz resistance.

Figure 15: Rocker Switch Dimensions

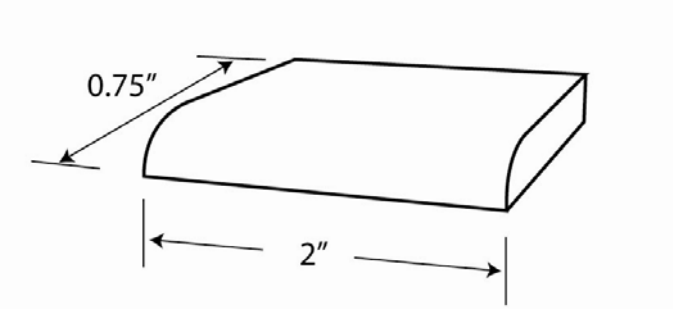


vii. Toaster Lever

Adults – Width is 0.875” – 3.125”, Depth is 0.75” – 1.25”.

Elderly – Width is at least 2”, Depth is 0.75”.

Figure 16: Toaster Lever Dimensions



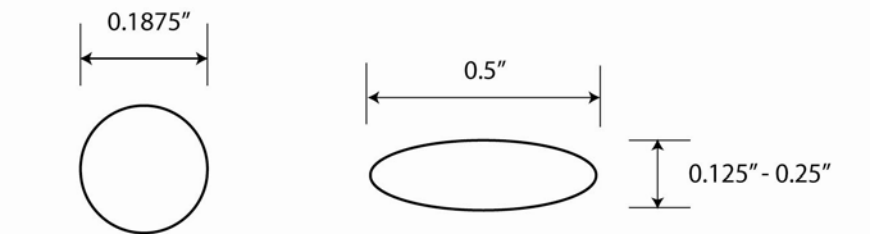
viii. Feeback

1. Lights

Adults – Luminance level is 550 lux, Circular lights: diameter is 0.125” – 0.25”, Oval lights: width is 0.5”, height is 0.125” – 0.25”.

Elderly – Luminance level is 650 lux, Circular lights: diameter is 0.1875”, Oval lights: width is 0.5”, height is 0.125” – 0.25”.

Figure 17: Light Dimensions



2. Sounds

Adults – 62 – 80 dB. Frequency is 30 – 3,000 Hz.

Elderly – 93 – 98 dB, Frequecy is below 900 Hz.

b. Handles

Adults – Rectangular handles: Width is 1.125” – 1.5”, Depth is 0.5” – 1.125”, Clearance is 1.125” – 1.5”, Oval handles: Width is 1” – 1.5”, Depth is 0.5” – 1”, Clearance is 1.125” – 1.5”, Round handles: Diameter is 1” – 1.25”, Clearance is 1” – 1.5”, Handle Length is 3.25” – 4.25”.

Elderly – Oval handles: Width is 1.5” – 1.75”, Depth is 1” – 1.25”, Clearance is 1.5” – 2”, Handle Length is 4.125” – 4.625”.

Figure 18: Handle Dimensions

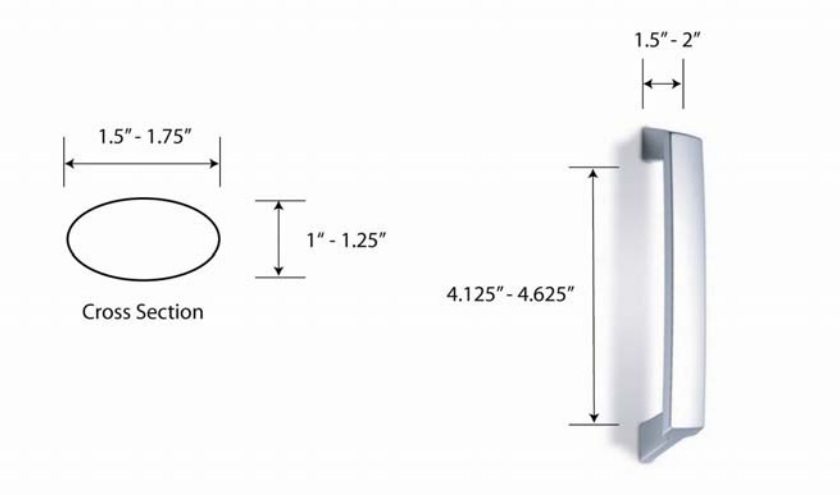


Image from www.fixturesetc.com

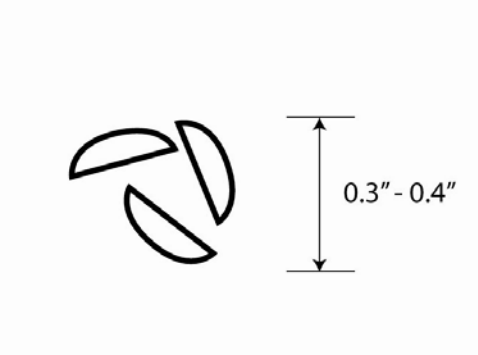
c. Displays

i. Graphics

Adults – Height is 0.1875” – 0.25”.

Elderly – Height is 0.3” – 0.4”. Refer to Figure 7 for acceptable graphics.

Figure 19: Graphic Dimensions

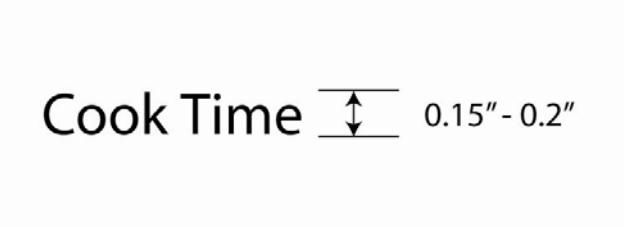


ii. Lettering

Adults – Height of letters is 0.09375” – 0.125”, San serif typeface, Title case and uppercase are used.

Elderly – Height of letters is 0.15” – 0.2”, Helvetica typeface, Title case.

Figure 20: Letter Dimensions



iii. Colors

Adults – Either white characters on black background, black characters on white background, or black characters on stainless steel background. Red, yellow, and green.

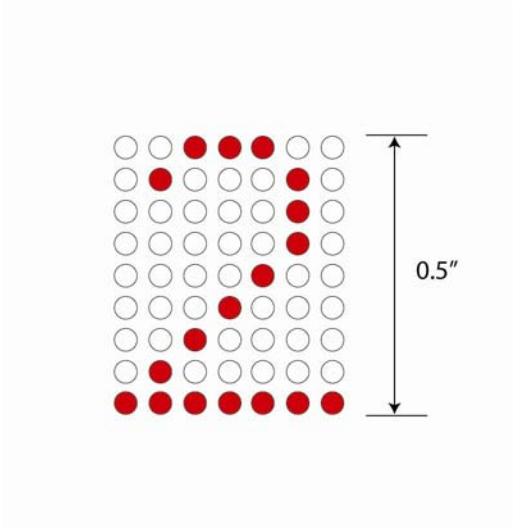
Elderly – Black lettering on white background, Red and yellow can be used. If green is used it should be brighter than a standard green.

iv. Digital Displays

Adults – Majority are LED, some are LCD, LED are red, yellow, and green, Height is 0.5”.

Elderly – Dot matrix 7 x 9, Height is 0.5”, LED are red or yellow.

Figure 21: Digital Display Dimensions



d. Technology and Form of Appliances

Elderly – Appliances should be recognizable and use technology that is similar to those commonly available.

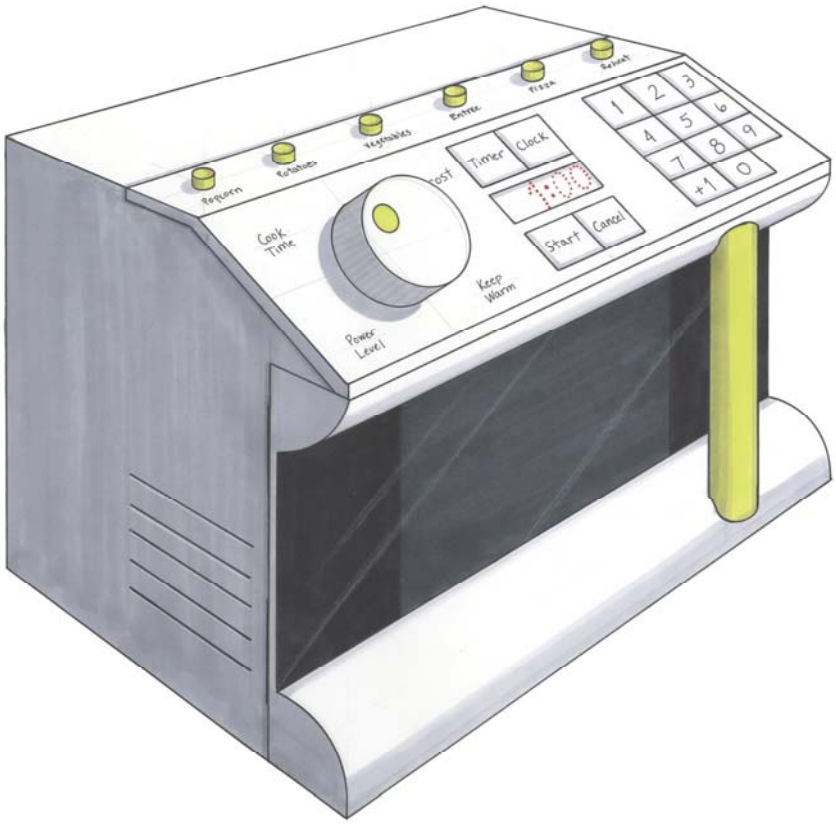
V. APPLICATION OF GUIDELINES

a. Idea Sketches

A microwave was designed using the guidelines that were created in this thesis. Shown below are some idea sketches of microwaves.

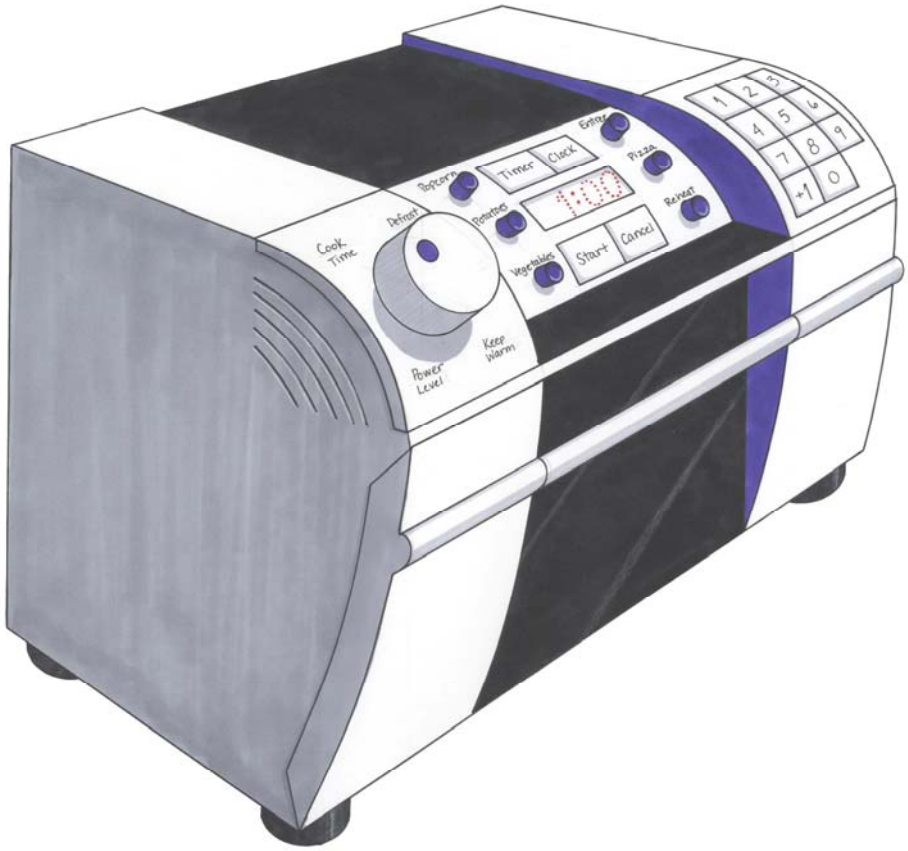
Concept A - The door on this microwave opens downward, which allows the user to pull their food onto the door after cooking. The control panel is at a 45 degree angle and placed on the top of the microwave so it is easier to see.

Concept B – The door on this microwave swings to the left similar to a conventional microwave. The control panel is placed on the top of the microwave and angled.

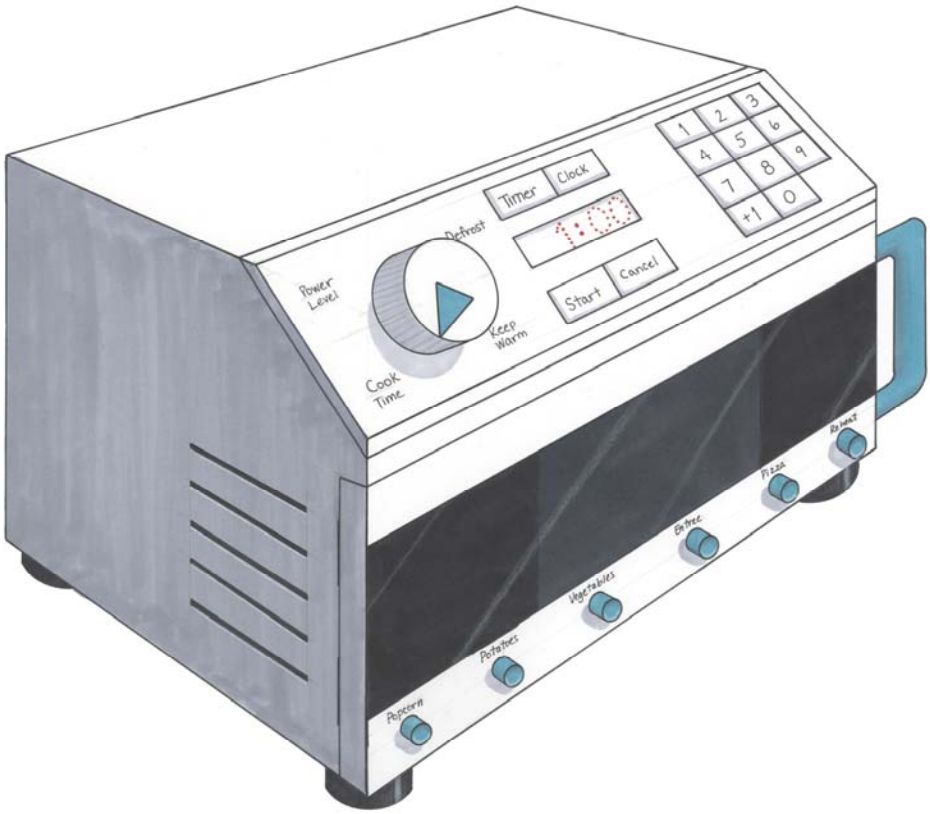


Concept C – The control panel is place on the top of the microwave door and the door opens downward.

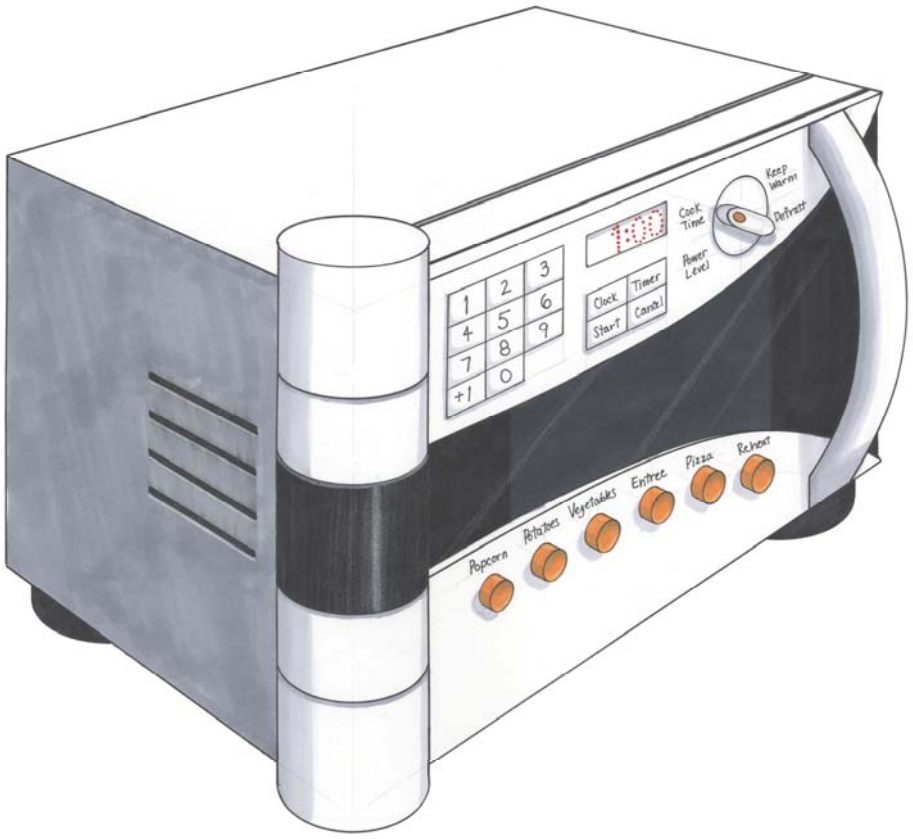
Concept D – The control panel is placed on the top of the microwave and angled, while the door opens downward.



Concept E – The control panel is angled and placed at the top. The door swings to the left like conventional microwaves.



Concept F – The control panel is placed on the door, the most important controls are at the top of the microwave. The door swings to the left like a conventional microwave.



b. Preliminary Models

Models were made of three of the concepts. The models were made from blue Styrofoam.

Concept A

Concept C


Timer
Clock
Cook Time
Defrost
2:00
1 2 3
4 5 6
7 8 9
+1 0
Power Level
Keep Warm
Start
Cancel

Concept F


1
2
3
4
5
6
7
8
9
+1
0
2:00
Timer
Clock
Start
Cancel
Popcorn
Potatoes
Vegetables
Entree
Pizza
Reheat

c. Final Model

Concept F was chosen as the final design because it is a more conventional than concept A and C. Refer to section III. Development of Design Guidelines d. Technology and Form of Appliance for more explanation.

Control Dimensions

Detail shot of round knob.

Detail shot of press buttons.

Detail shot of contact switches and clock.

Detail shot of round knob and handle.


4:00
Cook Time
Defrost
Timer
Clock
Start
Cancel
Power Level
2
3
5
6
8
9

d. Summary of Project

The microwave measures 12” in height, 16” in depth, and 18” wide, and the door hinges on the left side. Contact switches are used for the numbers, Timer, Clock, Start, and Cancel. The dimensions for the contact switches come from section IV. a. v., which explains that rectangular switches should have a height of 0.625” and a width of 1”-1.25”. A round knob is used for Cook Time, Defrost, Power Level, and Keep Warm. The dimensions of the round knob come from section IV. a. i., which states that the diameter should be between 1” and 2”, while the depth should be between 0.5” and 0.75”. Press buttons are used for the preset foods such as Pizza and Potatoes. Section IV. a. iii. states that the diameter of a press button should be between 0.5” and 0.625”. The handle length is 11”, while the viewing window measures 4” high by 10” wide. The handle dimensions are stated in section IV. b., which say that the oval handle should have a width between 1.5” and 1.75”, a depth of 1” to 1.25”, and a clearance of 1.5” to 2”. The turntable inside is 12 ¾” in diameter. The internal components of the microwave would be housed on the left side. The internal dimensions of the microwave are 10” high, 14 ½” deep, and 14” wide.

VI. CONCLUSIONS

The intention of the thesis was to develop guidelines for designers to use when they are designing kitchen appliances for the elderly population. Existing control standards on appliances are given along with physical and psychological characteristics of the elderly. The guidelines were formed by analyzing a specific characteristic of the elderly and the appliance standard used currently. The guidelines created can be applied to any kitchen appliance. All guidelines should be used when designing; if one or more are left out the user may have trouble operating that component of the appliance. Even though the guidelines are specific about each component, many different designs can be created.

In the thesis, the guidelines were applied to the design of a microwave oven. The final design is not the only possible solution; it simply illustrates how the guidelines are used.

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