The Development of a Personalised Multimedia System for Individuals with Dementia

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In memory of my grandparents

Dedicated to
the worldwide community
of people affected by dementia

This document is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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Journal of Geriatric Nursing. Elsevier, Volume 37, Issue 1, Pages 25–29

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Abstract

The rapid increase in the rate of global ageing implies generally longer and healthier lifespans. However, as people get older they become more prone to chronic and degenerative diseases such as dementia, the incidence of which is expected to rise from 35.6 million people in 2010 to 115.4 million in 2050 (Prince et al. 2013; World Population Ageing 2013).

'Dementia' describes a collection of medical conditions caused by the loss of neurons in the brain (Prince). The most common symptoms are behavioural (such as aggression), psychological (such as hallucinations) and a decline in the ability to remember new information (Alzheimer's Association 2014; Finkel et al. 1996).

As the symptoms exacerbate, family members find it increasingly difficult to handle and communicate with affected individuals (O'Connor et al. 1990). This often leads to their placement in aged-care facilities where professional help is available (Schultz and Williamson 1991). However, due to shortfalls in staffing levels, caregivers have busy schedules and are unable to provide residents with as much one-on-one attention as they would like (Cohen-Mansfield 2001). Individuals with dementia therefore spend much of their time in isolation (Alm et al. 2003).

Medication is the primary method of treating the symptoms of dementia, despite frequent reports of the efficacy of placebo treatments (Ballard and O'Brien 1999). More than 40% of people with dementia at aged-care facilities are being prescribed unnecessary medication (Margallo-Lana et al. 2001) which leads to reduced well-being and quality of life, and may expedite cognitive decline (Ballard et al. 2001; McShane et al. 1997).

According to the Alzheimer's Society (2006), all medications used for treating the symptoms of dementia have adverse side effects, the prevention of which encourages the use of non-medicinal interventions (Douglas et al. 2004).

Current literature has reported the use of personalised multimedia interventions in alleviating some of the symptoms of dementia (O'Connor et al. 2009), and touchscreen technology in providing a degree of autonomous use to this cohort (Astell et al. 2008; Cahill et al. 2008).

This thesis describes the design study of a non-medicinal intervention that addresses common symptoms at aged-care facilities prevalent in residents with mild, moderate or severe dementia (especially loss of self-reliance, boredom and isolation and/or loneliness). The research uses a mixed methods approach, in particular exploratory sequential mixed methods, through studio-based, social and clinical research.

The outcome is a multimedia system consisting of a dedicated physical dimension and specially considered information architecture that provides personalised media to individuals with dementia. This has shown potential in:

- providing a high degree of autonomous use to individuals at any stage of dementia
- reducing depression and anxiety in individuals with mild dementia
- reducing agitation in individuals with moderate or severe dementia
- adapting to the different impairment levels of dementia
- providing high levels of enjoyment to affected individuals, their family members and caregivers

This innovative intervention represents a significant contribution to the research field by demonstrating that with such a system, the current generation of people with dementia can independently access their favourite media, attain a higher degree of self-reliance and restore their own sense of joy and contentment as well as that of their family members and caregivers.

Where a reference is presented without its date, please treat as 'ibid'.
During field-tests (Chapter 6), the multimedia system was referred to as 'Memory Box'.

Chapter One Introduction

Chapter Overview

Chapter 1 outlines the areas that provide purpose for this research:

- Global ageing – its increasing impact over the years and its associated problems
- The increase in the incidence of degenerative diseases that are more common in older people
- Dementia – psychologically oriented paradigms and the reasons behind some of the symptoms of dementia, the alleviation of which forms the basis of this research
- The challenges faced by caregivers and individuals with dementia at aged-care facilities
- The problems with currently prescribed medication
- Non-medicinal therapies that offer potential in treating some of the symptoms of dementia

The chapter concludes by identifying the research question:

***How can a personalised multimedia system be designed to enhance the quality of life of individuals with dementia and provide them with a high degree of autonomous use, while adapting itself easily to the deteriorating stages of their condition from mild to moderate to severe*?**

In this research 'residents' refers to people with dementia who are in aged-care facilities.

'Levels of dementia' refers to the mild, moderate or severe stages of dementia.

Age and year bands vary according to the information available in referenced literature.

1.1 Global Ageing

The term ‘global ageing’ refers to an increase in the median age of the world’s population. This phenomenon, also referred to as the ‘demographic transition’, is caused by reductions in the rates of mortality and fertility (longer lifespans, fewer births), thereby tilting the global age ratio in favour of the older age bands (World Population Ageing 2013).

The population under the age of 65 is classified as ‘working age’, over 65 as ‘old’ and over 85 ‘oldest old’ (Powell 2009). Among these, the ‘oldest old’ is the fastest growing; by the year 2030 it is projected to exceed two and a half times its 2005 number. This increase of 151% compares with 104% for the 65+ and 21% for the under-65 age bands (Bengston and Lowenstein 2003) (*Figure 1.1*).

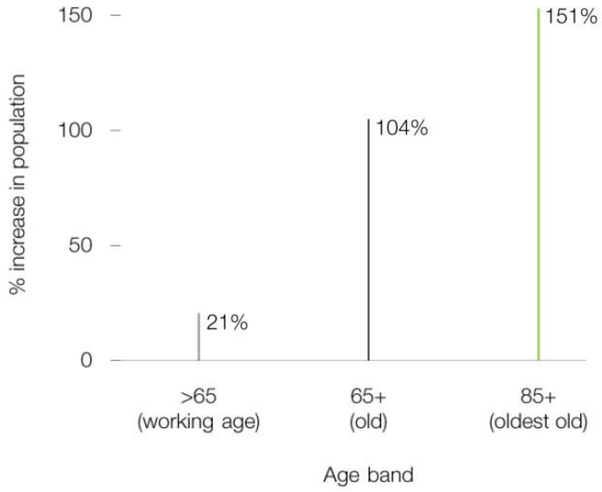


Figure 1.1 ***Global ageing between 2005 and 2030***
Bengston and Lowenstein 2003; Powell 2009

In 1995, the 65+ group numbered 542 million or 9.5% of the total population. By the year 2030, it is projected to reach 1.2 billion or 13% of the population (Krug 2002) (*Figure 1.2*).

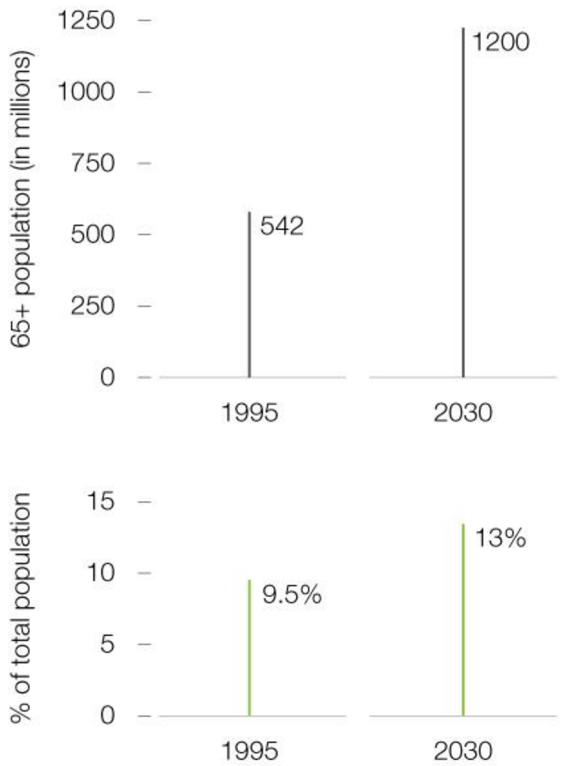


Figure 1.2 ***Global demographic transition between 1995 and 2030***
Krug 2002

The highest increase will occur in Japan where, by 2030, 24% of the 65+ population is expected to be at least 85 years old (Powell 2009). Between 2003 and 2004, the number of old people worldwide increased by 10.3 million. This translates, on a linear scale, to a net increase of 850,000 old people every month (Krug 2002). If this trend continues, by the year 2050 there will be more old people (65+) than young people (under 65) for the first time since formal record-collecting began (Powell 2009). *Figure 1.3* displays the prevalence of global ageing in men and women, separately and collectively, in the year 1995, and the projection for the year 2025.

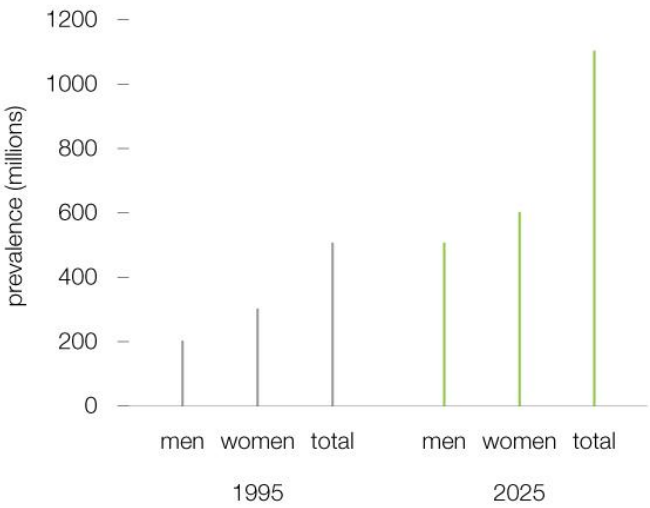


***Figure 1.3* An ageing population**
World Population Ageing 2013

The predominance of women in the older population is due to genetic, hormonal and lifestyle factors (Kraemer 2000; Mather et al. 2002; Wizemann and Pardue 2001). In 2013, the number of men per 100 women (known as the 'global sex ratio') was 80 in the 65+ group, and 62 in the 80+ group. This ratio will gradually become more balanced, projected to increase by the year 2050 to 83 in the 65+ group and 69 in the 80+ group (*Figure 1.4*). This is due to a projected decline in adult and old-age mortality in men (World Population Ageing 2013).

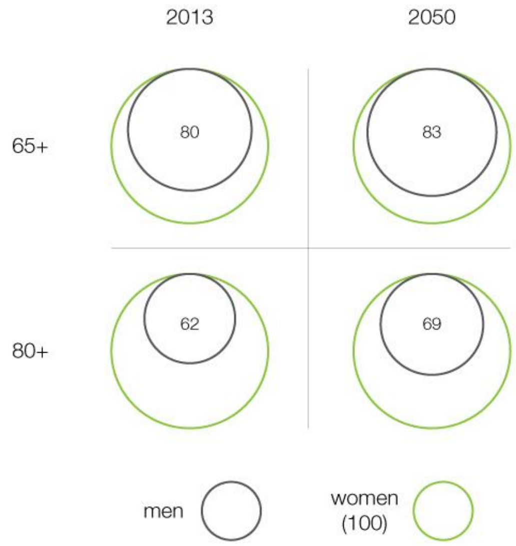


***Figure 1.4* The gender ratios in 65+ and 80+ populations in 2013 and 2050**
World Population Ageing 2013

Global ageing comes with a number of associated problems. One of these is the negative impact of increasing financial and social pressures on support systems like aged-care facilities. In the developed world, the number of working-age adults per older person in the population (the old-age support ratio) has declined continuously since 1950. The ratio has dropped from 12:1 in 1950 to 8:1 in 2013 and is expected to drop to only 4:1 by 2050 (World Population Ageing) (*Figure 1.5*). This means fewer people will be available within families or in facilities to provide aged-care support.

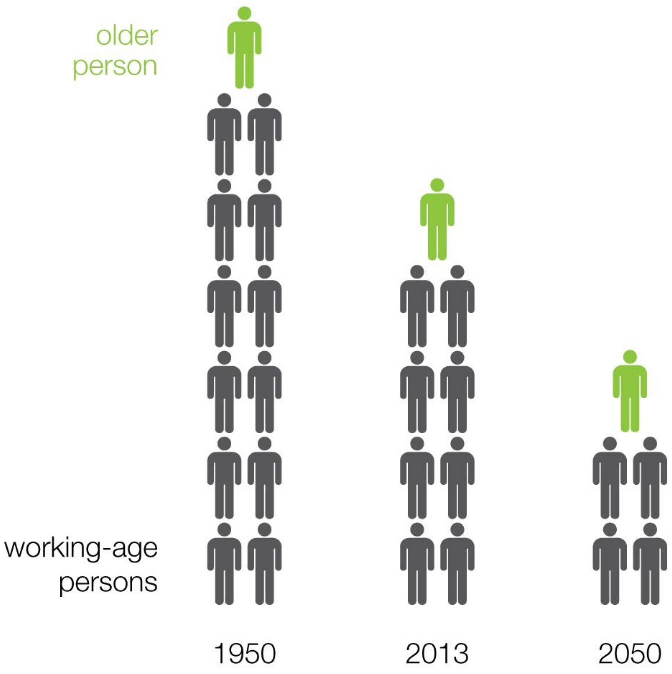


Figure 1.5 ***Number of working-age persons per older person***
World Population Ageing 2013

Longer lifespans raise the question of whether those additional years will be associated with continued good health or with prolonged disability and dependency. As people grow older, they become more prone to chronic and degenerative diseases. One such ailment is dementia, the incidence of which is proportional to age.

Dementia is expected to affect 115.4 million older people in 2050 if no major breakthrough is made before then (Alzheimer's Disease International 2009; Prince et al. 2013; World Health Organization 2007). Every 15 seconds, one new person joins the number of people diagnosed with dementia.

1.2 Dementia

The term 'dementia' describes a number of conditions caused by neuro-degeneration in excess of that resulting from natural ageing (Prince et al. 2013; Wimo et al. 2003). The deterioration in the volume of cortical tissue (from mildly-affected to severely-affected) creates voids in the brain that become larger, while the cortex undergoes shrinkage (*Figure 1.6*).

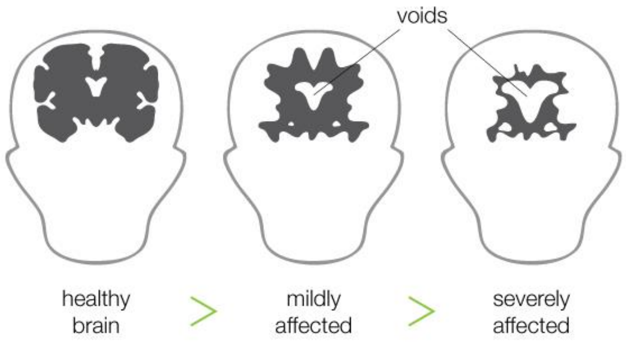


Figure 1.6 ***Healthy and affected brain tissue***
Alzheimer's Australia 2009

Dementia can occur at any stage of adulthood but is far more common in the geriatric population (Graham et al. 1997). Approximately 10% of adults over the age of 65 and 50% of those over 90 are affected (Bäckman et al. 2000; Jick et al. 2000; Jorm et al. 1987). Most of the conditions responsible for late-life dementia are progressive, degenerative and irreversible (Alzheimer's Australia 2009).

1.2.1 *The Prevalence and Incidence of Dementia*

In 2010, the population of people with dementia was 35.6 million. This number is estimated to nearly double every 20 years to approximately 65.7 million in 2030 and to 115.4 million by 2050 (Alzheimer's Disease International 2009; Prince et al. 2013; World Health Organization 2007).

With larger populations of older people, the low- and middle-income countries account largely for the global increase in the prevalence of dementia (*Figure 1.7*). As far as gender is concerned, Ruitenburg et al. (2001) reported that in many studies suggesting a gender imbalance, results were based on limited data and therefore inaccurate. The Rotterdam Study, however, reported that incidence was similar in men and women up to the age of 90, but higher in women over 90. This was particularly true for Alzheimer's disease. Meanwhile, men of all age groups had a higher incidence of vascular dementia (Ruitenburg).

Examples of low- and middle-income countries – Bangladesh, India, Nigeria, Pakistan, Sri Lanka, Sudan, Vietnam, Zambia.
Examples of high-income countries – Australia, Canada, France, Germany, New Zealand, Singapore, Switzerland, United Kingdom, United States.
(World Bank 2017)

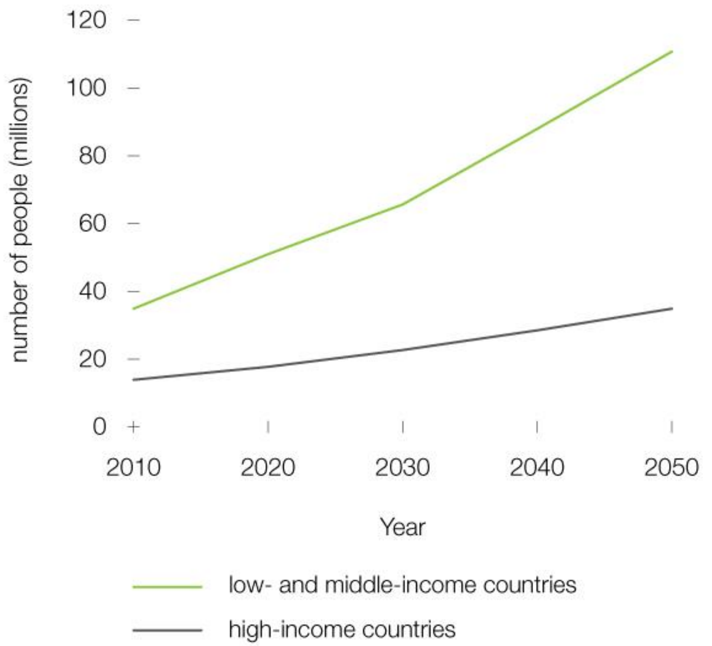


Figure 1.7 ***Projected growth in number of people with dementia in high-income and low- and middle-income countries***
Alzheimer's Disease International 2009

1.2.2 The Types of Dementia

Dementia may be caused by any of several diseases. The most common is Alzheimer's disease, also referred to as AD. It accounts for more than 50% of all cases. It is caused by the loss of nerve cells, resulting in shrinkage of the brain and abnormal changes in brain tissue. The second most common type is vascular dementia (VaD) which is caused by a lack of blood supply to the brain, most commonly through a stroke. It is possible for AD and VaD to be co-existent (*Figure 1.8*).

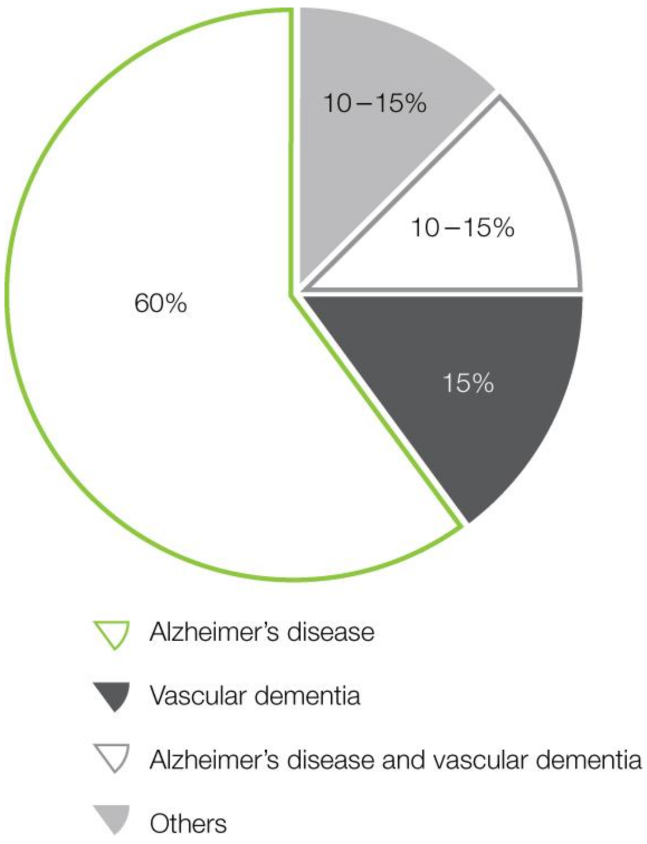


Figure 1.8 ***Distribution by causal disease***
Department of Health and Ageing 2006

The less common types of dementia include Parkinson's disease, dementia with Lewy bodies, frontotemporal dementia, Huntington's disease and Creutzfeldt–Jakob disease. The most prevalent among these is Parkinson's disease, caused by the loss of the neurotransmitter dopamine in the brain. It is a progressive disorder of the central nervous system that may result in tremors, body stiffness, speech disorders and difficulty in initiating physical movements. Parkinson's disease accounts for 3% to 4% of all cases (Department of Health and Ageing 2006).

1.2.3 *The Symptoms of Dementia*

Dementia has many symptoms. The most common initial symptom is a decline in the ability to remember new information. This is because the first neurons to die are in the regions of the brain where new memories are formed (Alzheimer's Association 2014).

The International Psychogeriatric Association (IPA) has grouped the symptoms of dementia under the umbrella term 'behavioural and psychological symptoms of dementia', also referred to as BPSD (Finkel et al. 1996). These may vary depending on the level of impairment. An individual with mild dementia may experience one or two symptoms such as misplacing items or repetitive questioning that have a relatively minor effect on day-to-day living. Those with moderate or severe dementia may experience a greater number of symptoms such as agitation or aggression that require constant oversight.

Behavioural symptoms of dementia include wandering, screaming and cursing, restlessness, culturally inappropriate behaviours and sexual disinhibition. Agitation and wandering have been reported as the most enduring symptoms of dementia (Devanand et al. 1997).

Psychological symptoms of dementia include depressive mood, anxiety, delusions and hallucinations. Other common symptoms (neither behavioural nor psychological) include loss of memory, confusion, loss of language and communication skills, loss of ability to perform everyday tasks, disorientation in relation to time and space, impaired judgement and physical coordination due to muscle rigidity, learning and concentration difficulties, altered sleeping patterns and eating disturbances (Alzheimer's Australia 2009, 2012; IPA 2012).

A British survey reported that among mildly, moderately or severely affected persons at aged-care facilities, the rates of aggression ranged between 4% and 42%, while the rates of agitation ranged between 48% and 82% (O'Connor et al. 1990).

BPSD make life very difficult for affected individuals, family members and caregivers (Burgio et al. 1996; Deimling and Bass 1986; Finkel et al. 1996). Untreated BPSD may contribute to premature institutionalisation (O'Donnell et al. 1992), increased financial cost (Cohen-Mansfield 1995), reduced quality of life for both caregivers and individuals with dementia (Burgio et al. 1996) and significant caregiver stress at aged-care facilities (Draper et al. 2000; Rodney 2000).

Psychologically oriented paradigms have emerged to explain BPSD and to generate feasible interventions. Inappropriate behaviours in residents can become entrenched when caregivers reward them with attention. For example, the frequency of calling out increases if caregivers attend to residents when they are noisy but ignore them otherwise (Teri et al. 1998).

The *unmet needs paradigm* states that inappropriate behaviours stem from caregivers not perceiving or addressing basic physical, emotional and social human needs (Cohen-Mansfield 2001). Individual needs for social interaction and physical movement, for instance, can be addressed through carefully selected group activities and exercise. According to the stress threshold model, dementia reduces the ability to deal with stress, resulting in unbefitting behaviours (Hall and Buckwalter 1987). Attending to signals of distress and allowing alternating periods of activity and rest can decrease stress levels (O'Connor et al. 2009).

O'Connor et al. (1990) observe that carer burden is proportional to the severity of the symptoms of dementia. The behavioural patterns of individuals with dementia pose a challenge to the inexperienced family members charged with the responsibility of caring for them. More severe stages of dementia result in individuals being admitted to aged-care facilities, where they can be cared for and monitored by professional health workers (Schultz and Williamson 1991). The result is a high prevalence of BPSD in resident populations (Haupt and Kurz 1993).

1.3 *The Challenges at Aged-Care Facilities*

Moving from the comfort of family homes to residential care can be very challenging. The sudden change of routine, loss of self-reliance and lack of familiarity in a new environment often result in depression, which can affect a resident's quality of life and increase the risk of cognitive impairment (Baldwin 2008; Boyle and Wilson 2010). The situation may be compounded by family members gradually finding it more difficult to communicate with their loved ones in the facility.

Shortfalls in staffing levels due to low wages and lack of adequately trained personnel may result in limited personal attention, assistance and social stimulation for residents (Cohen-Mansfield 2001), creating a sense of boredom and isolation and/or loneliness in the interned population (Alm et al. 2003; Cohen-Mansfield 2001). This leads to a lack of meaningful activities in aged-care facilities (Brooker et al. 1998; Chung 2004). By providing more stimuli and activities, the quality of life of people with dementia could be improved (Marshall and Hutchinson 2001; Robinson et al. 2006).

1.4 *The Problems with Medication*

Even though there is currently no cure for dementia (Alzheimer's Australia 2009), medication is used to treat BPSD (not including common symptoms such as loss of memory, which are neither behavioural nor psychological). Despite evidence of high placebo response rates, medication continues to be the primary form of treatment for BPSD (Ballard and O'Brien 1999; Douglas et al. 2004). According to Douglas et al. (2004), medicinal approaches, due to their adverse side effects, should be the second-line approach in treating BPSD. In the developed world, more than 40% of people with dementia are being prescribed unnecessary medication. Prescribing these drugs without first considering other treatment options can be of particular concern (Margallo-Lana et al. 2001). They may produce adverse side effects such as sedation, falls, reduced well-being and quality of life (Ballard et al. 1997), and even cognitive decline (McShane et al. 1997).

Other side effects include drowsiness, shaking and unsteadiness, increased risk of infections, blood clots, stroke, worsening of other dementia symptoms and possibly an increased risk of death (Ballard; McShane).

Drugs may help reduce BPSD, but at the expense of a person's quality of life (Ballard and O'Brien 1999; Douglas et al. 2004). *Table 1.1* displays the adverse side effects associated with the more commonly used antipsychotic drugs.

adverse effect	amisulpride (Solian, Sulprix)	aripiprazole (Abilify)	chlorpromazine (Largactil)	clozapine (Clopine, Clozarill)	haloperidol (Seranace)	olanzapine (Zyprexa)	paliperidone (Invega)	quetiapine (Seroquel, Seroquel X R)	risperidpne (Ozidal, Resdone, Rispa, Risperdal, Rixadone)	ziprasidone (Zeldox)
weight gain	+	+	+++	+++	++	+++	++	++	++	+
sedation	+	+	+++	+++	+	+++	++	+++	++	++
dry mouth, dizziness, constipation	+	+	+++	+++	+	+++	+	++	+	+
involuntary reflexes and movement	++	+	++	+	+++	+	++	+	++	+
low blood pressure, dizziness	+	+	+++	++	+	+	++	++	++	++
involuntary movement (lower mouth)	Occurs more frequently with 'conventional' antipsychotics									
QTc prolongation (in heart)	Can occur with all antipsychotics: ziprasidone has a greater risk									
fever, muscular rigidity, altered mental status and autonomic dysfunction	Reported with all antipsychotics									

+ = 10%
++ = >10%
+++ = > 30%

Table 1.1 ***Common and serious adverse effects of oral antipsychotics***
National Prescribing Service 2011

The medical terms for the adverse side effects in Table 1.1 have been changed to their more common names for purposes of this research.

It has been reported that antipsychotic drugs help 50% of people with dementia; however, they can cause serious side effects, especially if used for more than three months. According to the Alzheimer's Society (2006), all medication used for treating the symptoms of dementia has side effects that may worsen those symptoms. This encourages the use of non-medicinal approaches to alleviate some of the symptoms of dementia. Douglas et al. (2004) point to an increasing recognition for pharmacological treatments to be used as a second-line approach and for non-pharmacological options, in best practice, to be pursued first.

1.5 Non-Medicinal Therapies

O'Connor et al. (2009) reported that non-medicinal therapies, in particular those tailored to participants' backgrounds, interests and skills, were effective in reducing some of the symptoms of dementia. Increasing numbers of non-medicinal therapies are available for individuals with dementia, with several areas of overlap among them. It is very rare for one therapy to be used on its own (Ballard et al. 2001). It is therefore important for therapists to carefully select the combination that best suits an individual's preference. These therapies fall within the three highlighted categories listed in *Table 1.2*.

standard therapies	alternative therapies	brief psychotherapies
behavioural therapy	art therapy	cognitive behavioural therapy
reality orientation	music therapy	interpersonal therapy
validation therapy	activity therapy	
reminiscence therapy	complementary therapy	
	aromatherapy	
	bright-light therapy	
	multi-sensory approaches	
	simulated presence	

Table 1.2 ***Types of non-medicinal therapies for treating BPSD***
Douglas et al. 2004

Of these, reminiscence therapy, music therapy and simulated presence reported high beneficial effects (O'Connor et al. 2009). The chapter now discusses studies involving these three therapies. Information on other types of non-medicinal therapies can be found in *Appendix A* (*page 184*).

1.5.1 *Reminiscence Therapy*

Reminiscence therapy is a way of reviewing one's past or telling others about past experiences. It focuses on positive events to facilitate pleasure, improved quality of life or adaptation to present circumstances. This is accomplished with the aid of tangible reminders such as photographs, familiar items, music and archived sound recordings (Cappeliez et al. 2005; Dochterman and Bulechek 2003; Woods et al. 2005).

Research on reminiscence systems has focused largely on people with dementia and kindred ailments (Astell et al. 2008; Sarne-Fleischmann and Tractinsky 2008). During an assessment of reminiscence therapy, its benefit and value to people with dementia were shown by Wang (2005). However, Woods et al. (2005) showed that there was not enough evidence to reach a definite conclusion. Chaudhury (2003) has suggested place-based reminiscence as potentially beneficial to enhancing the quality of life of older adult residents, including those using reminiscing facilities (Kuwahara et al. 2006). Bohlemeijer et al. (2007) showed that reminiscence, in particular life review (elements of familiarity), improved psychological well-being.

A study on the effectiveness of life review (Cohen-Mansfield and Werner 1998) focused on bare surroundings at aged-care facilities that caused a lot of pacing in residents. Two of the most used corridors were chosen as the setting. A 'natural' scene was created in one corridor using posters, plants, forest smells and taped bird-chirping sounds. In the other, a 'home and people' scene was created using family photographs, traditional music and an aroma of citrus. The behaviour of residents was measured by direct observation, photoelectric counters and activity monitors. This inexpensive and easy-to-set-up experiment resulted in residents doubling the amount of time they spent in the corridors and cutting down on pacing and frequent wandering. Time spent seated in the hallway increased significantly with the home and people scene, but not with the natural scene. Wandering reduced by a small degree, and caregivers and relatives also enjoyed the improved environment. The studies reported that reminiscence therapy had potential in enhancing the quality of life and psychological well-being of residents, as well as in reducing pacing and wandering.

1.5.2 *Music Therapy*

According to Killick and Allan (1999), several studies have reported the benefit of music to people with dementia. Music therapy involves engagement in activities such as singing, playing an instrument or simply listening to music. Positively reported interventions for BPSD using non-personalised music and sound are reviewed here, while those using personalised music are addressed in *Section 1.5.3*.

Ragneskog et al. (1996) played three genres of music to residents during mealtimes. The results reported that restlessness declined by 25% with modern pop songs, 33% with 1930s jazz and 75% with soft, soothing music. The residents also ate a little more than usual when music played in the background.

Burgio et al. (1996) played soothing sounds of mountain streams or gentle ocean waves to severely verbally disruptive residents and measured their responses. Periods of verbal disruption were significantly fewer when the sounds were played. Stream and wave sounds were just as effective in relaxing residents as the music in the study by Ragneskog et al. (1996).

Groene (1993) observed that residents who had been prone to wandering stayed closer to therapists while music played, even though their movement was not restricted. Music, even when not personalised, was more effective than readings of interest. Lord and Garner (1993) reported higher levels of well-being and social interaction in residents when music was played to them. Remington (2002) subjected agitated residents to treatments of calming music (a soft, repetitive baroque classic), gentle hand massage, or a combination of the two. After the treatments, mean agitation counts fell from baseline by 37% with massage, 50% with music and 61% with the combination.

These studies reported that music had potential in enhancing the levels of well-being and social interaction, and in reducing restlessness, verbal disruption, wandering and agitation.

According to Baird and Samson (2009), parts of the brain associated with music and emotional memory are preserved in individuals with dementia. This may be one reason for the effectiveness of music.

1.5.3 *Personalised Music*

Several studies on the effectiveness and benefits of individually tailored music as a therapy for the reduction of some of the symptoms of dementia have shown its superiority to randomly selected music.

An American organisation called Music and Memory has trained caregivers to set up personalised music playlists for people with dementia on hand-held music players. The aim is to stimulate long-term memories that have not been lost to dementia, enabling individuals to converse and to socialise (Music and Memory 2010).

In a study claimed by Music and Memory, a resident called Henry, who had suffered from dementia for a decade during which he barely spoke, was video-recorded listening to his favourite music at an aged-care facility. According to the organisation, observations by trained caregivers reported that as the music came on, his face lit up, his eyes opened wide, his body began to dance, and he was seen to be animated by the music (*Figure 1.9*). Similar results were noted each time he was treated to his favourite music. Parts of this study were video-taped and used to encourage this intervention in nursing homes.

Figure 1.9 ***Henry, before and after listening to his favourite music***
Music and Memory 2010

This program has been implemented by Wisconsin Nursing Homes to reduce unnecessary prescription of medication to its residents, in a nationwide effort to reduce the use of medication in aged-care facilities.

A survey reported that availability of music was a priority for people seeking aged-care facilities for themselves or their family members. Up to 83% preferred facilities offering music players with personalised music, even if it meant spending more money (Music and Memory).

In another study, Clark et al. (1998) observed aggressive residents being bathed while their favourite music played in the background. Compared to a control group of aggressive residents being bathed without music, cases of physical violence against caregivers fell by 27%, grabbing by 35% and yelling by 64%. Rates of observed aggressive behaviour were halved overall. In a similar study by Thomas et al. (1997), the behaviour when bathing with preferred music showed a 42% decline in physical aggression.

Sherratt et al. (2004) tested the importance of personal engagement and interaction by playing recorded music, the same music covered by a musician, and a live performance by the same musician, who attempted to engage participants in the activity. The music chosen was based on the preference of the residents. Results showed that the live performance reported the highest rates of excitement, engagement and well-being, and the lowest rates of boredom and sleep.

Gerdner (2000) observed the behaviours of agitated residents when exposed to either soothing 'classical relaxation music' or music that was carefully matched to their interests. Rates of agitated behaviours fell from baseline by 49% with classical and 61% with personalised music. Music personalised to residents' preferences proved more effective than a random selection. The rates of agitation were lower even 30 minutes after completion of the study.

These studies reported a decline in yelling, grabbing and physical violence, concluding that personalised music had potential in reducing aggression. The study by Music and Memory also demonstrated that personalised music could help reduce the amount of medication prescribed to individuals with dementia.

1.5.4 Simulated Presence

Visits by family members provide comfort to residents of aged-care facilities. However, the effect does not last beyond visit times. Simulated family presence aims to improve stressful situations for residents by having relatives make recordings of scripted 'telephone conversations' about valued memories from the past. The conversations are designed to stimulate long-term memory in residents (O'Connor et al. 2009).

Camberg (1999) compared simulated presence audiotapes with recorded readings from a newspaper. The audiotapes were played by caregivers in random order at least twice daily to 54 residents who were agitated or socially withdrawn. Behaviours for each condition monitored over a four-week period showed that most participants responded well to the audiotapes. However, no difference was observed during the intervals between treatments.

Garland et al. (2007) compared simulated presence audiotapes, recordings of music tailored to residents' previous interests and a placebo condition of readings from a gardening book. Researchers applied treatments at times when residents were most agitated. Agitation rates fell from baseline by 15% during the placebo condition, 25% during personalised music and 30% during simulated presence. For verbally agitated behaviours, the rates fell by 18%, 29% and 33% respectively. Counts of both physical and verbal behaviour were still lower than baseline 15 minutes after treatment. Half of the participants showed a drop in behaviour counts of 50% or more for one condition or the other. However, a few residents became more disturbed, and the recording of positive memories proved time consuming and laborious to many family members. Music recordings were easier to prepare and worked almost as well as simulated presence.

Similarly, Cohen-Mansfield and Werner (1997) compared simulated presence videotapes with audiotapes of preferred music and one-on-one interaction in a repeated-measures study on residents exhibiting verbally disruptive behaviours such as shouting, complaining and repeating words. The content of the simulated presence tapes was chosen by family members. Each of the three treatments worked better than no treatment at all. Results reported that rates of verbal agitation fell from baseline by 34% during preferred music, 50% during simulated presence and 66% during one-on-one interaction. Behaviours returned quickly to baseline levels once treatments stopped. Carefully constructed one-on-one social interaction had a healing effect on two mute participants, who started to speak again after a couple of sessions.

While simulated presence in general reduces verbal agitation among residents in aged-care facilities, videotape simulation is considerably more effective than audiotape simulation due to the combination of visual and audio elements (Cohen-Mansfield and Werner).

Overall, simulated presence recorded higher potential than personalised music in reducing agitation (including verbally agitated behaviours).

1.5.5 *Summary of Non-Medicinal Therapies*

In summary, reminiscence therapy, music therapy and simulated presence have all been reported as effective methods for addressing different symptoms of dementia. In particular these studies indicated that:

- reminiscence therapy was most effective when using photographs (Astell et al. 2008; Bohlemeijer et al. 2007; Cappeliez et al. 2005; Cohen-Mansfield and Werner 1998; Dochterman and Bulechek 2003; Kuwahara et al. 2006; Sarne-Fleischmann and Tractinsky 2008; Woods et al. 2005).
- personalised music was more effective than randomly selected music (Clark et al. 1998; Gerdner 2000; Music and Memory 2010; Sherratt et al. 2004; Thomas et al. 1997).
- videotaped simulated presence was far more effective in reducing agitation than audiotaped simulated presence (Cohen-Mansfield and Werner 1997).
- a combination of therapies was more effective than any one therapy by itself (Remington 2002).
- one-on-one interaction was more effective in reducing verbal agitation than personalised music or simulated presence.

1.6 *The Research Question*

Studies have reported that reminiscence therapy, personalised music and simulated presence improved the quality of life, psychological well-being and levels of social interaction in people with dementia, and reduced levels of agitation, aggression (yelling, grabbing, physical violence), pacing, wandering, restlessness and boredom. As in the study by Remington (2002), which combined two therapies and reported higher reductions in BPSD, there was clearly potential for developing an effective non-medicinal intervention that provided reminiscence, personalised music, simulated presence and autonomous use to individuals at any stage of dementia. Such an intervention might reduce some of their common symptoms and provide them with a higher degree of self-reliance.

The aim of this research was to propose and develop a response to the challenges posed by the common symptoms of dementia in residents at aged-care facilities, in particular:

- loss of self-reliance, which may lead to depression
- boredom
- isolation and/or loneliness (Alm et al. 2003; Cohen-Mansfield 2000a)

Based on the potential demonstrated by non-medicinal interventions, the research question asked:

***How can a personalised multimedia system be designed to enhance the quality of life of individuals with dementia and provide them with a high degree of autonomous use, while adapting itself easily to the deteriorating stages of their condition from mild to moderate to severe*?**

Figure 1.10 summarises the problem areas discussed in this chapter and how they are linked to one another. Based on knowledge gaps identified after the review of literature, a design hypothesis was formulated.

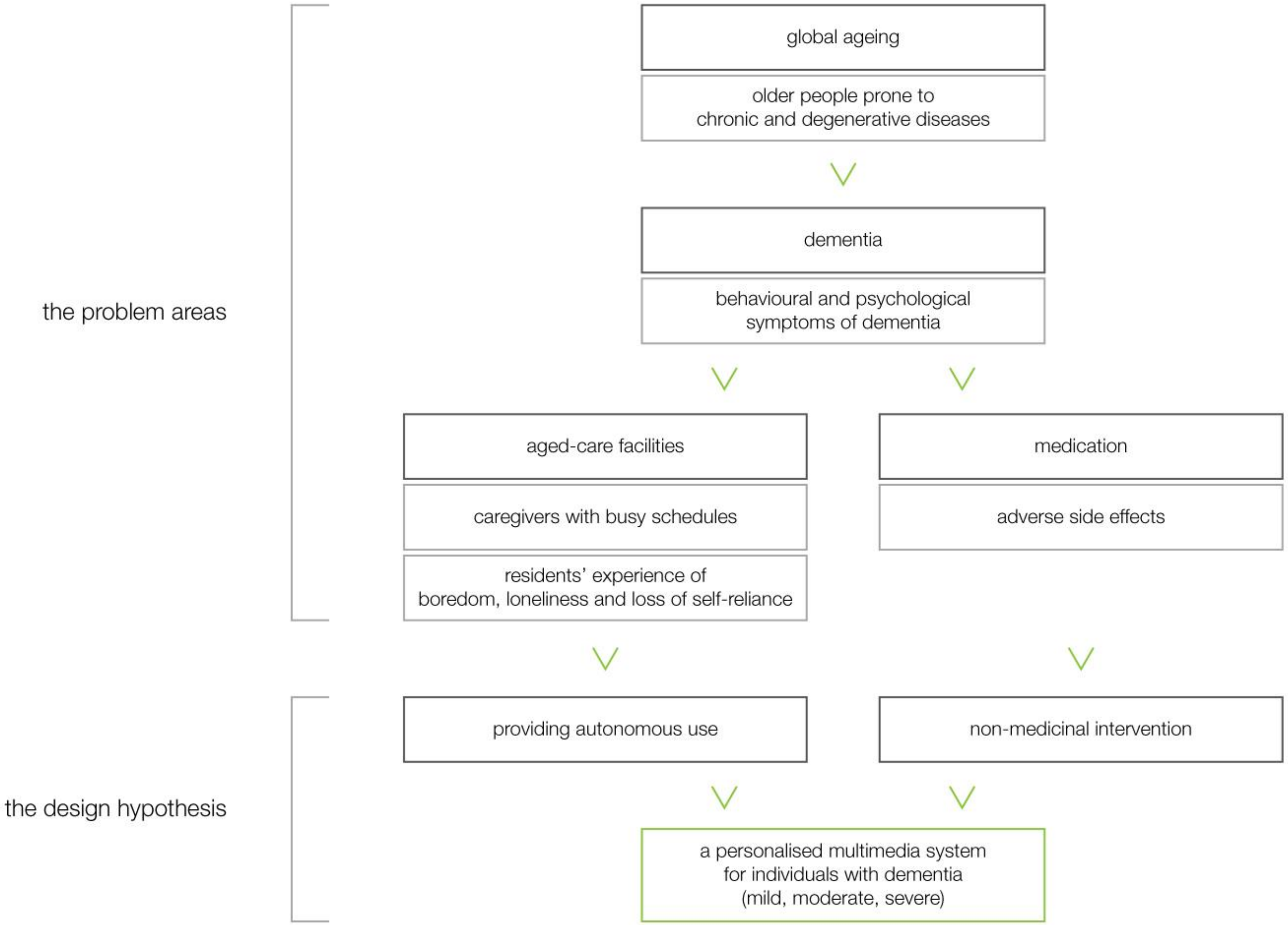


Figure 1.10 ***Framing the problems and identifying the design hypothesis***

Chapter Overview

Chapter 2 begins by stating the aim of the research and discusses the action research methodology that was implemented to achieve it. It does this by providing an outline of the work required in each chapter, the methods that were used and the desired outcomes. Each stage directed the ensuing stage of research until the aim was achieved.

For reasons outlined in the chapter, use was made of a mixed methods approach, in particular exploratory sequential mixed methods through studio-based, social and clinical research.

2.1 *The Research Methodology*

This research aimed to propose and develop a response to challenges posed by the common symptoms of dementia prevalent in residents at aged-care facilities, in particular:

- loss of self-reliance, which may lead to depression
- boredom
- isolation and/or loneliness

(Alm et al. 2003; Cohen-Mansfield 2000a)

Undertaken within the context of an industrial design study, the research aimed to develop its response in the form of a multimedia system consisting of a dedicated physical dimension offering personalised multimedia to people with dementia through specially considered information architecture. The design of the system lent itself to studio-based methodology.

Studio methodology is a form of action research (research through designing) that allows for the development of flexible methods to accomplish a desired outcome and to evaluate its effectiveness through continuing cycles of investigation (Stringer 2013). Studio methodology entails the collation of current and subsequent knowledge to inform the direction of creative concepts, leading to a more coherent and elegant solution. It uses sketches and models (computer-aided and physical) to create experimental ideas. According to Hanington and Martin (2012), it is important to contextualise and communicate design action during the ideation process.

The research used a mixed methods approach involving the integration of qualitative and quantitative data. In particular it used exploratory sequential mixed methods where the research began with a qualitative phase that explored participants' views on multimedia technology. The data was analysed to identify variables that could be used in a follow-up quantitative phase (Creswell 2013).

Figure 2.1 illustrates the action research plan that was used to achieve the research aim. It provides an outline of the work required, the methods by which the work was conducted and the desired outcomes, each directing the next stage of research. A detailed explanation of each stage then follows.

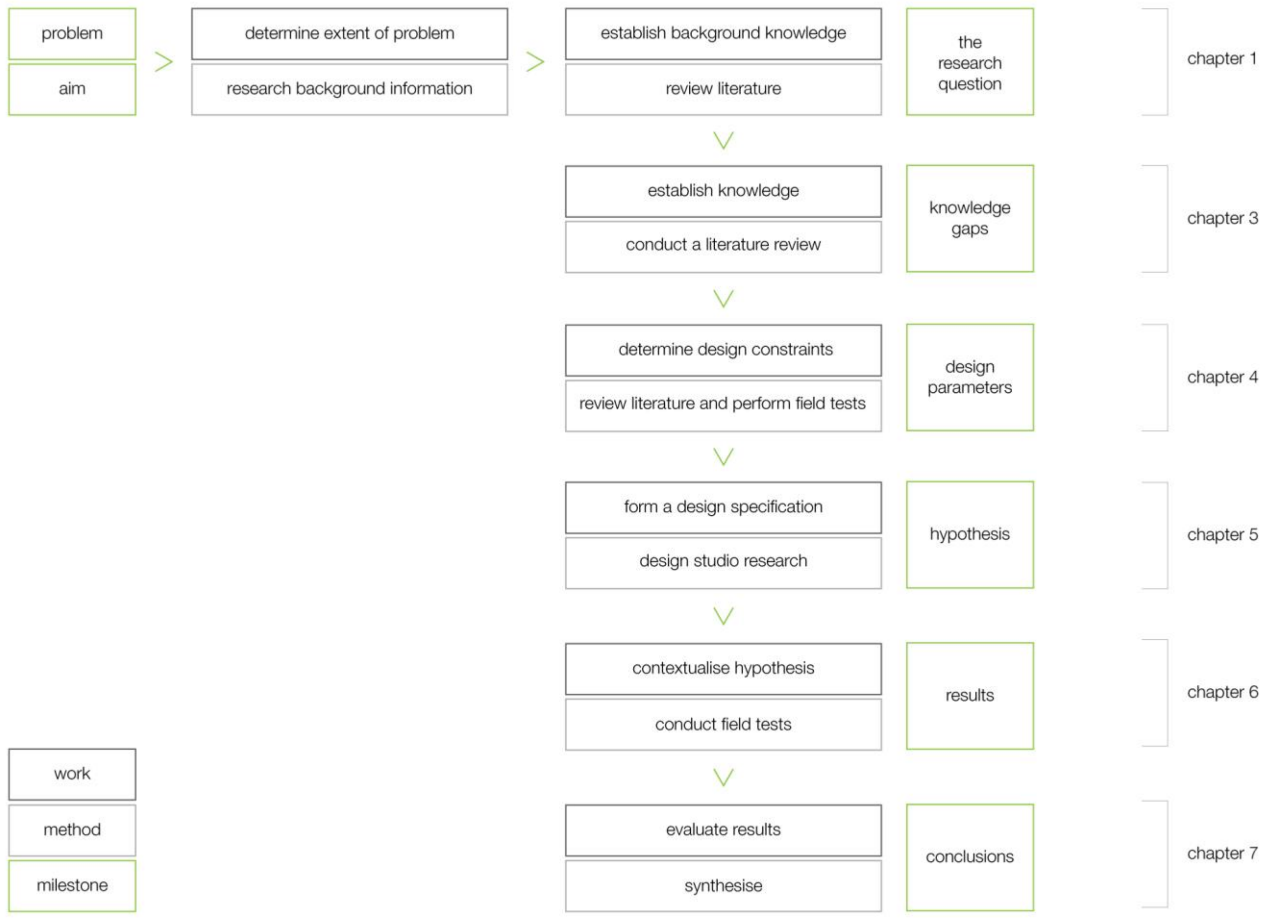


Figure 2.1 ***The action research plan for this research***

2.1.1 Chapter 1 *Introduction*

Douglas et al. (2004) encouraged the use of non-medicinal interventions as an alternative to medication in treating the symptoms of dementia. O'Connor et al. (2009) reported that non-medicinal therapies, in particular those tailored to participants' backgrounds, interests and skills, were effective in reducing some of the symptoms of dementia. Another review of effective non-medicinal therapies (reminiscence therapy, music therapy and simulated presence) established background knowledge in this area (*Section 1.5, page 12*).

According to Jesson et al. (2011), a review of literature is a method of becoming aware of and summarising existing literature on a subject so that it may be interpreted; it is different from a literature review which focuses on carefully analysing similar work within an area (Jankowitz and Jesson 2011) and adding the new dimension of one's own interpretation (Blumberg et al. 2005).

2.1.2 Chapter 3 *The Literature Review*

Chapter 3 details a literature review which used a systematic approach to identify multimedia interventions/systems for people with dementia, based on set criteria, with emphasis on those providing autonomous use. Literature was collected from books, journals, digital databases (such as Scopus, PubMed, PsycINFO and Google Scholar), conference proceedings, monographs and websites. Each intervention/system was evaluated following a discussion on those that met or came close to the desired specification. The limitations identified provided opportunities for further investigation and testing.

2.1.3 Chapter 4 *Design Constraints and Parameters*

Chapter 4 identifies constraints through a review of literature. These informed parameters for the development of the multimedia system. The process of parameter compilation began by reviewing literature concerning age-related physical and perceptual impairments, touchscreen technology (in particular touchscreen tablets) and knowledge from the literature review. This knowledge guided the development of prototypes that were tested over a period of five months on seven individuals with mild dementia at an aged-care facility.

It was at the field-testing stage that the first phase of the exploratory sequential mixed methods approach began. Use was made of questionnaires (social research methods) (Bryman 2016) and cohort studies (clinical research methods) (Hulley et al. 2013). The challenges faced by people with dementia when using technology were explored via prospective studies, where studies were conducted repeatedly. Both social and clinical research methods required ethical consideration and carefully selected sample groups (Hulley).

2.1.4 Chapter 5 *The Multimedia System*

Chapter 5 details the multimedia system's design process which, through ideation, experimentation, critique and iteration, led to a desired design specification and outcome. An anthropometric review (measurements and proportions of the human body) provided descriptive statistics of the Australian elderly to assist in informing the overall dimensions of the system. The research then demonstrated visual synthesis in the form of sketches, a method of visualising the ideas in the mind of a person (externalising the internal) by supporting design thinking and enhancing collaboration. It involves creating and removing, adjusting and compromising, and evaluating outcomes that may be incomplete but provide a better understanding of a goal through visual renders (Craft and Cairns 2009). According to Schütze et al. (2003), studies that use sketching result in significant benefits. Sketches were used in this research to assist in the early concept development of the physical dimension of the multimedia system, in response to the knowledge obtained and the anthropometric review. The most successful ideas were highlighted, evaluated and refined.

Tangible mock-ups or prototypes are limited representations of design concepts that allow users to touch, hold and interact with the designs. They provide designers with the opportunity to choose between alternatives, test the technical aspects of an idea, clarify requirements and test usability.

Tangible mock-ups are more effective than sketched or digital models, as their three-dimensional form is perceptible by more senses (Bødker and Buur 2002). This research used low-fidelity prototypes, which are inexpensive and easy to produce, using soft materials like cardboard and wood. High-fidelity prototypes are expensive as they are made from the same material as the final product (Preece et al. 2002). This method ensured that the physical dimension and its individual components (such as overall size, weight and structural integrity) conformed to the design specification, resulting in enhanced usability. The research then used computer-aided design (CAD) to conduct a material and aesthetic study on digital models of the multimedia system, eliminating the high costs of developing full-scale physical models.

The information architecture was developed through a review of literature. Terminology used in the search process included: 'interface design for the elderly', 'product design for people with dementia', 'semiotics' and 'design of information architecture'. Information architecture simulations were then developed. Based on knowledge from literature, structure models (qualitative) were first evaluated using hierarchical flow diagrams. After a process of iteration, refined concepts used iconic models (quantitative) that were programmed using screen-based technology.

Finally, a multimedia system simulation was developed for testing at aged-care facilities (*Chapter 6*).

2.1.5 Chapter 6 *The Field Tests*

Chapter 6 details tests of multimedia system use on eleven participants at two Melbourne-based aged-care facilities. This was the second and final phase of the exploratory sequential mixed methods approach, where quantitative research was conducted with the help of residents with mild, moderate or severe dementia. To ensure optimal integrity, the tests were conducted by psychologists who made use of the following social and clinical research methods:

- Obtain ethics approval.
- Select a sample group using a screening process based on the inclusion and exclusion criteria.
- Collect data before, during and after tests.
- Use a randomised cross-over design (description on next page).
- Evaluate results.
- Identify limitations.

Ethics approval was obtained from the Monash University Research Ethics Committee and Dementia Collaborative Research Centre (DCRC). Senior members of staff from the aged-care facilities assisted in the sample selection process by identifying potential participants through a discussion with the psychologists on the inclusion and exclusion criteria. A screening process verified the presence of at least mild cognitive impairment and agitated behaviour in participants, using a Clinical Dementia Rating Scale (CDR) and a Cohen-Mansfield Agitation Inventory (CMAI) (Cohen-Mansfield et al. 1989; Hughes et al. 1982).

A CDR is an instrument commonly used in clinical research to assess six areas of cognitive and functional impairment in people with dementia (Hughes et al. 1982). A criterion for the tests in this research was that all participants would have at least mild cognitive impairment. A CMAI measures the frequency with which a person with dementia demonstrates a list of 29 agitated behaviours over a one-week period (Cohen-Mansfield et al. 1989). This was used in the research to ensure that all participants displayed some form of agitation – another criterion for the tests. Participants' family members were provided with a detailed description of the study for obtaining their consent to their relative's participation.

Data was collected by psychologists before, during and after the tests. Prior to commencement, levels of depression, anxiety, agitation, caregiver burden and quality of life were measured at baseline (pre-intervention levels). Symptoms of depression were evaluated using the Cornell Scale (Alexopoulos et al. 1988); symptoms of anxiety by the Rating Anxiety in Dementia scale (RAID)

(Shankar et al. 1999); caregiver burden by the staff-rated Burden Interview (Sourial et al. 2001); and quality of life by Quality of Life in Alzheimer's Disease (QOL–AD) (Logsdon et al. 2002). During the tests, data was collected by the psychologists through observation and questionnaires (Bryman 2016). After the tests, data on patterns of use was collected from the multimedia system (automatically logged), while data on the satisfaction and feasibility of using the multimedia system routinely was collected through caregiver and family-member interviews (Bryman).

A mini-mental state examination (MMSE) is a 30-point questionnaire used for measuring cognitive impairment (Folstein et al. 1975; Pangman et al. 2000). It categorises participants according to their impairment levels. The MMSE provides an overall score out of 30. The following ranges were used in this research: 25–30 for normal cognition; 19–24 for mild cognitive impairment; 10–18 for moderate cognitive impairment; and 0–9 for severe cognitive impairment (Ward et al. 2002).

A randomised cross-over design provided two interventions, one after the other, to a group of participants while observations were made and data collected by psychologists (Hulley et al. 2013). This was used to identify differences in behaviour while using the multimedia system and a social control intervention (the same conditions without the multimedia system), each over a one-month period. A random number generator was used to assign the order in which the multimedia and the social control intervention were used.

A technique called spaced retrieval was employed as part of the multimedia system intervention (Hopper et al. 2001; Squire 2004; van der Ploeg et al. 2013). It tested recall of task accomplishment methods over increasing intervals, which helps people with dementia to learn and retain information (Creighton et al. 2013). This procedure has also been effective on people with severe dementia (Hopper; Squire; van der Ploeg).

The results were then evaluated and discussed, and limitations identified. Conclusions are drawn in *Chapter 7*, which determines how the research aim was achieved.

Chapter Three *The Literature Review*

Chapter Overview

Chapter 3 begins with the aim of the review, the criteria used for the selection of literature, interventions that were excluded for review and the review method. A qualitative analysis of the aims, methods and results of seven media interventions endeavours to identify potential media types that may be beneficial to the development of the multimedia system. This is followed by a discussion on the interventions, with emphasis on two that came close to meeting the desired specification. The conclusion identifies limitations that also provide opportunities for further investigation and testing.

3.1 *The Aim of the Literature Review*

Prior to commencement of the development of the multimedia system, it was necessary to obtain existing knowledge in the field of research through a review of the literature (Jesson et al. 2011).

There is a wide amount of research on non-medicinal, dementia-related interventions. This includes standard therapies, alternative therapies and brief psychotherapies as discussed in *Section 1.5* (*page 12*) (Douglas et al. 2004). According to O'Connor et al. (2009), reminiscence therapy, music therapy and simulated presence reported high beneficial effects in mitigating some symptoms of dementia. Of these, personalised photographs, personalised music and videotaped family presence showed potential in treating some symptoms of dementia, thereby justifying their inclusion in the multimedia system. The studies also reported that a combination of therapies was more effective than any one therapy on its own (Remington 2002).

Based on this knowledge and on the research question, the aim of the literature review was to identify and learn from those existing state-of-the-art media interventions that:

- utilised a combination of personalised media (particularly photographs, music and/or family-videos)
- provided a high degree of autonomy to individuals with mild, moderate or severe dementia
- adapted to the deterioration in users' impairment levels

3.2 *The Criteria*

A list of carefully considered criteria was developed for the literature review to ensure that only the most appropriate state-of-the-art media interventions were selected for review. The criteria were thus:

- Only interventions designed specifically for the demographic of this research – people with mild, moderate or severe dementia – were reviewed; those designed for spouses or caregivers were discounted.
- Interventions designed for joint use (persons with dementia and their caregivers or spouses) were not reviewed unless the intervention encouraged autonomous use by the person with dementia.
- An intervention was reviewed only if it was published, peer-reviewed, field-tested or already on the market. Therefore, several mobile phone or tablet apps for people with dementia were disregarded.
- Interventions with one media type were reviewed only if they utilised personalised media (preferably photographs, music and/or family-videos). This was so that additional knowledge obtained on that media type might assist in the development of the multimedia system.
- Robot interventions that were assistive, or provided companionship or monitoring, were not reviewed.

Every effort has been made to use the most current literature available. In cases where recent literature on a particular topic was either not available or did not meet the literature review criteria, the last available literature conforming to the selection criteria was reviewed.

Table 3.1 provides examples of interventions that did not meet the set criteria, resulting in their exclusion from the review.

intervention name / paper title	year	author(s)	reason(s) for exclusion
An interactive tool to promote musical creativity in people with dementia	2009	Riley, P., Alm, N. and Newell, A.	The intervention did not come equipped with music that was personalised to the users taste, thereby placing it in the 'non-personalised' media category
'YouTube': a useful tool for reminiscence therapy in dementia?	2011	O'Rourke, J., Tobin, F., O'Callaghan, S., Sowman, R. and Collins, D. R.	This intervention was designed to present videos based on topics generated by participants. As the intervention was facilitated by a therapist, it did not encourage autonomous use
Comparison of verbal and emotional responses of elderly people with mild, moderate and severe dementia in responses to seal robot, PARO	2014	Takayanagi, K., Kirita, T. and Shibata, T.	The intervention was not based on any media type
Feasibility of a Pocket-PC based cognitive control intervention in dementia spousal caregivers	2015	Callan, J, A., Siegle, G. J., Abebe, K., Black, B., Martire, L., Schulz, R., Reynolds, C. and Hall, M. H.	The intervention was designed for spousal caregivers (to encourage self-directed cognitive training)
Computer-based cognitive interventions for people living with dementia: a systematic literature review and meta-analysis	2016	Garcia-Casal, J. A., Loizeau, A., Csipke, E., Franco-Martin, M., Perea-Bartolome, M. V. and Orrell, M.	The intervention compared computer-based interventions with non-computer-based interventions, however did not provide forms of reminiscence, music or simulated presence
A systematic review of Internet-based supportive interventions for caregivers of patients with dementia	2017	Boots, L. M., de Vugt, M. E., van Knippenberg, R. J., Kempen, G. I. and Verhey, F. R.	The interventions were designed for caregivers
Music-based therapeutic interventions for people with dementia	2017	van der Steen, J. T., van Soest-Poortvliet, M. C., van der Wouden, J. C., Bruinsma, M. S., Scholten, R. and Vink, A. C.	The intervention offered music to individual and group participants; however, the music was not personalised
Viewing art on a tablet computer: a well-being Intervention for people with dementia and their caregivers	2017	Tyack, C., Camic, P. M., Heron, M. J. and Hulbert, S.	The art selected for this intervention was not personalised. The intervention was designed as a joint activity between a person with dementia and a caregiver, with no aim of encouraging autonomous use by the person with dementia

Table 3.1 ***Examples of interventions excluded from the literature review***

3.3 *The Method*

The literature review used a systematic approach to identify media-related interventions for people with dementia, with the criteria guiding the literature selection process. Literature was sourced from books, journals, digital databases (such as Scopus, PubMed, PsycINFO and Google Scholar), conference proceedings, monographs and websites. Each intervention is detailed here, stating its aim, method and results. In the discussion that follows, conclusions are drawn, and limitations identified, providing opportunities for further investigation and testing.

The following seven interventions best met the set criteria and were therefore selected for review:

- Personalised reminiscence photo-videos
- The Picture Gramophone
- Giraff (correct spelling)
- 3D environments (part of the 'Living in the Moment' project)
- Painting a pot (part of the 'Living in the Moment' project)
- Project CIRCA (Computer Interactive Reminiscence and Communication Aid for people with dementia)
- The Interactive Reminiscence Aid

Of these, Project CIRCA and the Interactive Reminiscence Aid provided the highest number of media types (three each). Only the Interactive Reminiscence Aid was available on the market; the others remained research studies.

3.4 *Personalised Reminiscence Photo-Videos*

Old photographs with sentimental value can be therapeutic to people with dementia. However, they may also reinforce feelings of loneliness and depression and therefore need careful management (Sandoz 1996). Family members or caregivers often compile scrapbooks with personalised images and photographs. While memory books are effective in providing reminiscence, they take a lot of time to compile; the photographs are usually too small for comfortable viewing by people with dementia; and the books may become heavy and bulky, requiring a family member or caregiver to facilitate the intervention (Yasuda et al. 2009). According to Mulvenna et al. (2011) and Yasuda et al. (2009), a screen-based alternative would facilitate the collation and enlargement of photographs, enhancing visual appeal and the overall experience.

Reminiscence interventions take advantage of the fact that long-term memories stay preserved well after short-term memories have faded (Rentz 1995). The interventions can prove difficult to administer at home due to a shortage of experienced personnel (Wang 2007). It is therefore important to identify convenient home-based reminiscence interventions such as watching familiar television which will trigger old memories. However, not all TV programs cater to personal preferences (Lund et al. 1995). Moreover, people with dementia often experience a decline in language comprehension, making it difficult for them to follow TV programs and day-to-day conversations (Hopper and Bayles 2001).

Studies by Lund et al. (1995) ('video respite') and Yasuda et al. (2007) on gardening videos, family events and old songs reported that generic videos were ineffective in providing enjoyment to people with dementia. This was due to the semantic amnesia that develops in this cohort, resulting in the inability to recall generic memories (Hopper and Bayles 2001; Yasuda et al. 1997).

In another study called 'video biographies', Cohen (2000) tested the efficacy of old photographs and favourite stories using personalised media. Results reported that they reduced agitation in people with dementia and improved their overall mood. According to De Renzi et al. (1987), people are more interested in themselves and their autobiographies than in generic affairs. The aim of the study was to determine the effectiveness of photo-videos as a reminiscence therapy for people with Alzheimer's disease.

Since personalised photographs provide higher levels of reminiscence to people with dementia (Cohen-Mansfield and Werner 1998), interventions using them were selected for review to obtain knowledge on methods of designing effective photo-videos, which might assist in the development of the multimedia system.

A comparison of effectiveness in providing reminiscence was made between personalised photo-videos and two TV shows. The photo-videos consisted of 40 photographs that played for 15 seconds each. Photographs were displayed in chronological order (childhood to adulthood) and panned and zoomed-in for 15 seconds each, with the aim of increasing participants' enjoyment levels. Old music or children's songs playing in the background kept participants calm and enhanced the overall experience of the intervention (Remington 2002; Yasuda et al. 2006). Each photo was accompanied by a narration in a young woman's voice speaking slowly and in short sentences, simulating how caregivers (the majority of whom are female) engage with individuals with dementia at aged-care facilities (Gormley et al. 2001; Romero and Wenz 2001).

The TV shows consisted of a popular variety show and a news show. Participants watched the photo-video twice, and each TV show once, using a clinical 'ABCA' design where the first and second 'A' were the same photo-video; 'B' was the TV variety show and 'C' the TV news show. If concentration levels were high for the second photo-video session, that was considered an effective intervention. Three speech therapists evaluated the participants' concentration and distraction levels, in particular their utterances, gestures, facial expressions and eye movements.

Overall, the photo-videos elicited higher levels of concentration than the TV shows. The first photo-video received the highest scores, followed by the second photo-video. All participants reported high levels of distraction when viewing the TV shows (particularly the news show). This was especially the case with those who had severe impairment, suggesting a decline in their language ability (Hopper and Bayles 2001; Yasuda et al. 1997).

3.5 *The Picture Gramophone*

Individuals with dementia who participate in different activities have higher levels of well-being, satisfaction, self-esteem and self-respect, and an improved quality of life. Studies have also reported reduced levels of challenging behaviour and confusion (Marshall and Hutchinson 2001). The activities include those that provide reminiscence, as in the previous study by Yasuda et al. (2009).

The chapter now looks at its second intervention, called the Picture Gramophone (PG), by Topo et al. (2004) that provides reminiscence using photo-videos on a touchscreen device instead of a TV set.

Touchscreen devices provide direct contact with onscreen selections, obviating the need for a mouse or keyboard therefore requiring minimal or no training. Astell et al. (2010) reported that touchscreen devices offered a supportive interaction environment for people with dementia and their caregivers. Since not all individuals with dementia are regular computer users, user-friendly interfaces would facilitate accessibility to media that provide reminiscence.

PG used a touchscreen device that offered photo-videos to individuals with dementia. The aim was to provide reminiscence and enjoyment, to encourage autonomous use and to determine if there were any adverse side effects associated with its use. Twenty-three people with varying impairment levels and dementia types received the PG intervention for three weeks at day-care centres in four countries (England, Norway, Ireland and Finland). The dementia types included AD, VaD and dementia with Lewy bodies (*Section 1.2.2, page 8*).

Each photo-video showed personalised photographs, accompanied by preferred songs and synchronised lyrics. A home-screen displaying between two and six selections of music genres or artists was presented to participants. When a selection was made, a new page appeared, displaying the selected photo-video with its respective title and associated photograph.

Overall, the results reported that all participants enjoyed and benefited from the use of PG, with no noticeable adverse side effects. They did, however, encounter some problems. Owing to differences in touchscreen device models in the four countries, levels of touchscreen sensitivity varied, making some touchscreens difficult for participants to use. Small screen sizes made it difficult to read text, affecting the participants' ability to view lyrics and photo-video titles. Some songs evoked negative memories, while others were too fast to sing along to (Topo et al. 2004).

Caregivers requested the option of switching off lyrics, as they threw some participants off time; alternatively, they asked for the incorporation of a pause button that enabled participants to catch up with a song. Songs that were too long caused some participants to fall asleep before realising there was a 'choose another song' option on the screen (Topo).

3.6 Giraff

An important aspect of dementia care is to provide a degree of communication between residents and family members or caregivers. Residents should be able to express their needs rather than face social isolation (Moyle et al. 2013). However, due to family members' and caregivers' busy schedules, this is often not the case (Alm et al. 2003; Cohen-Mansfield 2001). The situation may be compounded by work pressures whereby family members gradually find it more difficult to travel long distances to aged-care facilities and communicate with their loved ones (Moyle 2013; Schultz and Williamson 1991).

People with severe dementia have greater difficulty in communicating due to loss of verbal expression. Analysing non-verbal behaviours in people with dementia makes it possible to evaluate emotional conditions and help caregivers and family members to individualise ways of encouraging positive emotions (Bar 2003).

The next intervention used a telepresence robot (a robot with a screen) to address the issue of social isolation in residents. Telepresence robots have demonstrated their potential in helping people with dementia to communicate with their family members (Boissy 2007). Robots such as TRIC (Telepresence Robot for Interpersonal Communication) and the Physician-Robot have been tested on older people and on patients in hospitals (Tsai 2007).

The chapter now reviews a telepresence robot called Giraff, developed by Giraff Technologies. Giraff was a 5-foot tall motorised robot with a camera, microphone, speaker, screen and motorised wheels (*Figure 3.1*). It made use of simulated presence to facilitate a two-way video call between a resident and family members or caregivers at home or in an office. Moyle et al. (2013) described Giraff as 'Skype on wheels'. Giraff provided family members with a specialised interface that they could access on their personal computers. The interface allowed family members to view their relative's bedroom via the camera mounted atop Giraff and navigate through the bedroom (or facility) via its motorised wheels.

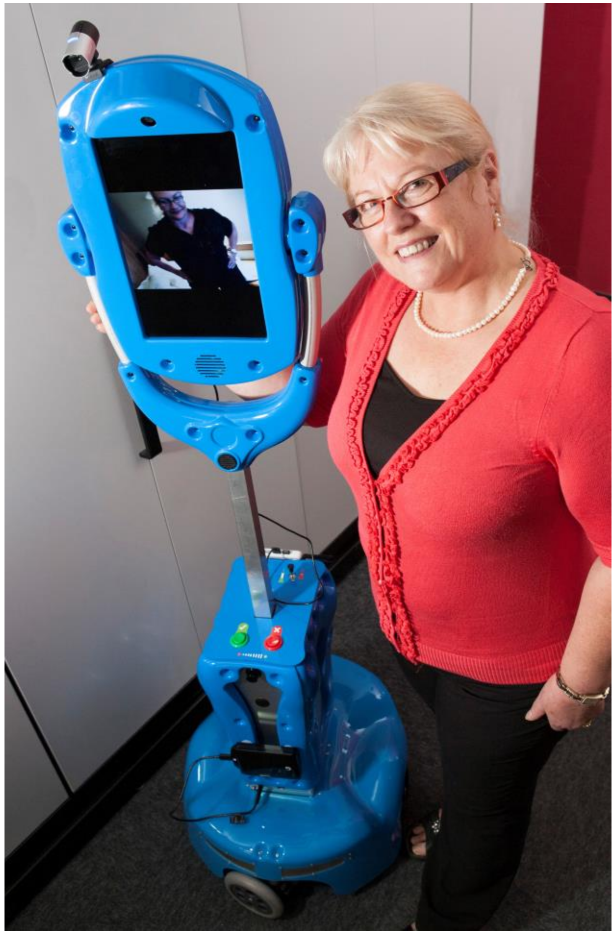


Figure 3.1 ***Giraff***
Medical News Today 2013

Five individuals with mild to moderate impairment, having no (or minimal) hearing impairment and demonstrating capability of engagement, participated in a study. It used a mixed methods approach consisting of semi-structured interviews and caregiver observations of verbal and non-verbal behaviours over a period of six to eight weeks. The aim was to facilitate an average of six video calls between a participant and a family member.

Caregivers reported that people with dementia and their family members thoroughly enjoyed the telepresence interaction sessions. The sessions reduced the levels of social isolation in the residents and facilitated family members to communicate with them (some after years) without making long trips to aged-care facilities. Face-to-face interaction was preferable as, during telephone conversations, participants forgot who they were talking to, got bored or held their phones upside down, making conversation very difficult. According to Moyle et al. (2013), one family member commented that face-to-face interaction made the experience 'more real'. This may have been due to the sincerity evident on the large face size on the screen. Another family member, babysitting her grandchildren (the relative's great-grandchildren), included them in the conversation, enhancing the session.

Two family members commented on the benefits of having the screen mounted; they previously had trouble in maintaining the angle of their digital tablets during video calls. An additional benefit was that, unlike telephones or tablets, Giraff could not be misplaced. There was concern that Giraff was not equipped with a wireless internet feature, which limited the overall number of video-calls, as not all areas in the facilities had wall-mounted internet outlets.

Overall, Giraff provided reassurance to residents and family members in spite of the distance between them. The study demonstrated that participants not only accepted the new technology but were neither confused nor frightened by it (Moyle).

3.7 Living in the Moment 3D Environments

Computer games promote a sense of achievement and can provide 'flow' or immersion in an activity that makes a player lose track of time (Gee 2005). In order to maintain flow, the level of challenge of an activity should match a person's ability. If the challenge is greater than the ability, the person becomes overwhelmed and anxious, whereas if it is lower, the person gets bored. It is therefore important to have the perfect balance when designing an activity (Csikszentmihalyi 1996).

Navigating through 3D environments is one such activity designed to maintain a person's flow. It is the first of two studies by the University of Dundee under the Living in the Moment project to be reviewed in this chapter. The aim of the study was to develop systems that people with dementia could use with a high degree of autonomy, enabling them to experience flow.

Five people with dementia explored three virtual environments on a touchscreen computer (Astell et al. 2006). The environments were a botanical garden, a pub and an art gallery. *Figure 3.2* shows the interface that participants used to navigate through the botanical garden environment.

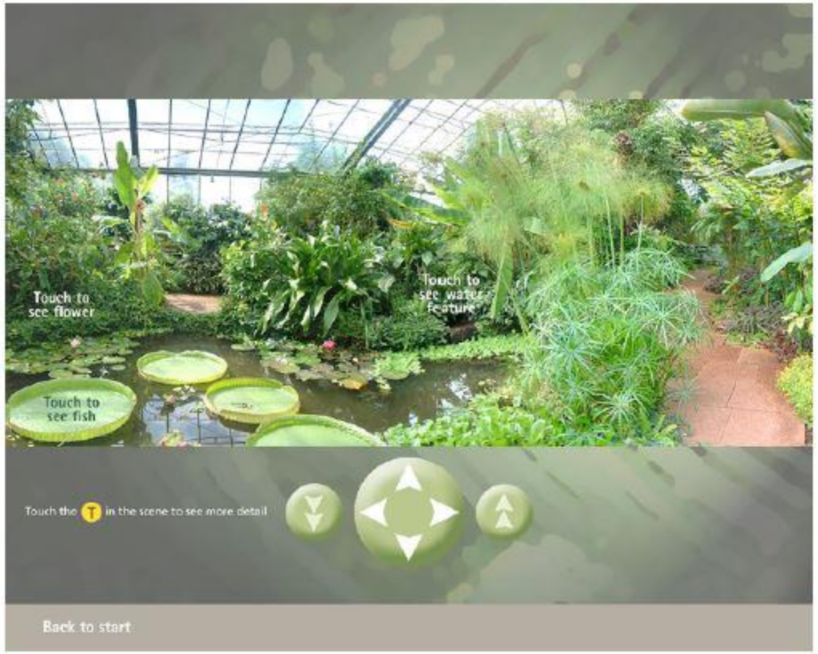


Figure 3.2 ***Botanical garden environment***
Astell et al. 2004, 2008

The simple interface allowed participants to change the horizontal and vertical viewing angles and move in a transverse manner. They were able to touch objects on the screen to view more details; for example, if they touched the water, they were able to see the fish swimming in it (Astell et al. 2008).

The study showed that all participants were able to navigate unaided through the three environments. They found the interface easy to use, with large arrows prompting them where to touch the screen. Participants commented on the environments during the study and continued to talk about their experience afterwards. The botanical garden was the most popular as it created a sense of relaxation and being around nature. The study showed that participants were able to imagine themselves in the virtual environment, for example sitting on a bench in the park or having a beer at the pub (Astell).

3.8 Living in the Moment Painting a Pot

Following their success with the 3D environments, the University of Dundee developed a second activity within the Living in the Moment project that would really put touchscreen technology to the test. It involved people with dementia painting a pot on a touchscreen. The aim was to determine if people with dementia could use touchscreen technology with proficiency and adapt it to activities such as painting. Eighteen people with dementia (all non-computer users) were required to spend five minutes on their own, painting a pot. The screen provided participants with a clay-like pot and a choice of four colours, as shown in *Figure 3.3*. After the study, they completed a questionnaire on the aspects of the activity that they enjoyed or did not enjoy, and their experience while using the touchscreen computer.

Results showed that most of the 14 participants found it easy to paint the pot on the touchscreen, enjoyed the activity and asked if they could do it again. Among the aspects participants did not enjoy were repeating the activity until their five minutes were up and worrying about doing it right. Features that participants enjoyed were selecting the colours, making patterns on the pot and the simplicity with which it could be done (Astell et al. 2008).

Figure 3.3 ***Painting a pot on a touchscreen computer***
Astell et al. 2008

The University of Dundee went on to develop other activities and games. These are listed in *Table 3.2* with a description of each activity.

activities	games
video-clip viewer walking a dog, observing dolphins	amusement arcade games pinball, bingo, slot machine
virtual animal watching a bird in a birdhouse	fairground games shooting, throwing balls into a hole
creative activities blowing bubbles, making a sculpture	sports crazy golf, ten-pin bowling
xPress play music composition software	

Table 3.2 ***Other activities and games by the University of Dundee***
Alm et al. 2009

The results demonstrated that the activities and games provided enjoyment and a degree of autonomous use due to their user-friendly interfaces, visual reminders (such as flashing buttons) and aural messages/instructions. Participants described the activities as 'engaging', 'attractive' and 'colourful' (Alm et al. 2009).

The chapter now reviews the two touchscreen interventions that provided three media types to people with dementia.

3.9 Project CIRCA

According to Alm et al. (2009), an important part of people's lives is the ability to entertain themselves. However, that ability is lacking in people with dementia, who require constant and uninterrupted attention. This can fatigue and challenge family members and caregivers and may create a sense of boredom and isolation in the interned population at aged-care facilities (Alm et al. 2003; Cohen-Mansfield 2001).

Conversation is the basis of communication. It is through talking and socialising that one's confidence and self-esteem are established. One side-effect of dementia, is the inability to converse due to loss of working memory (immediate, conscious, perceptual and linguistic processing). As a result, people with dementia become socially isolated in their everyday lives, thereby putting a strain on themselves, their family members and caregivers (Alm).

Usually stored in an unaffected part of the brain, long-term memory is better preserved than short-term memory in people with dementia (Astell et al. 2008). It is therefore important to find ways of stimulating these preserved memories. While family members would know the person's past better than anyone else, having a conversation may be difficult as it is often one-sided. Therefore, if conversation could be encouraged with the help of technology, it would result in an enjoyable experience for both parties (Astell).

The University of Dundee developed enjoyable interventions for people with dementia. The 3D environment activity provided entertainment and the 'painting a pot' activity encouraged creativity (Astell et al. 2008). The chapter now reviews an intervention called Project CIRCA (Computer Interactive Reminiscence and Communication Aid) for people with dementia, also developed by the University of Dundee. The aim of CIRCA was to develop a multimedia system which facilitated more meaningful conversation between caregivers and individuals with dementia by tapping into long-term memories that are typically well preserved in this cohort (Astell et al. 2004).

Two groups of nine participants each, together with their caregivers, undertook reminiscence sessions; one group used the CIRCA prototype, the other used traditional reminiscence methods such as one-on-one sessions with caregivers (Alm et al. 2003). CIRCA presented users with a touchscreen interface that offered a choice of three themes (entertainment, sport and recreation). Each theme used video-clips, music-clips and photographs based on suggestions from participants, family members and caregivers.

People with dementia find it challenging to cope with multiple sources of information; the CIRCA interface was designed to be simple but attractive, and to encourage interaction. Soft colours identified the three themes. Vector-based icons (simple stylised symbols) for selected themes became brighter than those of the unselected themes (*Figure 3.4*). Thus, even a black-and-white photograph stood out clearly as a focal point for the attention of users (Astell et al. 2008).

Caregivers were able to upload a user's personalised media. The interface was designed so there was no right or wrong place to be in the system (McKerlie and Preece 1992). According to Astell et al. (2008), this obviated the need for this cohort to remember what they were doing previously and to ensure they did not get lost when navigating the interface.

Figure 3.4 ***Vector-based styling representations of a music player***
Alm et al. 2007

Results showed that the prototype had some advantages over the traditional reminiscence sessions in all three areas of study. Participants enjoyed using the prototype as it encouraged and supported them in initiating conversation. Although designed for indirect operation, with participants needing caregiver assistance to press the navigation buttons, many of the individuals reacted immediately or with minimal encouragement and reached out to the screen to take control of the system and, therefore, the conversation (Astell).

The project established that individuals with dementia could make use of touchscreen technology that offered enough affordance to work well with even those who had severe impairment (Alm et al. 2001, 2003, 2004).

CIRCA provided residents and caregivers with an opportunity for interaction between them. The person with dementia often took control of the navigation (Astell et al. 2007, 2008). Caregivers commented on the ease with which their partners could use the system and the pleasure it gave them (Astell et al. 2007). They learnt a lot more about their partners and developed higher levels of respect for them; CIRCA challenged the low esteem in which caregivers often held individuals with dementia and encouraged mutual respect between the two (Astell).

3.10 *The Interactive Reminiscence Aid*

A company called My Life Software has developed programs that provide a range of interactive features for people with cognitive impairment. This section focuses on its reminiscence software called the Interactive Reminiscence Aid, which is available on the market. As with project CIRCA (Astell et al. 2008), the aim of the reminiscence program is to encourage interaction between people with cognitive impairment and their caregivers and friends.

The Interactive Reminiscence Aid can be installed on generic computers or touchscreen devices, the latter obviating the need for a mouse or keyboard for enhanced user experience. The system contains a database of photographs, video-clips and music available in the public domain, some dating back to the 1930s. Family members can also upload personalised media, which is more effective than generic media in providing enjoyment to people with dementia (My Life Software 2014). Media preferred by a person with dementia may be added to a 'favourites' list, while that disliked may be deleted by pressing a 'don't show again' button. Other features include zooming into photographs to emphasise particular areas. *Figure 3.5* shows an example of the software's interfaces.

While there is no published material on the Interactive Remininscence Aid, according to My Life Software (2014) it provides an opportunity for people with cognitive impairment and their family members to interact. The company has also reported a degree of autonomous use on touchscreen devices, but the specific levels of impairment have not been indicated.

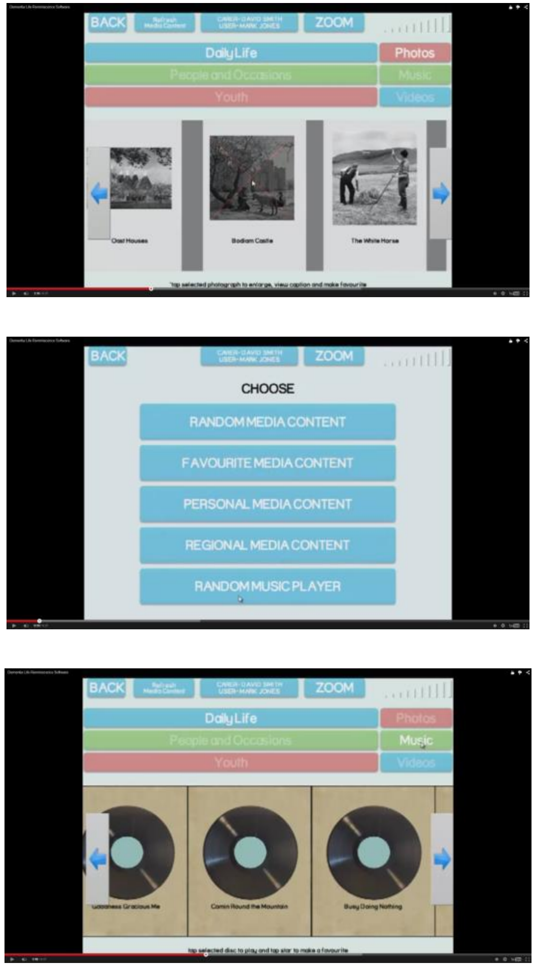


Figure 3.5 ***Reminiscence software interfaces***
My Life Software 2014

3.11 Discussion

Photo-videos have demonstrated their ability to hold the attention of people with dementia, particularly those with moderate or severe impairment. This encourages their inclusion in the multimedia system as they may address the problems associated with boredom at aged-care facilities. If such an intervention could be used autonomously, it would offer the user immediate access to photo-videos, eliminating the need for a family member or caregiver to set up the intervention.

A study reported high distraction levels when participants viewed TV shows, suggesting a decline in language comprehension ability (Hopper and Bayles 2001; Yasuda et al. 1997). This indicated that TV shows and other non-personalised media types such as radio stations were poor candidates for inclusion in the multimedia system.

Old music and children's songs accompanying the photo-videos enhanced the overall reminiscence experience (Remington 2002; Yasuda et al. 2006). While this was effective, it was reported that personalised music was more effective in reducing some symptoms of dementia than randomly selected music (Clark et al. 1998; Gerdner 2000; Music and Memory 2010; Sherratt et al. 2004; Thomas et al. 1997) (*Section 1.5.5, page 16*). Therefore, the multimedia system should use personalised music to accompany photo-videos, with the aim of further enhancing the reminiscence experience. The pan and zoom feature also reported high efficacy, warranting their inclusion in the system.

In *Section 1.5.4* (*page 15*), the study by Garland et al. (2007) reported that family members found it time consuming and laborious to record simulated audiotapes. While the photo-video study showed that narration elicited praise, this process may also prove burdensome to family members and caregivers. Therefore, narration was excluded from photo-videos in the multimedia system.

The study did not report problems with either the 15-second duration of each photograph or the challenges in viewing photographs on the TV screen. These factors were considered in the multimedia system development process. Limitations of the photo-video study included small sample sizes and no reports on either the long-term benefits of the intervention or its effectiveness on individuals with other types of dementia. These provide opportunities for further investigation.

PG has established that photo-videos are effective in providing reminiscence to people with mild, moderate or severe dementia (Yasuda et al. 2009). Despite the issues associated with small screens on touchscreen devices, the technology demonstrates potential in providing autonomous use to individuals with dementia. This knowledge provided opportunities for further investigation, particularly in areas concerning touchscreen size, sensitivity (*Chapter 4*) and text/type specification (*Chapter 5*).

The intervention also provided knowledge on an effective approach to the design of the photo-video information architecture. The navigation process begins on a home-screen with a maximum of six categories which take participants deeper into the information architecture, providing them with more options within a category. The positive results of the intervention suggested that the combination of titles and associated photographs may provide more options to a participant to better recognise a photo-video, given the challenges of legibility of text (Topo et al. 2004).

The study reported several issues with lyrics. They were too small to read and too fast for some participants to sing along to. As with the previous study, diminishing language ability in this cohort may cause difficulty with a lyrics feature (Hopper and Bayles 2001; Yasuda et al. 1997). This discouraged the incorporation of lyrics in the multimedia system.

Careful selection of personalised media is vital in ensuring high levels of engagement by participants, as demonstrated in the PG study. The incorporation of a pause option may be beneficial to users who wish to go to the bathroom or leave their rooms for meals or activities. Reports of participants forgetting about the 'choose another song' option suggested that the button was not easily noticeable. This highlighted the importance of a prominent 'Back' or 'Stop' button to resolve the problem. The knowledge obtained from the interventions of Yasuda et al. (2009) and Topo et al. (2004) facilitated the incorporation of photo-videos in the system.

This research aimed to develop a personalised multimedia system that provided autonomy to individuals with mild, moderate or severe dementia.

The photo-video study by Yasuda et al. (2009) demonstrated that despite the issues associated with small screen size, touchscreen technology had potential in providing autonomous use to individuals with dementia.

The Giraff study was selected for the effectiveness of simulated presence in reducing social isolation in residents with mild or moderate dementia. It confirmed that video was more effective than audio (Cohen-Mansfield and Werner 1997) (*Section 1.5.4, page 15*); this encouraged the inclusion of a call feature in a multimedia system that included a video component. However, for this intervention to be used routinely at aged-care facilities, a family member would need to be available for the telepresence interactions, which may not always be practical due to work commitments (Moyle 2013; Schultz and Williamson 1991). This reduced availability may exacerbate the levels of isolation or depression in residents. An alternative may be for family members to record short video messages that are easily accessed by residents on a touchscreen device. Though not live, it would still provide a person with dementia with a type of simulated video-presence of as yet unknown effectiveness, providing an opportunity for further investigation on people with mild, moderate or severe dementia. This may also obviate the need for an internet connection if the family messages are uploaded using a USB or CD. Other concerns included the design of Giraff's physical dimension, in particular its bulky base, which could prove to be a tripping hazard. This was a crucial factor in the design of the system's physical dimension, given the peculiar limitations found in this cohort.

The Living in the Moment studies demonstrate that people with dementia can adapt to touchscreen technology if the activity is tailored to their preference and the interface is easy to use. It is important that activities provide flow so that participants are kept engaged and prevented from getting bored. Gaming activities can be enjoyable and rewarding for users (Astell et al. 2008). Achieving flow in the multimedia system may enhance the user's overall experience.

It was important for the multimedia system to have an easy-to-use interface that enabled users to reward themselves with their favourite media. Unlike the photo-video study by Mulvenna et al. (2011), the pot painting study did not report problems associated with screen size. *Figure 3.3* (*page 35*) suggests that a screen 15 inches or larger would provide comfortable viewing for people with dementia (*Chapter 4* provides more information on this). The photo-video studies by Yasuda et al. (2009) and Mulvenna et al. (2011) and the studies by the University of Dundee confirm that touchscreen technology offers potential in providing a degree of autonomous use to people with dementia.

Project CIRCA offered valuable knowledge that assisted in the development of the multimedia system. Most importantly, it demonstrated that touchscreen technology had potential in providing a degree of autonomy to people with mild, moderate or severe dementia (Alm et al. 2001, 2003, 2004). This warranted its use in the multimedia system. CIRCA was developed to encourage conversation between a resident and a caregiver. It facilitates people with dementia and their family members to share an activity together, making visits by family members to aged-care facilities more meaningful.

Due to time and work constraints, an avenue that allows media upload over the internet from home or office may result in family members once again feeling involved in their relative's life and creating opportunities for new conversations when they are able to visit. This, however, will require internet access at aged-care facilities, which proved to be a challenge in the Giraff study (Moyle et al. 2013).

The CIRCA interface presented useful information on contrast when a theme was selected and on the use of vector-based styling within each theme. This provided a starting point in the design of the multimedia system information architecture. However, while there is no information on the ease with which users were able to read the text in the CIRCA study, the difficulties in the legibility of the text size in the PG study (*Section 3.5, page 31*) suggested that participants may have successfully recognised a theme in the CIRCA study by its vector-based icons (*Figure 3.4, page 37*). Moreover, the gradual decline in language ability in people with dementia (Hopper and Bayles 2001; Yasuda et al. 1997) suggested the importance of representational icons.

Finally, the CIRCA interface was designed to ensure that a user was always in the right place on the system, with each page performing as if it were a homepage. This was an important consideration in the design of the information architecture as it may prevent users from getting confused if they forgot what they were previously doing (Astell et al. 2008).

While My Life Software reported that the Interactive Reminiscence Aid provided a degree of autonomous use to people with cognitive impairment, *Figure 3.5* (*page 38*) suggests that autonomous use by people with dementia may prove challenging given their difficulties in coping with multiple sources of information (Astell et al. 2008). An assumption made was that the reports from the company were based on results from touchscreen use, which people with cognitive impairment would find easier to interact with than a keyboard or mouse on a generic computer. This demonstrated the importance of interventions having their own dedicated hardware for optimal use.

3.12 *Conclusions*

The aim of the literature review was to identify state-of-the-art media interventions that met the following desired specifications:

- Utilised personalised media, in particular photographs, music or/and family-videos
- Provided a high degree of autonomy to individuals with mild, moderate or severe dementia
- Adapted to the deterioration in impairment levels

In addition, the review looked for effective media types, knowledge of which may assist in the development process of the multimedia system. Seven interventions that met the criteria in *Section 3.3* (*page 30*) were selected for review. While each intervention provided vital knowledge in areas that may assist in the development of the multimedia system, two (Project CIRCA and the Interactive Reminiscence Aid) came closest to meeting the desired specifications. The two interventions demonstrated that multimedia platforms provided a capacity and enthusiasm for interaction by individuals with dementia, as opposed to mere passive immersion. However, they were not without their associated limitations.

Despite reports of the interventions providing a degree of autonomous use to individuals with dementia (Astell et al. 2008; My Life Software 2014), it was unclear to what impairment levels of dementia (mild, moderate or severe) and to what exact degree of autonomy the interventions afforded autonomous use. However, touchscreen technology had demonstrated its potential in providing autonomous use to people at any level of dementia and was therefore the platform used in the multimedia system.

Given the progressive and irreversible decline in the degree of dementia, with a corresponding decline in the ability to perform even the most routine tasks, there was no suggestion that either of the interventions could provide continuing autonomous use through the deterioration process from mild to moderate to severe. Moreover, the interventions focused on their software component; there was no indication if the design of dedicated hardware or associated features such as physical adjustability were considered.

Further trials were therefore necessary to determine whether individuals with mild, moderate or severe dementia could use multimedia systems with a high degree of autonomy, and whether this degree of autonomy could be maintained as the level of impairment deteriorated from mild to moderate to severe.

Based on knowledge from *Chapters 1 and 3* at this stage, the following media types were presented to people with dementia on the multimedia system:

- Personalised music
- Personalised photo-videos with supporting personalised music
- Pre-recorded family video-messages

It is important that the multimedia system maintains flow for its users via enhanced usability and experience (Csikszentmihalyi 1996). The research now goes on to identify design parameters which assisted in its development.

Chapter Four Design Constraints and Parameters

Chapter Overview

Chapter 4 identifies the constraints that informed parameters for developing the physical dimension and information architecture of the multimedia system. It begins with a review of literature on age-related physical and perceptual impairments, and discusses problems associated with touchscreen technology, in particular touchscreen tablets. The chapter then details field tests conducted at an aged-care facility and concludes with design parameters.

4.1 *Aim*

The aim of this chapter is to identify the constraints that informed parameters that in turn assisted in the development of the physical dimension and information architecture of the multimedia system.

4.2 *Method*

The process of parameter compilation begins with a review of literature on age-related physical and perceptual impairments. It then discusses the problems associated with touchscreen technology, in particular touchscreen tablets, when used by the older population. Together with the knowledge from the literature review, this guided the development of prototypes to be put to test at an aged-care facility, where the first phase of the exploratory sequential mixed methods approach began.

4.3 *Age-Related Physical and Perceptual Impairments*

The rapidly growing older population is accepting the use of technology in activities that provide reminiscence, one example being touchscreen devices (as discussed in *Chapter 3*). This cohort does, however, have a different attitude towards technology from the technologically savvy younger generation, due mainly to the impact of ageing and its associated problems (Mulvenna et al. 2011). Upton et al. (2011) suggest the importance of anticipating the difficulties faced by older people, as the designers would normally not face those difficulties themselves.

These age-related physical and perceptual problems include:

- loss of hearing (deafness)
- loss of sight (blindness)
- cognitive impairment
- loss of physical strength
- loss of dexterity

Loss of hearing (also referred to as presbycusis) is inevitable in older people and has varying severity. Noticeable auditory conditions include difficulty in detecting sound and determining its location, and perceiving speech and complex sonority (Gates and Mills 2005; Jonsson and Rosenhall 1998, Jonsson et al. 2004). One solution is the use of a hearing aid, which is not always welcomed by people with dementia.

Blindness (due to macular degeneration) is a common age-related problem. When visual ability decreases, older people find it difficult to:

- resolve detail
- focus on close objects
- discriminate or perceive shorter wavelengths
- detect contrast
- adapt quickly to darker conditions
- deal with reflection or glare
- estimate motion due to the eye focusing more slowly
- enjoy full peripheral vision due to the narrowing field of vision

They also undergo the following changes:

- The eye’s reaction time doubles.
- The effect of glare doubles.
- A 60-year-old requires up to 5 or 6 times more light than a 20-year-old (necessitating a 20% increase in illumination for older people).
- Older people need larger visual detail.

(Taylor et al. 2013)

Loss of hearing and vision contribute to a loss in confidence, thereby affecting how older people absorb information (Holzinger et al. 2007). Cognitive impairment due to natural ageing, dementia and the adverse side effects of medication, for example a decline in the power of recall, may affect the way an older person engages with technology (McShane et al. 1997; Mulvenna et al. 2011; Prince et al. 2013; Wimo et al. 2003).

Loss of physical strength and dexterity are other factors that could make the use of technology difficult for the elderly. A few examples are reduction in grip strength, tremors in hand movement due to Parkinson's disease (*Section 1.2.2, page 9*), or the general slowdown in mobility (Mulvenna et al. 2011), estimated as follows:

- A reduction of between 16% and 40% in hand strength
- A reduction of about 50% in arm strength
- A reduction of about 50% in leg strength
  (Tilley 2002)

Due to these age-related problems, older people develop different needs and characteristics, and are therefore a complex group as technology users. They have slower response times, weaker coordination and limited flexibility (Rogers et al. 2006). These factors warrant careful consideration when developing the multimedia system, particularly in the areas of:

- auditory amplification
- screen illumination
- visual detail
- system placement (freestanding or mounted)
- ideal seating position while using the system

4.4 *Touchscreen Tablets*

Touchscreens have demonstrated potential in providing a degree of autonomy to people with mild, moderate or severe dementia (*Chapter 1* and *Chapter 3*) and were therefore employed in the multimedia system. They have enhanced the quality of life of people with dementia by aiding recall, increasing personal interaction, promoting inter-generational relationships and improving staff–resident relationships (Upton et al. 2011). Touchscreen tablets have provided users with an experience where interaction occurs via direct contact with the screen. The direct approach has addressed usability issues on traditional computers that are navigated by using a mouse or touch-pad (Hertzum and Hornbaek 2010) and has alleviated confidence issues faced by the elderly when using this form of technology (Prensky 2001).

While there are several touchscreen tablets of various sizes available from a variety of manufacturers, Apple's iPad enjoys market dominance (Lambrechts 2018; Pavel et al. 2010) and therefore represents touchscreen tablets in this chapter. According to Pavel et al. (2010), the iPad appeals to the older population because of its intuitive interface and forgiveness of mistakes. However, despite the opportunities afforded by iPads, they are not without limitations and usability issues (Upton et al. 2011).

4.4.1 *Challenges with Hardware*

iPads are available in a range of sizes as shown in *Figure 4.1*; the smallest model has a 7.9-inch screen and weighs 341 grams, while the largest has a 12.9-inch screen and weighs 723 grams (Apple 2018). *Chapter 3* reported that small screen size made it difficult for participants to read text (*Section 3.5*, *page 31*) and that a screen of 15 inches or larger would provide comfortable viewing (*Section 3.8, page 35*). This suggested that even the largest iPad may not provide optimal visibility to people with dementia; however, further trials were necessary to confirm this.

Figure 4.1 ***Examples of iPad models***
Apple 2018

The form factor (size and shape) of an iPad suggests that one hand is necessary to hold it, while the other is used for navigation (Upton et al. 2011). Despite even the largest iPad weighing less than a kilogram, it is likely to feel heavier when held for prolonged periods, given the loss of physical strength in the elderly (as discussed in *Section 4.3, page 46*).

According to Alzheimer's Australia (2009, 2012), individuals with dementia are prone to misplacing items. A study by Cohen-Mansfield (1989) reported that aggressive behaviour in a group of residents at an aged-care facility resulted in the violent tossing of objects such as TV remotes and mobile phones. This demonstrates the importance of mounting an iPad on a stand when used by this demographic, given its smaller size and weight, and easier portability compared to traditional computers.

Finally, a study by Favilla and Pedel (2014) reported that individuals with dementia attempting to use iPad apps were unable to remember how to switch on the iPad, due to its subtle power button at the top. Once it was on, however, the participants were able to 'slide and unlock' the screen, an operation not forgotten during the session.

4.4.2 Challenges with Software

iPads have projected capacitive screens composed of a sheet of glass with embedded transparent electrode films and an integrated circuit chip. These create a three-dimensional electrostatic field. A finger touching the screen absorbs the charge, resulting in a change in the electrical current ratio that allows the exact point of contact to be detected (Banerji and Ghosh 2010; Bhalla and Bhalla 2010).

Capacitive screens have excellent image clarity, are durable and scratch resistant, and allow for multi-touch; however, they can only be activated by a finger that is bare or covered by a surgical or thin cotton glove (Banerji and Ghosh; Bhalla and Bhalla).

In the same study by Favilla and Pedel (2014), some people with dementia had difficulty using the iPad's touchscreen due to a lack of moisture on the surface of their fingertips, or because they used their fingernails. 'Tactile agnosia' is the inability to recognise objects by touch. It can affect interaction with iPads because of too much or too little pressure exerted on the screen. This knowledge suggested that further trials were necessary to identify alternative touchscreen types that may enhance usability. The study also reported that, due to partial deafness, participants had difficulty in hearing music on their iPads, even at maximum volume. This confirmed the importance of auditory amplification on devices used by this demographic.

iPads boast a long battery life (up to 10 hours) even during heavy use (Apple 2018). However, recharging requires the assistance of a caregiver or family member to ensure that the wires do not pose a tripping hazard. This suggests that when designing multimedia systems for people with dementia, a non-obtrusive self-charging method should be incorporated.

Based on knowledge from the literature review, the physical and perceptual impairments in the elderly, and problems associated with touchscreen tablets, the chapter now details the usability tests.

4.5 *The Usability Tests*

4.5.1 *Aim*

The aim of the tests was to gain further knowledge in the areas of challenge identified in *Chapter 3*, in particular problems associated with touchscreen size and sensitivity, and multiple sources of information. This resulted in the development of prototypes guided by *Chapter 3*, *Section 4.3* and *Section 4.4* (*pages 26, 46 and 47*).

4.5.2 *Method*

The tests were comprised of one-hour sessions every month for five months. They used social research methods (Bryman 2016) and clinical research methods (cohort studies), in particular prospective studies conducted repeatedly (Hulley et al. 2013). A psychologist who was an expert in the area conducted the tests, while the author of this research (referred to as the research candidate or RC) developed the prototypes. Ethical approval was received from the Monash University Human Research Ethics Committee. Each participant consented to participate in the tests; some had their families' consent for them.

4.5.3 *Criteria*

There were a number of conditions for participation in the tests. Participants had to be at least 60 years old and have a chart diagnosis of dementia. Exclusion criteria were a lack of comprehension of English, a severe medical illness likely to compromise participation in the study and known aggressive or unintentional dangerous behaviour or inappropriate handling of materials which could compromise user or prototype safety. Only those diagnosed with mild cognitive impairment participated in the tests, as individuals with moderate or severe impairment may experience deterioration in language ability (Hopper and Bayles 2001; Yasuda et al. 1997). Cognitive impairment was measured using the mini-mental state examination (MMSE) (*Section 2.1.5, page 24*).

Seven residents (six females, one male) met the participation criteria and were selected. While the prevalence of dementia in women is higher than in men (Alzheimer's Australia 2009), the female dominance in the tests was purely coincidental.

To ensure participants' privacy, the chapter provides each participant with an identity, for example F4 for fourth female and M1 for first male.

4.6 Session 1 *Meeting the Participants*

4.6.1 *Aim*

The aim of Session 1 was to:

- meet with the participants and facility staff and introduce them to the hypothesis
- determine if there were similarities in music and photograph preferences among the participants
- become familiar with aged-care facility milieus

4.6.2 *Method*

The psychologist and RC met the seven participants and four facility staff and introduced them to the hypothesis at a round-table discussion. To obtain feedback from the participants on their preference of media types, the social research method of a questionnaire was used (Bryman 2016). The questionnaire (*Figure 4.2*) was formulated by the RC around the three media outcomes from the literature review (personalised music, personalised photo-videos and pre-recorded family video-messages) and was conducted by the psychologist.

To familiarise themselves with the aged-care facility milieu, the psychologist and RC were conducted by the facility staff on a tour of the communal areas and three unoccupied but furnished resident bedrooms, each with its own layout.

music

Do you enjoy listening to music?
Yes ☐ No ☐

What type of music do you enjoy listening to? ____________

Who are some of your favourite singers? ____________

What are some of your favourite songs? ____________
____
____

How often do you listen to music?
Every day ☐ Once a week ☐ Once a month ☐ Other ____________

Is there any music you do not enjoy listening to? ____________

photographs

Do you enjoy looking at photographs?
Yes ☐ No ☐

What type of photos do you like looking at?
Family ☐ Friends ☐ Animals ☐ Other ____________

How often do you look at your photo albums?
Every day ☐ Once a week ☐ Once a month ☐ Other ____________

family messages

If you could talk to someone every day, to whom would it be?
Family ☐ Friends ☐ Other ____________

How would you want to talk to them?
Over the telephone ☐ In person ☐ Through a computer ☐ Other ____________

Would you enjoy watching video-recorded messages from your family (or selected person)?
Yes ☐ No ☐

Figure 4.2 ***Questionnaire used in Session 1***

4.6.3 Results

During the introduction of the hypothesis, immediate feedback from the participants confirmed that none of them had used a touchscreen device before, but they would be excited to do so. The facility staff suggested that the hypothesis include personalised movies; according to staff, some residents watched their favourite movies in their rooms at least once a week. (A staff member would set this up using a DVD player).

The psychologist was informed that apart from the common symptoms found in people with dementia (*Section 1.2.2*, *page 9*) (Alm et al. 2003; Cohen-Mansfield 2001), one participant had Parkinson's disease, while others had additional age-related impairments (*Table 4.1*). The psychologist observed that many of the residents in the facility (including six of the seven participants) used walkers. This confirmed the need for users to be seated while using multimedia devices, for optimal comfort and enhanced usability (*Section 4.3, page 46*).

ID	impairment
M1	colour-blind
F1	weak right arm
F2	–
F3	weak legs
F4	weak left arm
F5	–
F6	Parkinson's Disease

Table 4.1 ***Participants' details***

Results from the questionnaire reported that all participants ticked 'Yes' to 'Enjoy listening to music'. Apart from two, all answers in the music section were different; however, there were similarities in the genres they enjoyed (classical, Australian, rock 'n' roll and soft music), and in those they did not enjoy (rap and 'heavy' music).

In the photographs section, all participants ticked 'Yes' to 'Enjoy looking at photographs'. Overall, every participant selected 'Family' in the 'Type of photographs they enjoyed looking at'. Six participants also ticked the 'Animals' category. Each participant had a different response to 'Other'. These were 'Scenery', 'The Ocean', 'War Planes' and 'Elvis Presley'. Four participants mentioned that they looked at their wedding photographs a few times a month and would do so more often if they remembered to.

Finally, in the family video-messages category, when participants were asked whom they would like to talk to every day, everyone ticked 'Family' and for the method they ticked 'In person'. Other comments included 'Five minutes a day would be lovely, but the family works very hard and are busy', 'I tried the camera on the computer and it was marvellous' and 'My son calls me every evening on the phone in my bedroom'. All participants ticked 'Yes' to 'Would you enjoy watching video-recorded messages from your family?'

The study concluded that, overall, despite the small sample size, there were significant differences in preferences of song and photograph categories. This implied that a shared multimedia device in a facility's communal area would be ineffective in catering to all residents, suggesting the need for individualised units in residents' bedrooms. The results from the questionnaire corresponded with the literature review, confirming the importance of personalised media, reminiscence and family presence (McCreadie and Tinker 2005).

A study by Chou et al. (2002) reported that out of a thousand residents in different facilities, 88% were satisfied with the size of their bedrooms, 74% with their storage space, 79% with their bathrooms and 91% overall. Despite these results, and while the bedrooms at the test facility were quite large (4 m x 4 m), they appeared cluttered due to the amount of basic furniture required by an individual (bed, bedside-table, heater, chest of drawers, sofa-chair, etc.), leaving little space for other items. This suggested the need for a multimedia system with a compact physical dimension.

Moreover, the facility had its own restrictions. The system could not be suspended from the ceiling, screwed onto the wall or bolted into the floor, suggesting the need for a non-obtrusive, freestanding physical dimension. *Figure 4.3* shows a typical aged-care facility bedroom.

Figure 4.3 ***A typical aged-care facility bedroom***
Baptistcare 2015

4.7 Session 2 Touchscreens

4.7.1 Aim

The literature review determined that touchscreen technology demonstrated potential in providing autonomous use to people with mild, moderate or severe dementia and was therefore the preferred multimedia platform for incorporation in the multimedia system. However, there was not enough information on the technology used in the interventions.

The aim of *Session 2*, therefore, was to:

- test a range of touchscreen devices
- identify the touchscreen device providing optimal usability
- verify some of the problems of touchscreen tablets addressed in *Section 4.4* (*page 47*)

4.7.2 Method

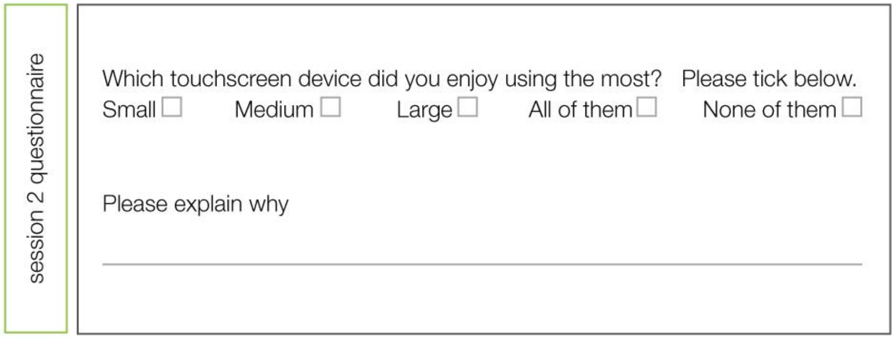
The psychologist presented three touchscreen devices to participants: a 9.7-inch Apple iPad, a 12.1-inch Asus tablet and a 24-inch Sony desktop (*Figure 4.4*).

Each participant sat at a table and spent approximately two minutes navigating through photographs on each device (termed ‘Small’, ‘Medium’ and ‘Large’), one after the other. A device was chosen at random using a digital word generator. The Small and Medium devices were mounted upright, while the Large device had an inbuilt stand.

***Figure 4.4* Touchscreen devices used during the tests**

While all participants had ticked ‘Family’ under photographs in *Session 1*, the devices displayed photographs of animals; these were easier to set up than family photographs and were the second choice by six of the seven participants. The devices displayed one photograph at a time, each with its own brief description in large white text. A black background was used to emphasise the photographs. Participants were able to navigate from one photograph to the next by swiping a finger across the screen, or by using one of two white arrows beside each photograph. Double-tapping a photograph acted as a toggle to enlarge it or reduce it to normal size.

The psychologist observed how each participant interacted with the devices, making note of obvious behaviours, and concluded the session using the following questionnaire (*Figure 4.5*).


session 2 questionnaire

Which touchscreen device did you enjoy using the most? Please tick below.

Small ☐ Medium ☐ Large ☐ All of them ☐ None of them ☐

Please explain why

Figure 4.5 ***Questionnaire used in Session 2***

4.7.3 Results

The questionnaire determined that six of the seven participants preferred the largest device. Under ‘Please explain why’, their responses included: ‘I liked the arrows’, ‘Good size for photographs’, ‘Easy to read’, ‘Easier for me to see’, ‘The small one moved a lot when I pushed it’ and ‘I can watch a movie on it from my bed’. One participant selected the ‘All of them’ option explaining that she had ‘No preference’ and ‘Liked them all’.

Other observations were:

- Three participants (M1, F2 and F4) had difficulty using the devices due to tactile agnosia. None of the participants, except F1, could use the double-tap feature due to the speed required between taps to register a double-tap.
- F3 had difficulty using the devices due to her long fingernails.
- Participants preferred tapping the arrows to swiping the screen; swiping was particularly difficult for F6, who had Parkinson’s disease.

The results suggested the need for a large screen and an alternative to capacitive touchscreens. While the devices were tested only on a small sample size, the psychologist concluded that double-tapping and swiping should not feature in the multimedia system, based on the symptoms of Parkinson’s disease (*Section 1.2.2, page 9*) and age-related physical impairments (*Section 4.3, page 46*).

4.8 Session 3 Infra-red Touchscreens

4.8.1 Aim

The results from *Session 2* reported usability challenges associated with capacitive touchscreens, encouraging further trials using alternative touchscreen types. The aim of *Session 3*, therefore, was to determine whether an infra-red touchscreen would address the problems encountered in *Session 2*, particularly those related to tactile agnosia.

4.8.2 Method

Session 3 presented participants with a 23-inch infra-red touchscreen (diagonal dimension). An infra-red touchscreen comprises light emitting diodes (LEDs) in the bezel (frame) at one horizontal and one vertical edge of the screen, and light sensors at the opposite edges, creating a light-beam grid. On interruption (referred to as 'beam break'), the screen uses the X and Y coordinates from the grid to determine the exact point of touch. Unlike capacitive touchscreens that can only be activated by a finger or thin glove, an infra-red screen is activated by any object that interrupts the beam. This includes objects as thick as woollen gloves or as thin as toothpicks (Bhalla and Bhalla 2010). It is also more durable than the capacitive touchscreen, therefore making it more appropriate for this demographic.

The physical size of an infra-red touchscreen would obviate the need for an external computer tower (central processing unit or CPU) as the circuitry could be incorporated into its casing. However, for the purposes of the tests, the full-size case was retained as a separate unit to permit rapid changes to be made to the prototype during testing and development; in production, this would not have an application. The CPU was concealed under the table during the session; participants could only see the infra-red monitors.

Session 3 was conducted in similar fashion to *Session 2* with participants being asked to navigate through photographs of animals using directional white arrows for approximately five minutes each. There were no double-tap or swipe features. The captions beneath the photographs were retained (*Figure 4.6*).

Figure 4.6 ***Infra-red touchscreen***

4.8.3 *Results*

The most positive result from *Session 3* was that the infra-red touchscreen resolved the problem of tactile agnosia. F3, who had difficulty using the devices in *Session 2* due to her long fingernails, was able to do so with ease in *Session 3*.

The psychologist observed that four participants got tired of constantly tapping the arrows to view photographs, resulting in their taking several breaks during the session. This may have been due to age-related physical impairments such as F1's weak right arm. Another observation was that three participants required constant confirmation about what each of the arrows would do; the direction alone was clearly not self-explanatory. Six of the seven participants acknowledged and enjoyed reading the photo captions; one participant just looked at the photographs.

Based on the results from this session, it was clear that infra-red technology (or comparable) would better suit people with dementia, given its durability and ability to address tactile agnosia. Physical impairments diminished the ability to constantly activate the screen manually, thereby encouraging the inclusion of photo-videos, as in the PG intervention (*Section 3.5*, *page 31*). Finally, providing users with more information may improve autonomy, suggesting the need for symbols with correlated text.

4.9 Session 4 *Multiple Sources of Information*

4.9.1 *Aim*

Astell et al. (2008) reported that people with dementia find it challenging to cope with multiple sources of information (*Section 3.9*, *page 36*); however, more knowledge was required to determine what constituted the appropriate amount of information for this cohort. The aim of *Session 4* was to obtain knowledge in this area.

4.9.2 *Method*

Before the session began, caregivers informed the psychologist that two participants' impairment levels had deteriorated (F3 and F6), placing them in the moderate dementia category based on the MMSE. Even though participation was restricted to residents with mild dementia, the psychologist and caregivers ignored this criterion as the two participants had been compliant at the commencement of the tests.

Participants were asked to spend approximately five minutes navigating through a range of photo-videos on an infra-red touchscreen (*Figure 4.7*). Each category contained 10 photographs. As in *Sessions 2* and *3*, a black background emphasised each photo-video. All photographs were obtained from public domain databases.

Figure 4.7 ***Photo-video categories***

The design of the photo-videos was based on the positive results of the PG intervention in the literature review (*Section 3.5, page 31*). The following features were particularly incorporated:

- The combination of a main photograph and respective title – this provided more options for a participant to better recognise a photo-video, given the challenges of text legibility (Topo et al. 2004)
- The pan and zoom effect – this was applied to every photograph in each photo-video
- The 15-second duration – each photograph was displayed for 15 seconds before gently fading into the next one

While the PG intervention offered between two and six music selections on a small touchscreen, the large touchscreen size in *Session 4* facilitated the display of eight photo-videos.

Figure 4.8 shows the screenshot after selecting the 'Landscape' photo-video.

Figure 4.8 ***'Landscape' photo-video***

On completion, a photo-video would automatically revert to the homepage, displaying the eight photo-videos once again.

4.9.3 Results

The results from *Session 4* demonstrated that participants enjoyed viewing the photo-videos and were able to use the touchscreen unaided, with the exception of F3 who stared at the screen looking for tactile buttons. It was difficult to associate this problem with the decline in her impairment level because F6 (whose impairment level had also declined) was able to use the touchscreen without difficulty. This issue, however, revealed the importance of providing this cohort with more options; perhaps the incorporation of physical push buttons corresponding to digital buttons on the touchscreen would enhance usability, and therefore autonomy, for people with moderate or severe dementia. However, further trials were necessary to confirm this assumption.

The psychologist observed how four participants made selections only from the four photo-videos at the bottom of the screen. Post-session interviews revealed that these categories were selected simply due to their proximity to the users and therefore the ease with which they could be reached; the categories themselves played no part in influencing the selection. This confirmed the prevalence of physical impairments in the cohort and the importance of addressing them by placing all selections on a horizontal axis. The screen height, too, would need to be adjustable to ensure that all selections were within comfortable reach of users of all sizes. *Chapter 5* details an anthropometric study on this demographic.

During the session, two participants touched the screen during a photo-video in an attempt to stop it and return to the homepage. This presented an opportunity for incorporating ‘Pause’, ‘Back’ and ‘Stop’ buttons that were prominently placed. Finally, caregivers requested that the homepage display the time and date to reduce the number of times residents asked staff about this.

While participants seemed to cope well with the amount of information on the homepage, it was difficult to know from *Session 4* how much information would be appropriate for this cohort. Further trials were therefore necessary to obtain more knowledge in the area.

The problems linked to loss of physical dexterity during the session informed a new homepage layout (*Figure 4.9*); coincidentally, it might work well as a starting point for the multimedia system’s homepage given the four media types it would incorporate (personalised music, photographs, movies and family messages).

Figure 4.9 also displays one option for placing a ‘Stop’ button while a photo-video is playing.

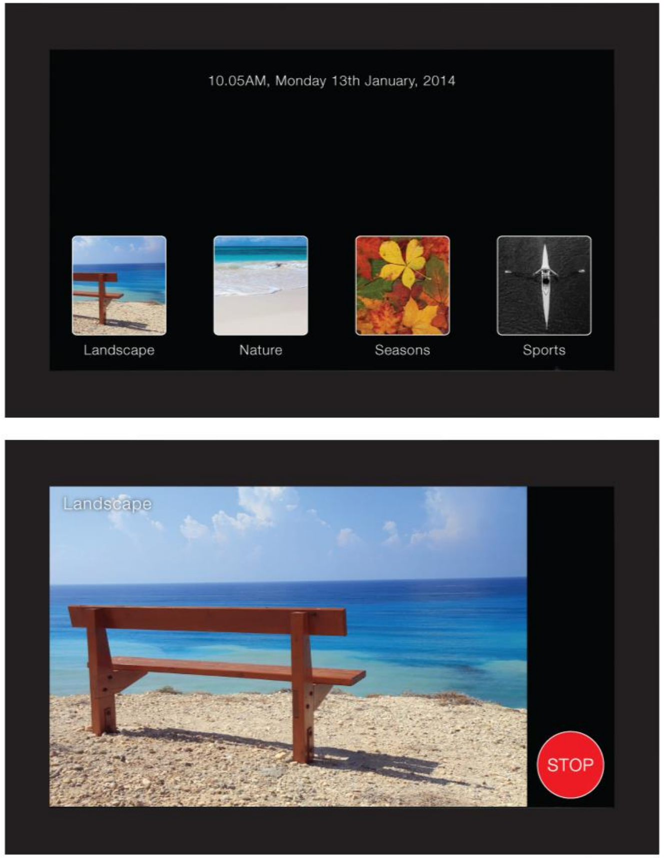


Figure 4.9 ***Revisions to homepage and photo-video***

4.10 Session 5 *Information Architecture*

4.10.1 *Aim*

Based on the outcomes of *Session 4* and knowledge from the literature review, the aim of *Session 5* was to determine:

- the participants' information architecture navigation capabilities
- the preference between tactile and digital buttons
- the participants' ability to recognise vector-based icons as in Project CIRCA (*Section 3.9, page 35*)

4.10.2 *Method*

An information architecture consisting of photo-videos was presented to participants on an infra-red touchscreen. The design was based on *Figure 4.9* in *Session 4* where four photo-video categories were displayed. The model categorised media into folders and sub-folders, and used an alphabetical organisation scheme at each step (Rosenfeld and Morville 2002). Each participant had five minutes to accomplish tasks set by the psychologist. On selecting a category, four associated photo-videos appeared in the same layout. While this increased the number of steps in the information architecture from one to two, it provided participants with more options within the selected category. On selecting one of the four photo-videos, 10 photographs were displayed, one at a time, for 15 seconds each as in *Session 4* (*pages 56 and 57*). At the end of a photo-video, the screen returned to the homepage. Participants had the option of pressing a Stop button at any time. The steps of the information architecture are shown in *Figure 4.10*, with yellow circles representing the selections made.

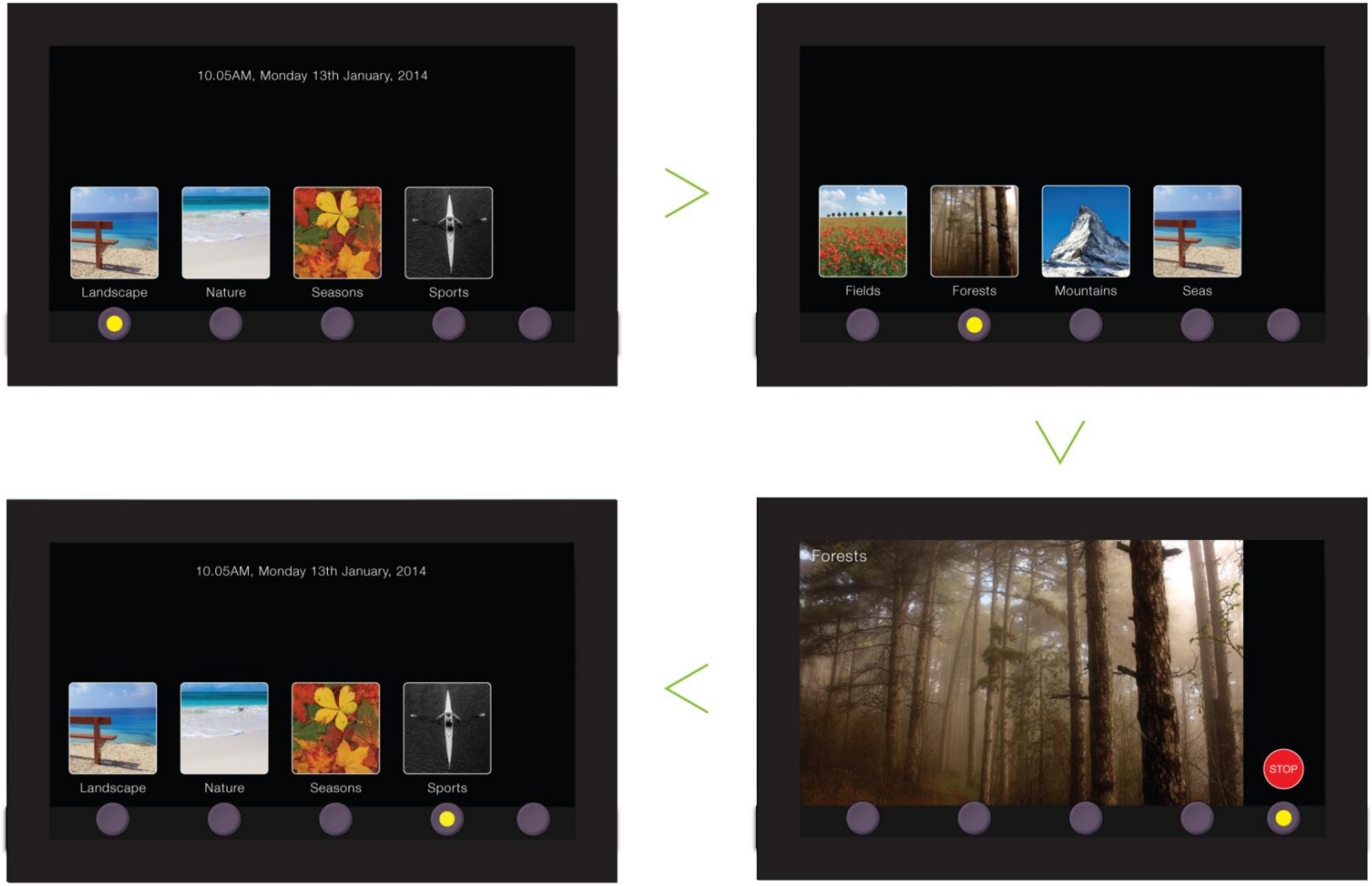


Figure 4.10 ***Steps of the information architecture***

Conventionally, tactile buttons are electrical momentary switches with a direct link to control circuitry. However, to avoid the cost of a wiring assembly, a more elegant approach was taken: tactile buttons were manufactured using a two-part silicone kit for use as proxies for the touchscreen icons; they were simply inert masses of moulded silicone, sensed no differently by the touchscreen than actual fingers, sitting in an inexpensive laser-cut plastic frame suspended over the screen. A wooden form resembling a button was developed in a workshop using a lathe. This was used to create a plastic vacuum-formed mould in which the silicone mix was injected, resulting in a flexible/elastic silicone tactile button (also referred to as an elastomer-membrane button) (Rahman et al. 1998). The silicone when mixed was pink by default; a black dye added during the moulding process produced a dark grey button with only a hint of pink as shown in *Figure 4.11*. The buttons had a diameter of 30 mm (providing button activation by finger or palm) and a travel distance (when pressed) of 2.3 mm based on recommendations by Tilley (2002) for round push buttons. Participants had the option of making selections using either a tactile or a digital button (*Figure 4.10*).

Figure 4.11 ***The development of silicone tactile buttons***

At the start of the session, a demonstration by the psychologist showed participants how to navigate through the different layers of the architecture using both the digital and physical buttons. Participants had to accomplish a list of tasks to determine how well they could navigate through the information architecture. The tasks were:

- to select a photo-video category from one of the options on the screen (one navigation step – Landscape)
- to select a photo-video of Forests (two navigation steps – Landscape > Forests)
- to select a Sports photo-video while the Forests photo-video was playing (three navigation steps – Stop > Sports > Tennis)

In this way, the psychologist was able to set tasks that required different numbers of steps for accomplishment.

According to Astell et al. (2008), participants in the Project CIRCA intervention (*Section 3.9, page 36*) were able to recognise vector-based representations of a music player. This encouraged the incorporation of such a method of styling in the multimedia system for presenting the four media types to its users: personalised music, photographs, movies and family messages. To put this to the test, a range of vector-based icons of these media types were selected by the RC and were placed in front of participants. Participants were asked to identify each media type based on the vector icons and to select one icon for each media type that they thought best represented it. Icons were presented in chronological order, dating as far back as the 1930s for music players and movie/cinema equipment. Examples are shown in *Figure 4.12*.

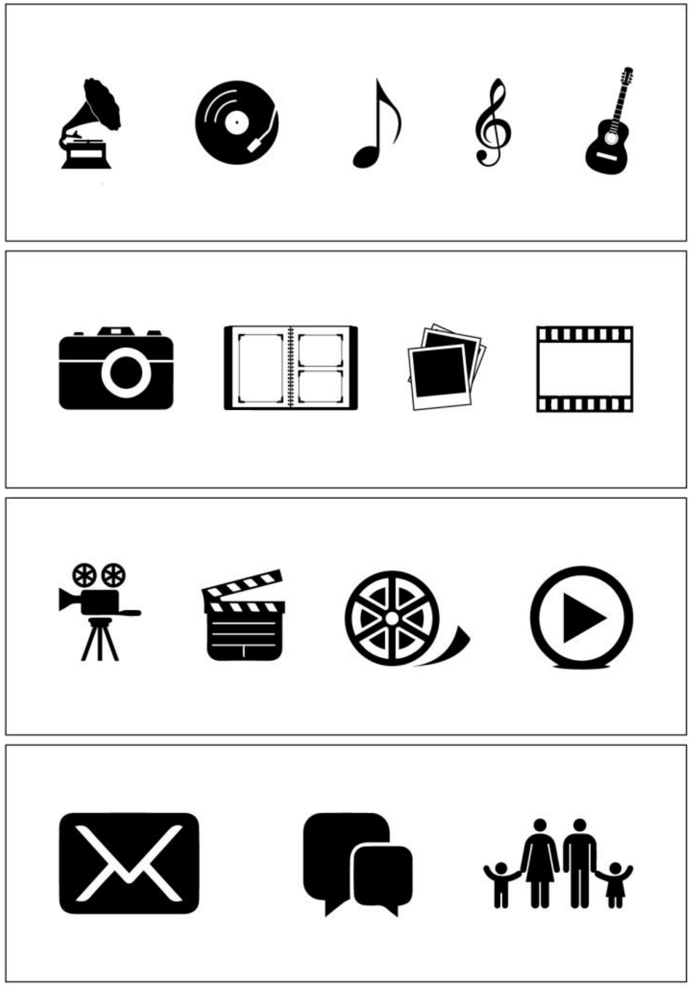


Figure 4.12 ***Vector-based media icons***

4.10.3 Results

Results from the navigation study reported a range of outcomes among participants:

- Three participants (F1, F3 and F6) were able to accomplish tasks that required one navigation step. However, they could not navigate further into the information architecture without assistance from the psychologist. Of these, F3 and F6 had moderate impairment.
- Two participants (F4 and F5) were able to accomplish tasks that required up to three navigation steps.
- Two participants (M1 and F2) were able to accomplish tasks that required up to five navigation steps.

This knowledge demonstrated the need for specially considered information architecture of varied complexity that may provide autonomy to people with mild, moderate or severe dementia while maintaining flow. This is detailed in *Chapter 5*.

Observations on tactile vs. digital buttons demonstrated the following:

- Five participants (M1, F1, F3, F4 and F6) used the tactile buttons only (F3 had difficulty with the touchscreen in *Session 4*).
- One participant (F5) used the digital buttons only.
- One participant (F2) used both tactile and digital buttons.

The results (summarised in *Table 4.2*) supported the importance of providing this cohort with more options, suggesting the need for corresponding tactile and digital buttons. However, more knowledge on the design of tactile buttons was required for this demographic. This is detailed in *Chapter 5*.

participant	impairment level	maximum navigation steps	tactile vs. digital selections
M1	mild	5	tactile
F1	mild	1	tactile
F2	mild	5	tactile and digital
F3	moderate	1	tactile
F4	mild	3	tactile
F5	mild	3	digital
F6	moderate	1	tactile

Table 4.2 ***Summary of navigation and button use results***

Results from the vector-based icon study demonstrated that each participant was able to identify the music, photo and movie media types by recognising one or more icons from each category; however, they were unable to associate with the icons used to represent family messages. The psychologist therefore asked participants to select one icon that they associated with family. These are shown in *Figure 4.13*. Further work was necessary to identify and develop an icon that would best represent the 'family messages' media type.

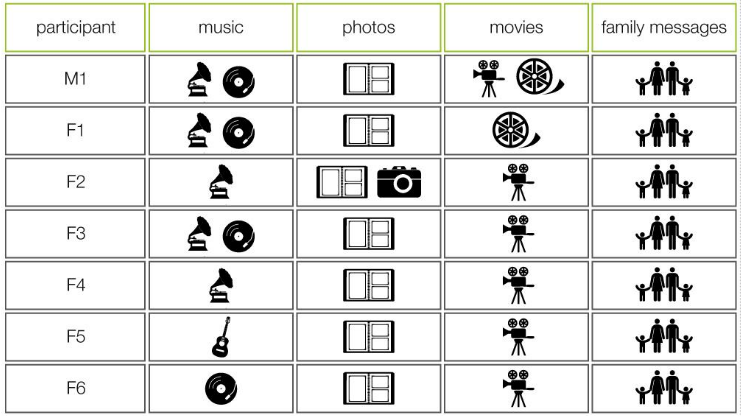


Figure 4.13 ***Summary of vector-based icon results***

Overall, the results supported the theory that long-term memories are better preserved than short-term memories (Astell et al. 2008; Rentz 1995); all participants selected icons they were familiar with during their younger years. This suggested the need for using icons familiar to this cohort when developing the multimedia system. *Chapter 5* provides more information in this area.

4.11 Conclusions

The aim of this chapter was to inform parameters that would assist in the development of the physical dimension and information architecture of the multimedia system. They are presented in *Table 4.3* with the inclusion of parameters obtained from the literature review (*Chapter 3*). These parameters were used to guide the development of the multimedia system in *Chapter 5*.

	the physical dimension – needs	the information architecture – needs
the literature review	*a large screen* *touchscreen technology* *dedicated hardware*	*personalised photo-videos (with supporting personalised music and a pan/zoom feature)* *to maintain flow* *representational icons* *personalised music* *pre-recorded family video-messages* *to provide more options to users (for all media to have associated photographs and titles)*
age-related impairments	*a freestanding physical dimension* *for users to be seated while using such a system*	*sufficient auditory amplification* *sufficient screen illumination* *large visual detail*
touchscreen tablets	*a non-obtrusive physical dimension* *a self-charging system*	
the usability tests	*individualised units* *a compact physical dimension* *an alternative to capacitive touchscreens* *physical adjustability* *corresponding tactile and digital selections* *infra-red (or comparable) touchscreen technology*	*personalised movies* *for symbols to have correlating text* *for all selections to be positioned horizontally at the base of the screen* *specially considered IA that vary in complexity* *icons that are familiar* *a Pause, Back or Stop button that is easily noticeable and recognised*

Table 4.3 ***The design parameters***

Chapter Five The Multimedia System

Chapter Overview

Chapter 5 provides the design specifications of the physical dimension and information architecture, which together form the multimedia system. The development of the physical dimension is guided by an anthropometric study and the parameters examined in the previous chapter. A review of tactile buttons resulted in the identification of a force–travel combination suitable for the research demographic. Finally, the chapter details the development of the system's information architecture guided by the parameters in the previous chapter, with a review of literature on interface design, typography, semiotics and colour theory for the older population.

–
All linear measurements are in millimetres (mm).

5.1 Aim

Chapter 4 informed the design parameters through a review of literature and prototype tests at an aged-care facility. The parameters were then used to guide the development of the physical dimension and information architecture of the multimedia system. The aim of this chapter is to detail the design specification that resulted in the design outcome.

5.2 Method

The desired design outcome has been developed using ideation, experimentation, critique and iteration. It begins with the development of the physical dimension, followed by the design of the information architecture.

5.2.1 The Physical Dimension

An anthropometric review, with descriptive statistics for the Australian elderly, assisted in informing the overall measurements of the physical dimensions.

Visual synthesis is demonstrated by sketching, a method of visualising the ideas in the mind of a person (externalising the internal). This aids design-thinking and enhances collaboration. It involves creating and removing, adjusting and compromising, and evaluating outcomes which may not be complete yet provide a better understanding of a goal through visual renders (Craft and Cairns 2009). According to Schütze et al. (2003), studies that use sketching result in significant benefits. In this chapter, sketching is used to develop ideas for the design of the physical dimension based on the knowledge obtained.

The chapter then uses CAD to conduct a material and overall aesthetic study on digital models of the multimedia system, alleviating the high costs associated with developing full-scale physical models. The most successful ideas are highlighted, evaluated and refined.

5.2.2 The Information Architecture

The information architecture was developed through a review of literature. Terminology used in the search process included: ‘interface design for the elderly’, ‘product design for people with dementia’, ‘semiotics’ and ‘design of information architecture’. Information architecture simulations were then developed. Structure models were first evaluated based on knowledge from literature using hierarchical flow diagrams. After a process of iteration, refined concepts used iconic models that were programmed using screen-based technology. These were put to the test at two Melbourne-based aged-care facilities (detailed in *Chapter 6*).

5.3 The Physical Dimension

5.3.1 Anthropometric Study

Chapter 4 highlighted the need for people with dementia to be seated while using a multimedia system (*Sections 4.3, 4.6.3 and Table 4.3, pages 46, 51 and 65*). *Figure 5.1* and *Table 5.1* show the body dimensions selected for measurement for elderly Australian males and females (aged 65 years and over) for the purposes of this research.

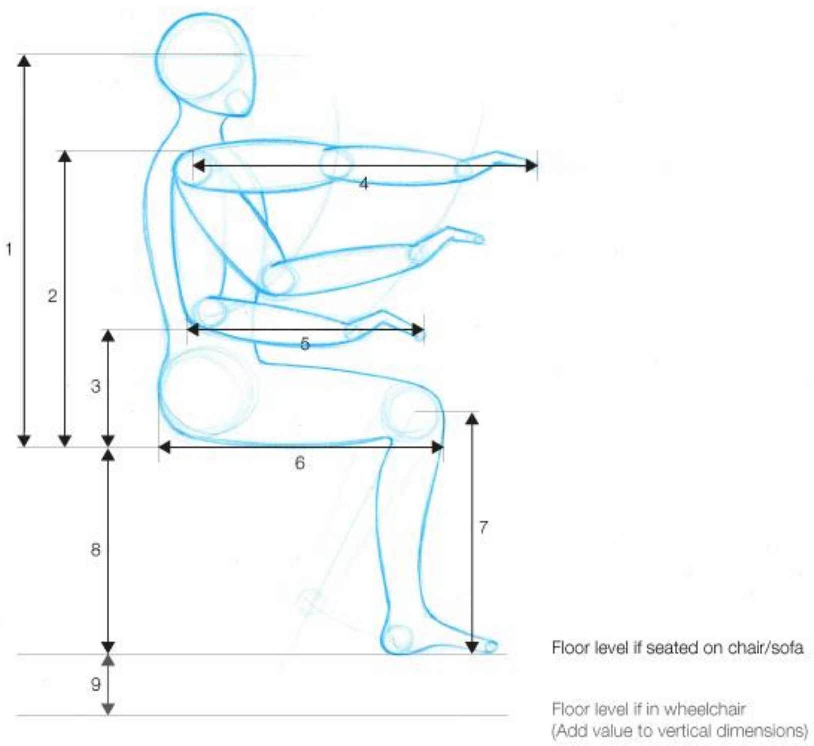


Figure 5.1 **Dimensions selected for the purposes of the research**

dimension number	measure
1	seated eye height
2	seated shoulder height
3	seated elbow height
4	upper limb length
5	elbow–fingertip length
6	buttock–knee length
7	knee height
8	floor–buttock height
9	floor–foot height (wheelchair)
not shown	age
not shown	weight
not shown	hand length
not shown	hand breadth

Table 5.1 **Dimensions selected for the purposes of the research**

Chapters 3 and *4* propose that the system's physical dimension should be comprised of a large screen with tactile buttons and a freestanding, non-obtrusive, adjustable stand (*Table 5.2*). The chapter now details these components.

	the physical dimension – needs
the literature review	*a large screen* *touchscreen technology* *dedicated hardware*
age-related impairments	*a freestanding physical dimension* *for users to be seated while using such a system*
touchscreen tablets	*a non-obtrusive physical dimension* *a self-charging system*
the usability tests	*individualised units* *a compact physical dimension* *an alternative to capacitive touchscreens* *physical adjustability* *corresponding tactile and digital selections* *infra-red (or comparable) touchscreen technology*

Table 5.2 ***Parameters for the development of the physical dimension***

5.3.2 The Screen

The literature review demonstrated the importance of providing individuals with dementia with large touchscreens (*Table 5.1*), while usability tests at an aged-care facility revealed that infra-red technology alleviated the challenges associated with capacitive touchscreens when used by this cohort.

Given the success of the 23-inch infra-red touchscreen used during the usability tests (*Section 4.8.3, page 56*), the research accepted this as the multimedia system's touchscreen size. The screen weighed 9.3 kilograms.

Figure 5.2 shows a vector representation of the infra-red touchscreen used in the usability tests.

Due to technological limitations, infra-red touchscreens require a bezel that contains LEDs (*Section 4.8.2, page 55*). To prevent injuries due to sharp corners, a rounded rectangle bezel (rounding radius 20 mm) would be ideal as shown below.

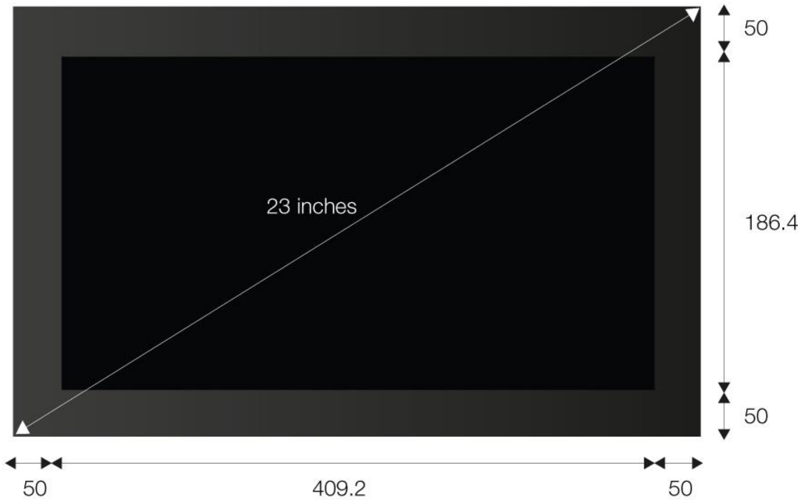


Figure 5.2 ***Vector representation of infra-red touchscreen with dimensions***

Figure 5.3 ***Rounded rectangle infra-red touchscreen bezel***

Figures 5.4 and *5.5* provide measurements for comfortable viewing and reach for elderly Australians.

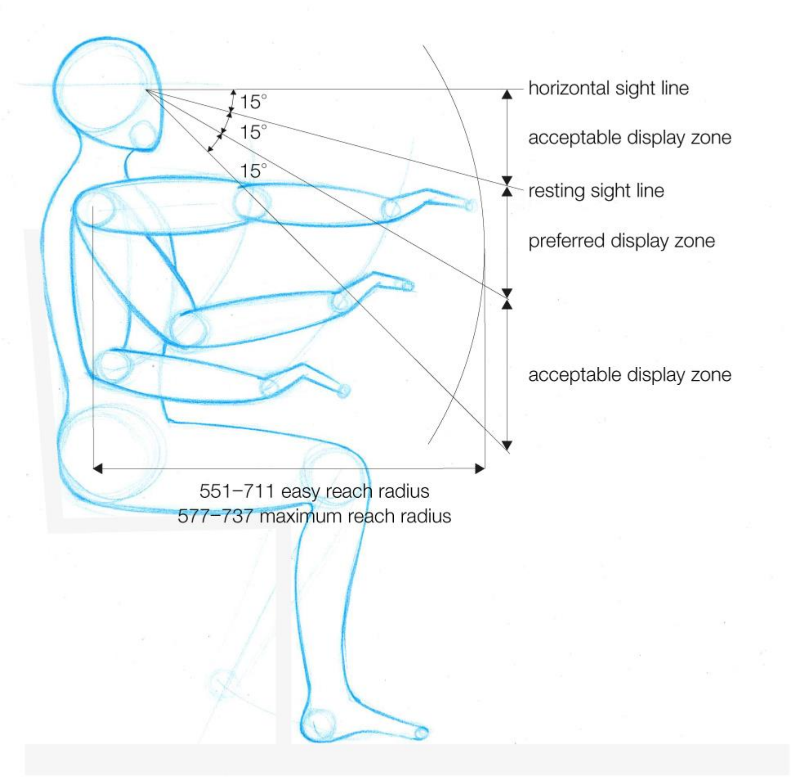


Figure 5.4 ***Measurements for comfortable viewing and reach for the elderly – profile view***
Tilley 2002

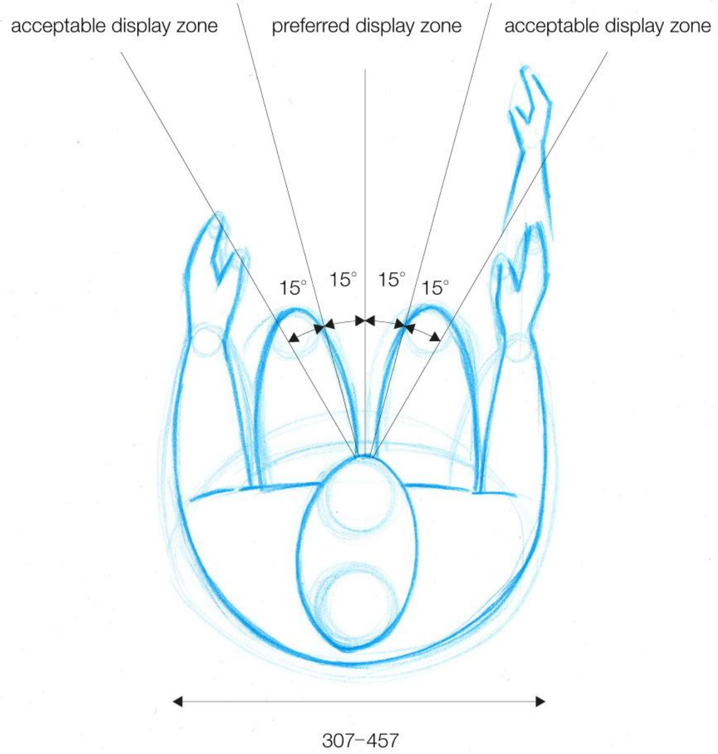


Figure 5.5 ***Measurements for comfortable viewing and reach for the elderly – plan view***
Tilley 2002

Figure 5.6 outlines the limits within which the screen must be contained for optimal use and compactness. The base of the screen, where the selection buttons are placed, must be within easy reach of the demographic, given that they may be affected by age-related physical impairments (*Section 4.3, page 46*). According to Tilley (2002), a 15° angle is ideal for normalising a screen or reducing reflection. Based on descriptive statistics and percentile values for Australian males (n=33) and females (n=138) (see *Appendix B, page 186*), the figure below shows the optimal height range for screen placement which lies comfortably within the acceptable display zone.

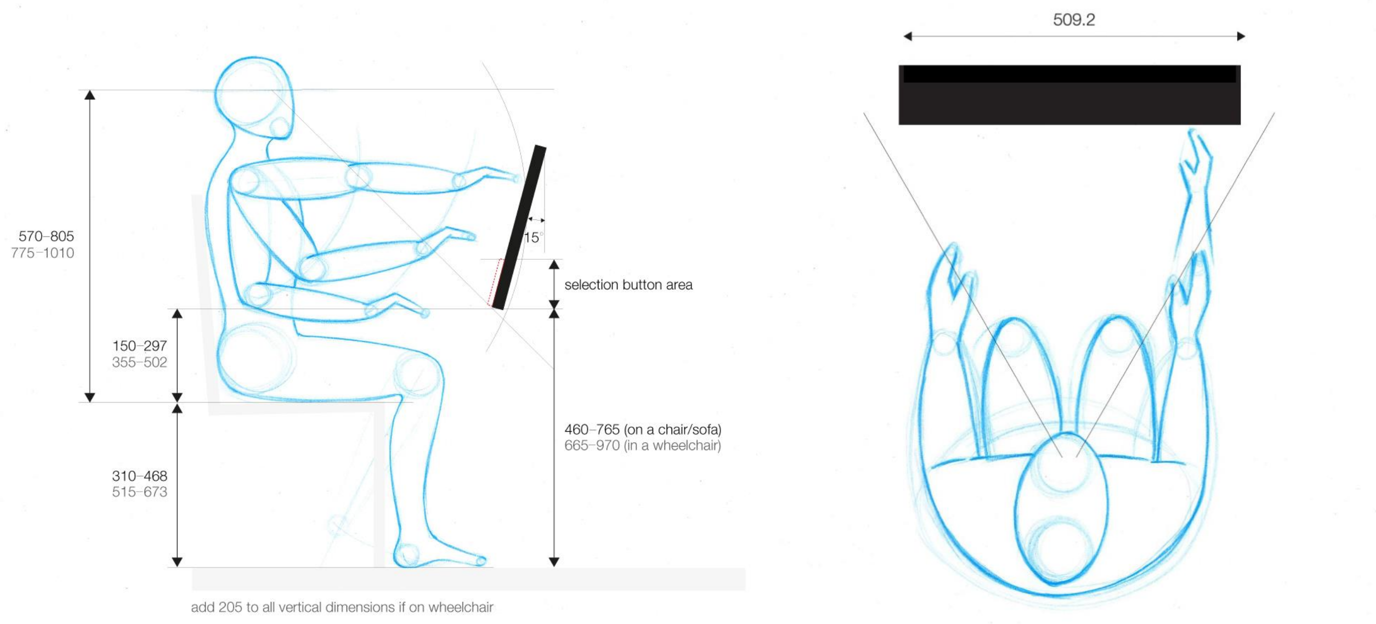


***Figure 5.6* Screen placement – profile and plan views**

Typically, the smaller single-occupant bedroom measures 2770 mm x 3150 mm (Tilley 2002). The minimum space of 559 mm required for a bed automatically determined the maximum width of the multimedia system if it was to be placed within this area (*Figure 5.7*).

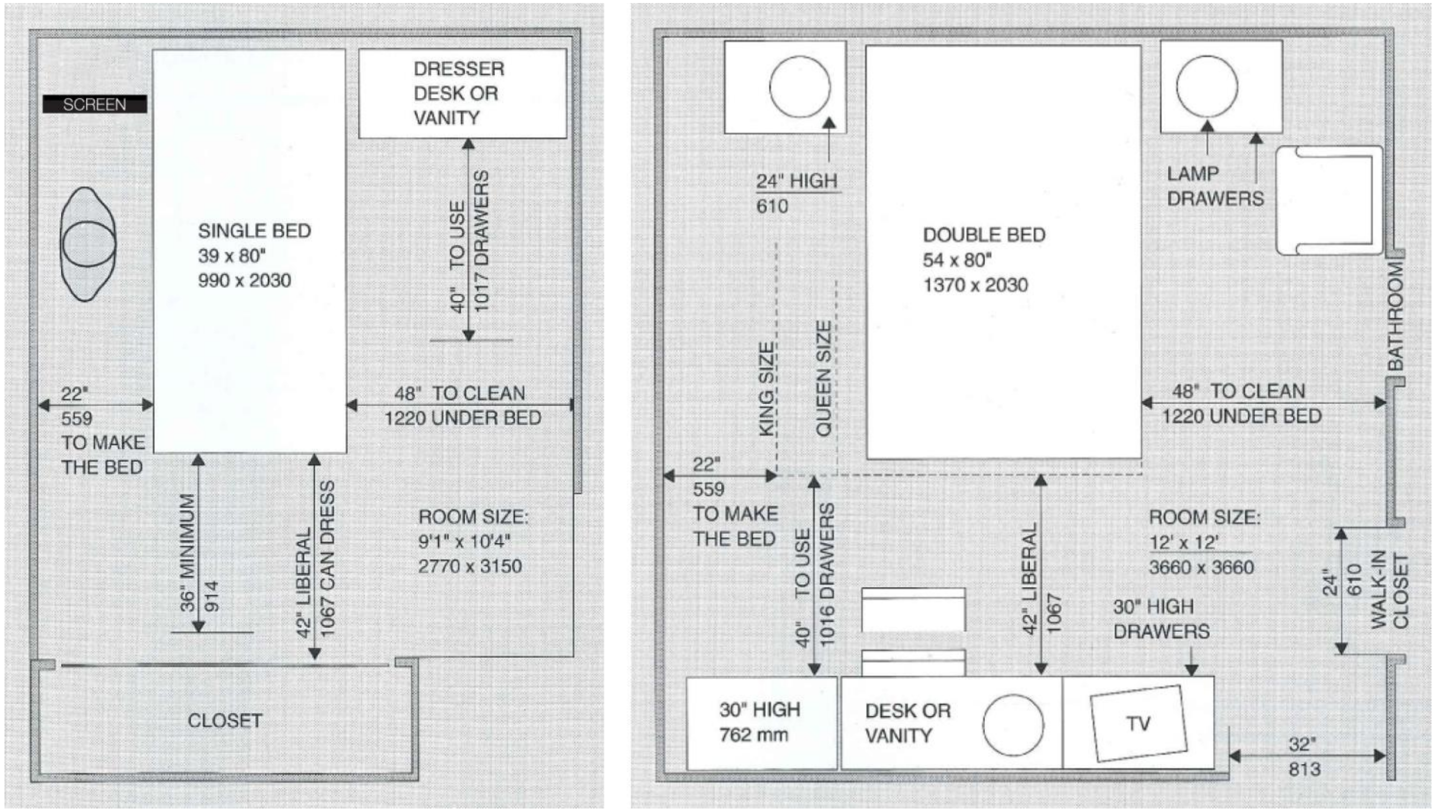


Figure 5.7 ***Small and standard bedrooms***
Tilley 2002

5.3.3 *The Stand*

Ideally, a 'floating' screen would address challenges associated with stands (such as visual mass, obtrusion and tripping hazard). However, technological and particularly aged-care facility limitations (*Section 4.6.3*, *page 52*) warrant the exclusion of the following mounting options (*Figure 5.8*):

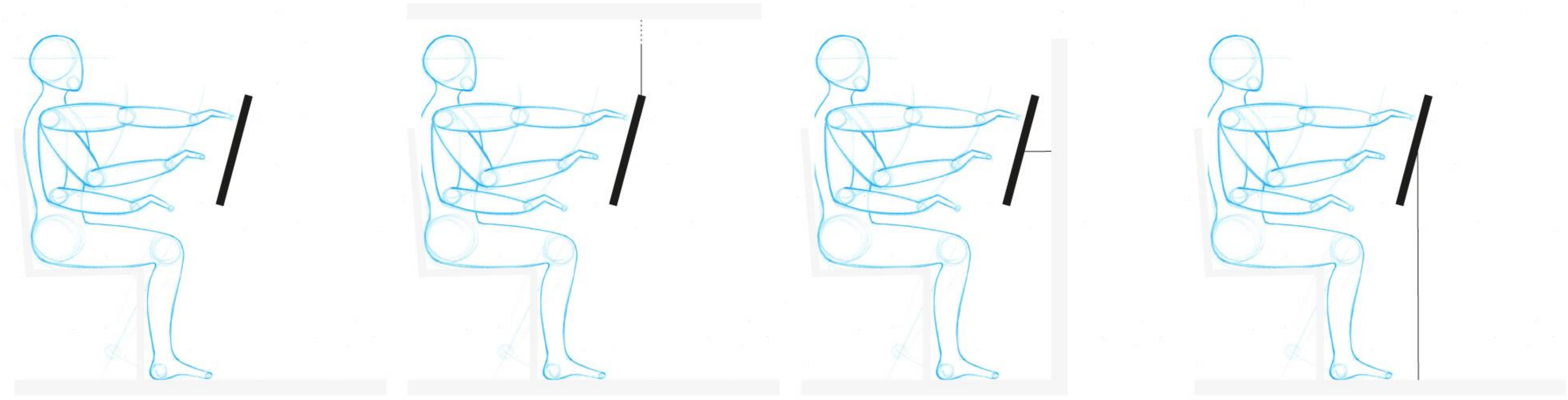


***Figure 5.8* Unsuitable screen mounting options**

The ideal option, therefore, was a freestanding mount/stand – one contained within the dimensions of the width of the screen and its height from the ground. This defined the workable area (*Figure 5.9*).

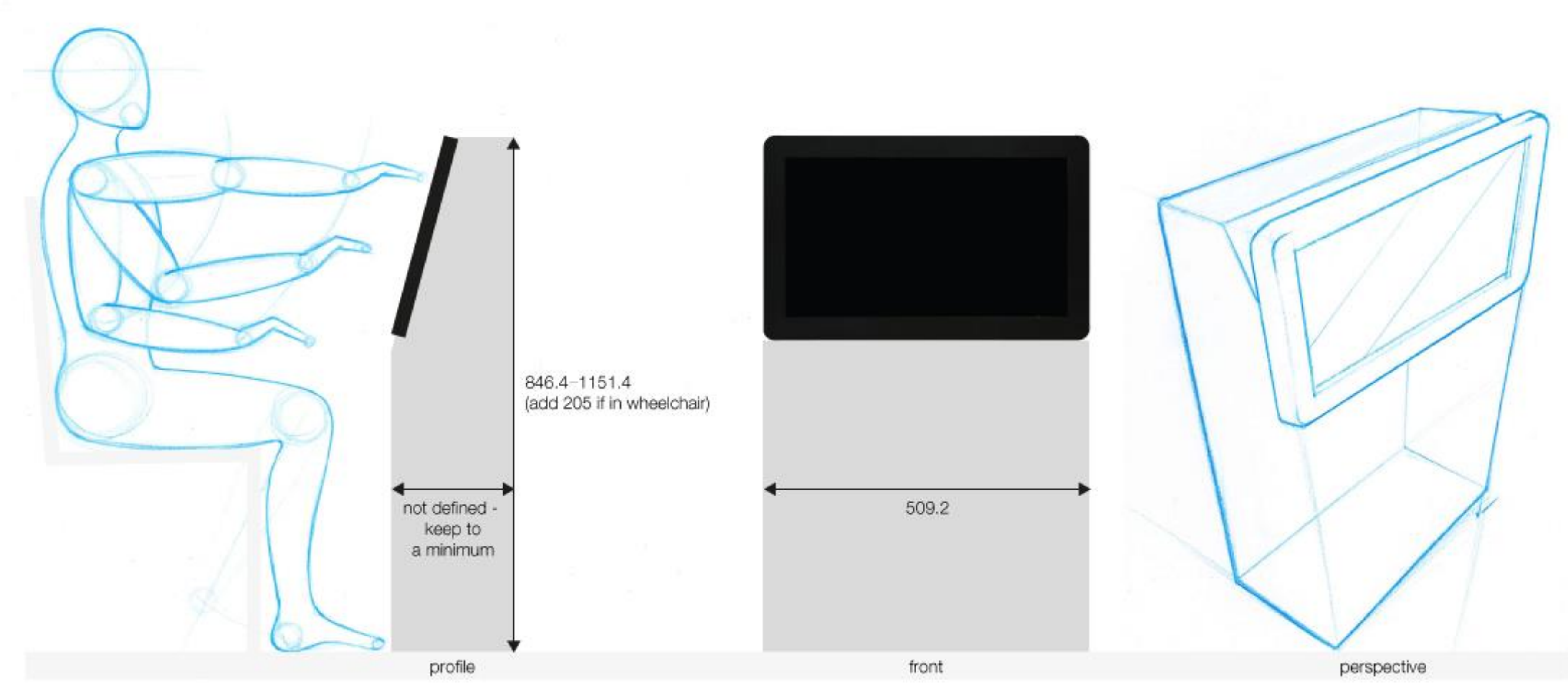


Figure 5.9 ***Workable area***

As the system was intended for long-term use by the same user (the remaining lifetime of an individual with dementia), it was unlikely to require height adjustment on a regular basis. This ruled out the need for a quick release mechanism. Bolting the screen to the stand would alleviate the risk of the screen falling off or being accidentally or intentionally dropped.

As the stand was not allowed to be fixed to the ground (*Figure 5.8*), the following design criteria were considered to ensure that it was safe for use by this demographic. The stand should:

- not be a tripping hazard
- be stable
- be designed to make it difficult to be used as a support during the process of sitting down or standing up
- not contain any sharp corners or edges
- be physically and aesthetically compact
- not distract the user from the media on the screen
- conceal all wiring in a safe manner

Figure 5.10 shows the approximate centre of gravity of an infra-red screen with an inbuilt CPU, offering optimal stability to the screen (assuming even weight-distribution within the screen).

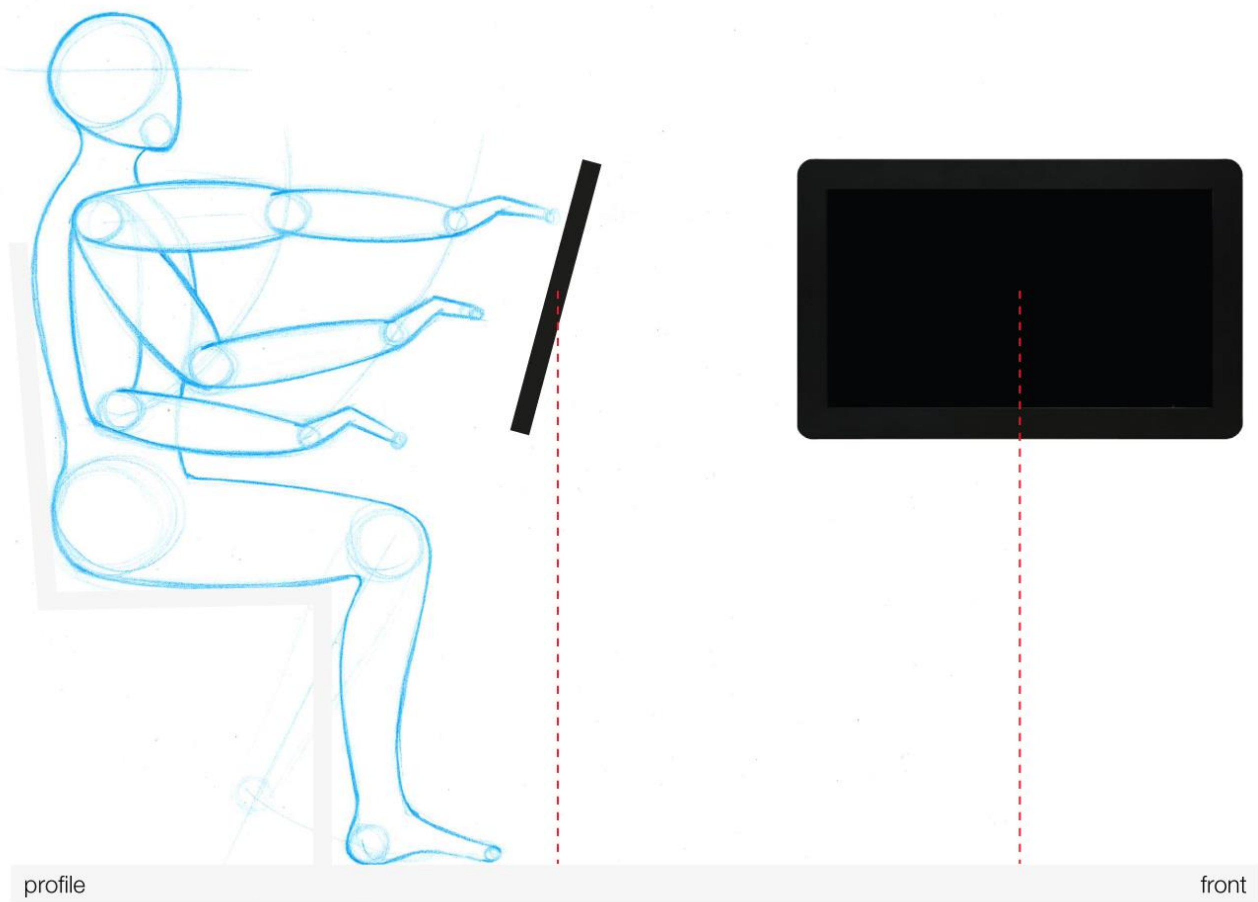


Figure 5.10 ***The screen's approximate centre of gravity***

A black-coloured stand would give the system the look of an integrated unit rather than just a screen on a stand.

Figure 5.11 shows the front view of the screen and the stand. To maintain optimal engagement and least distraction, the design of the stand had to be mimimal.

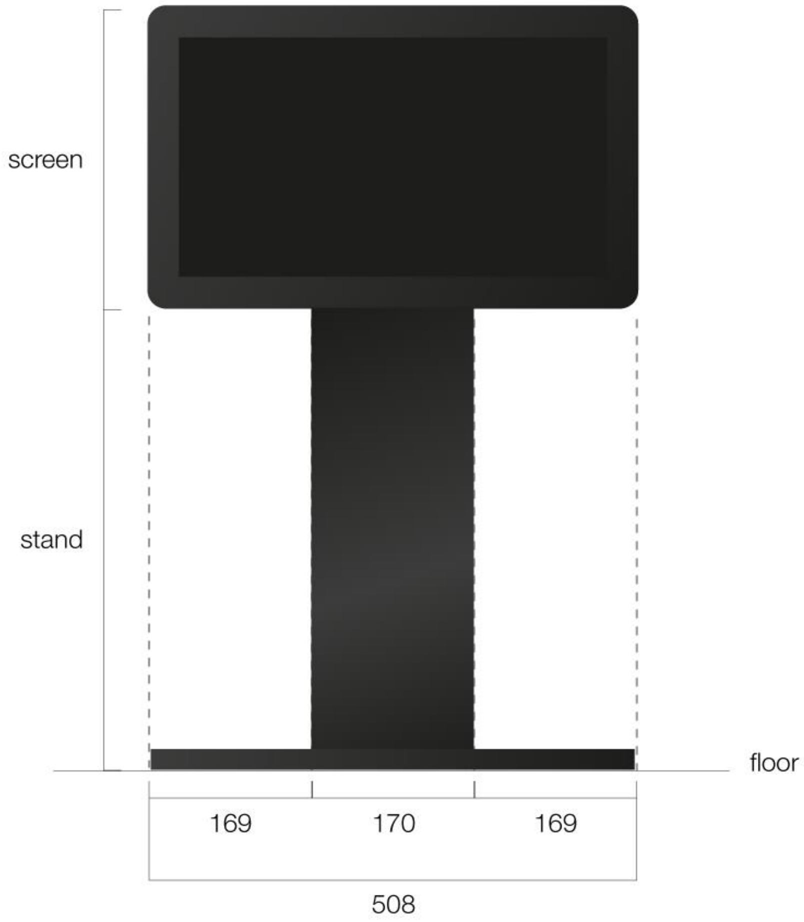


Figure 5.11 ***Front view of stand in relation to screen***

The research then explored other options for the stand using sketches and vector representations.

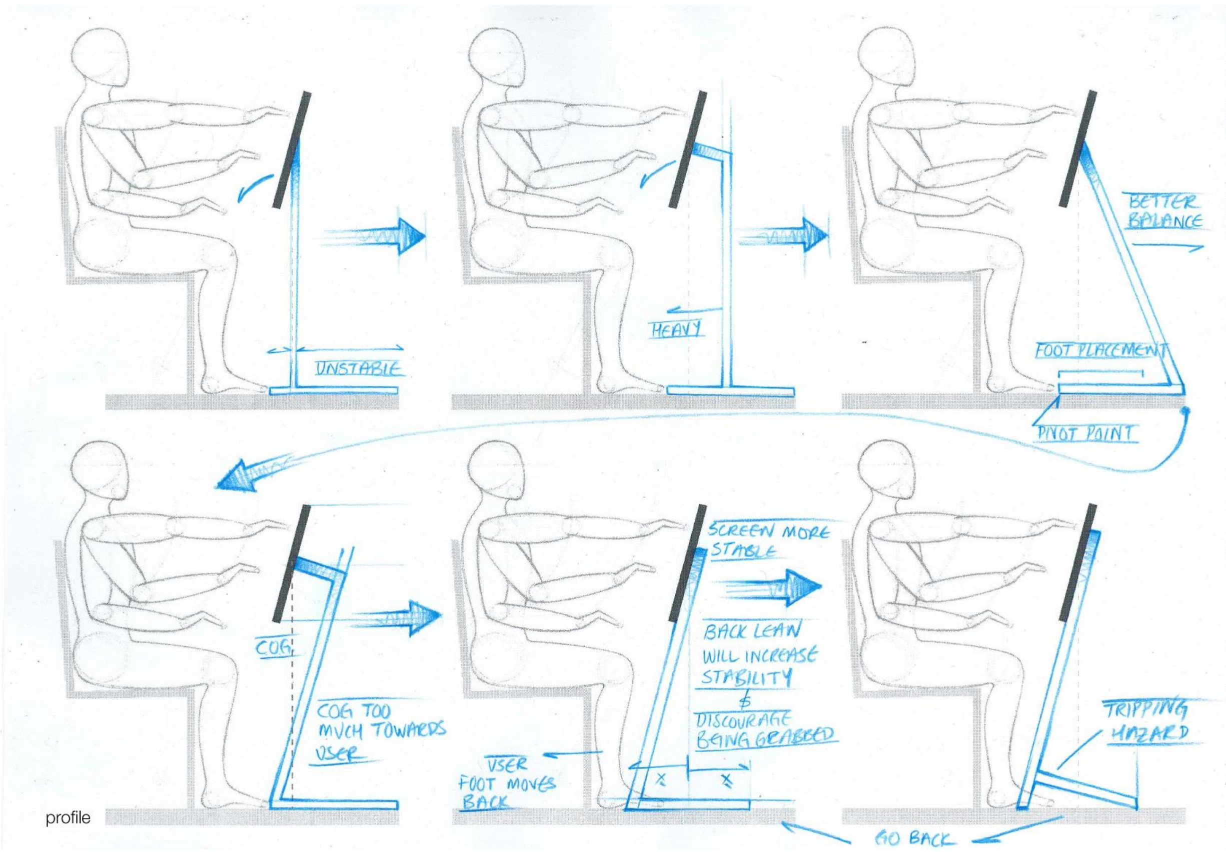


Figure 5.12a ***Stand ideation***

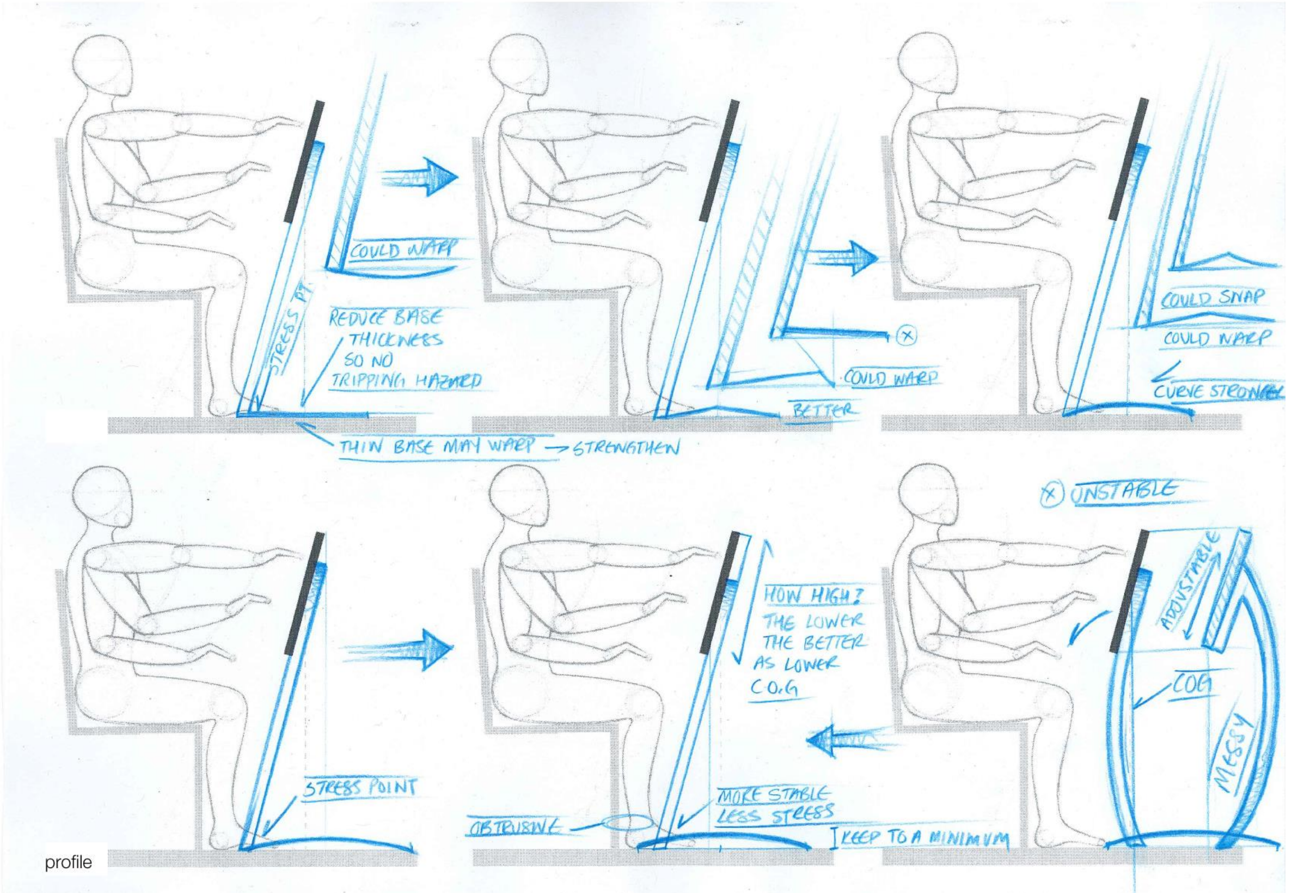


Figure 5.12b ***Stand ideation***

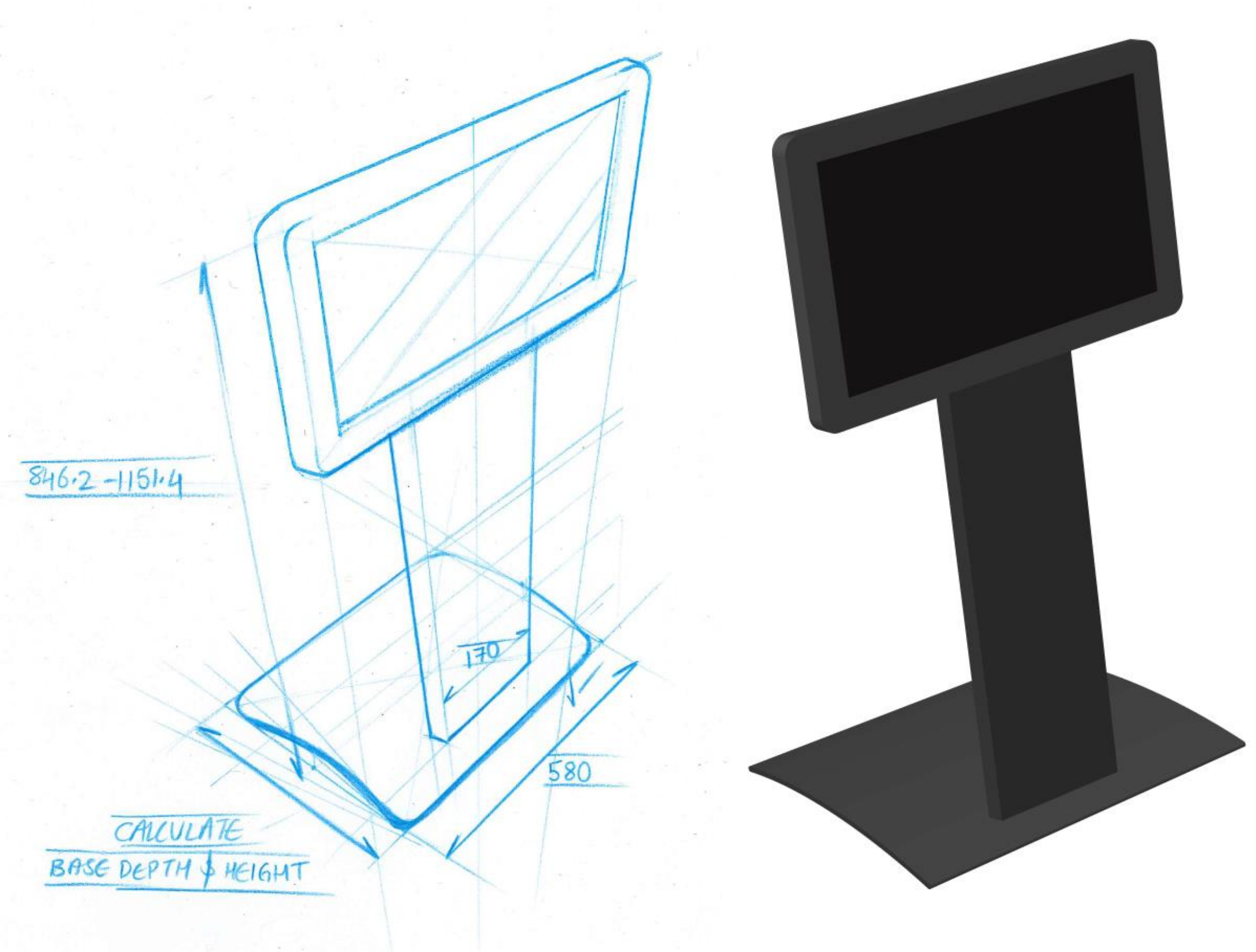


Figure 5.12c ***Stand ideation***

***Figure 5.12d* Stand ideation**

Figure 5.13 ***Desired outcome***

Figure 5.14 shows the desired outcome, which obeys the design criteria in the following manner:

- *not be a tripping hazard* – a low and relatively flat base to reduce chances of tripping
- *be stable* – an angled stand to move the centre of gravity towards the back, making it more stable; a base with a large surface area extending away from the user
- *be difficult to use as a support during the process of sitting down or standing up* – the stand to be angled to discourage this action
- *not contain any sharp corners or edges* – the corners to be rounded wherever possible
- *be physically and aesthetically compact* – the stand to be contained within the width of the screen; visual mass to be reduced – the stand stem when viewed from the front to be approximately one-third of the screen's width with little or no volume in the back section
- *not distract the user from the media on the screen* – the stand to be plain and dark (matching the colour of the screen)
- *conceal any wiring in a safe manner* – the stem of the stand to serve as the conduit for the wiring

Two actions may lead to possible instability in the system:

1. *Being pulled forward with a horizontal force at the top of the screen* – This produces an anti-clockwise moment about the front tip of the base plate (which is equal to the horizontal height of the top edge of the screen multiplied by the estimated maximum force a user applies). Opposing this moment is a clockwise moment due to the weight of the assembly (*Figure 5.14*).

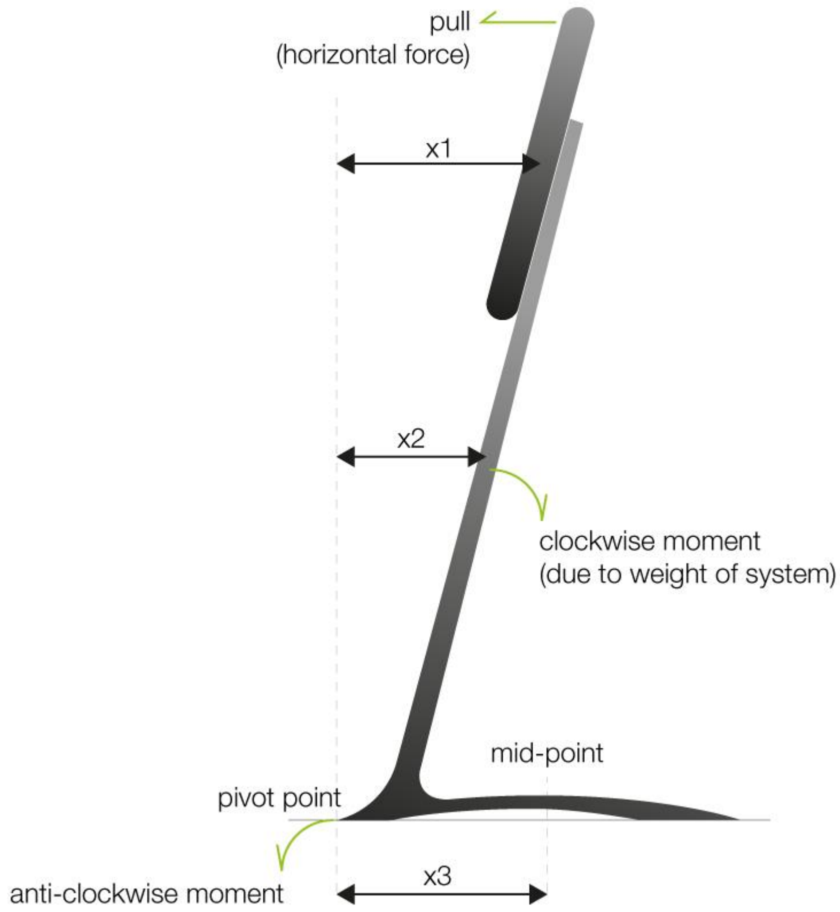


Figure 5.14 ***System being pulled***

In order to achieve stability, the clockwise moment must be restored; *x*1 is the horizontal distance of the centre of the screen, *x*2 is the horizontal distance from the centre of the sloping support piece, and *x3* is the horizontal distance from the centre of the base plate, all measured to the front tip of the base. For both the sloping support and base plate, their centres of gravity are assumed to be at their mid-points.

The clockwise moment is restored thus:

W (screen) x *x*1 + W (sloping support) x *x*2 + W (base plate) x *x*3

(W = weight; *x* = distance to the front tip of the base)

For safety, the restoring moment should effectively be two to three times the disruptive moment.

2. *Being pushed over with a horizontal force at the top of the screen* – This produces a clockwise moment about the backward tip of the base plate (which is equal to the horizontal height of the top edge of the screen multiplied by the maximum estimated force a user applies). Opposing this moment is an anti-clockwise moment due to the weight of the assembly (*Figure 5.15*).

Therefore, the anti-clockwise moment is restored as above:

W (screen) x *x*1 + W (sloping support) x *x*2 + W (base plate) x *x*3

(W = weight; *x* = distance to the rear tip of the base)

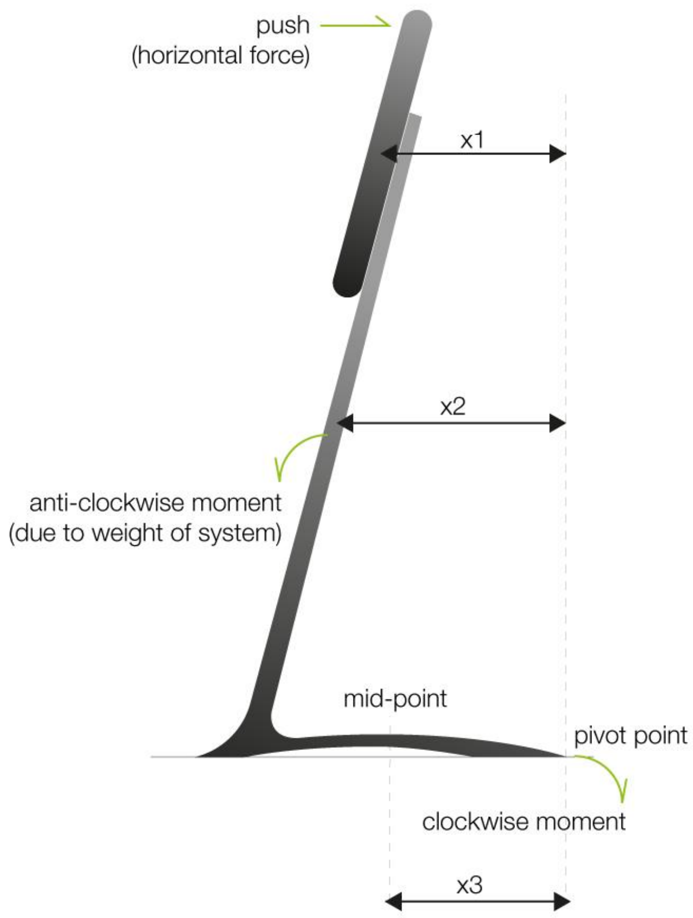


***Figure 5.15* System being pushed**

As shown in *Figure 5.15*, the values of *x*1, *x*2 and *x*3 when the system is pushed will be greater than when it is pulled. Since the weights are the same, the restoring force will be less critical.

The 15° angle of the stand shifts the centre of gravity towards the centre of the base, making it more stable. *Figure 5.16* shows this. A precise measurement in determining the centre of gravity can be obtained using the following formula:

$$x = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

(*m* = mass; *x* = distance from a reference point)

Figure 5.16 ***The system's centre of gravity***

Based on these measurements, *Figure 5.17* shows the approximate dimensions and realistic look of the stand (not taking its material, volume or density into consideration).

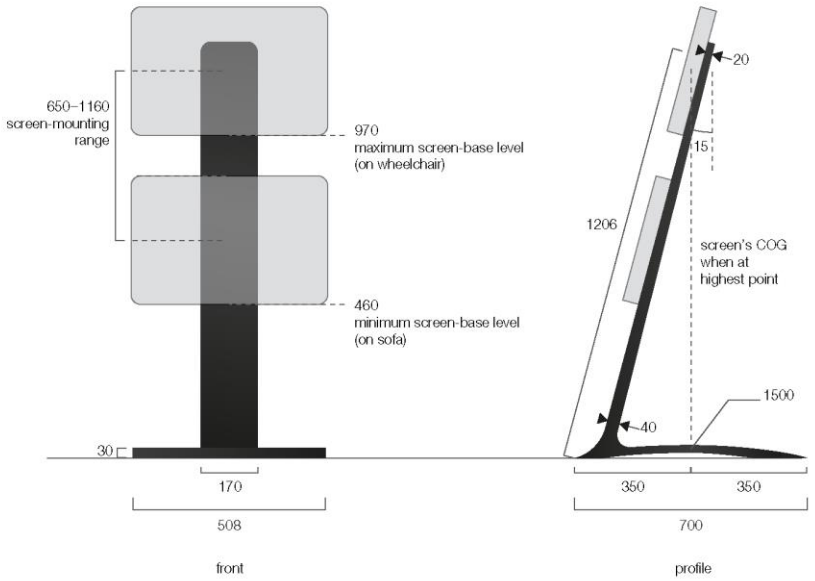


Figure 5.17 ***Stand with dimensions***

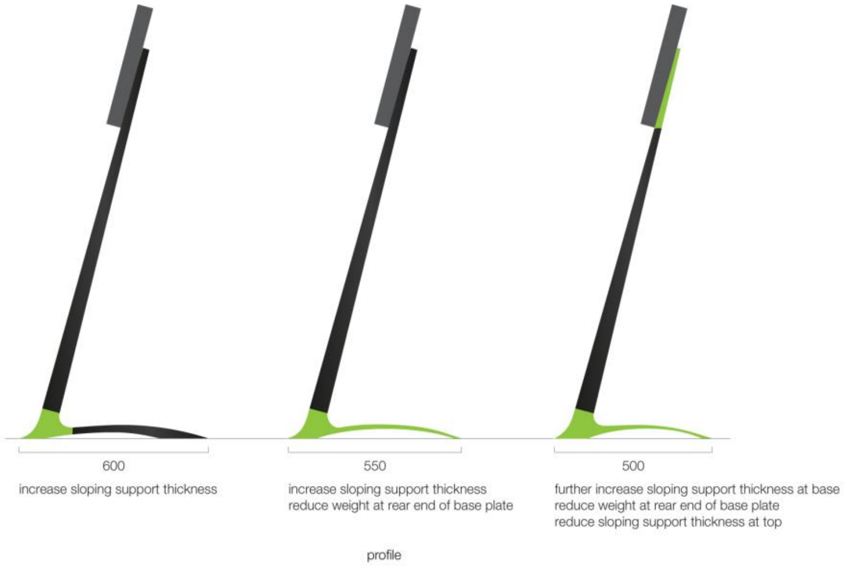


Figure 5.18 ***Options to increase the anti-clockwise moment***

Given that the system was being designed to cater to the elderly, including those on wheelchairs, the stand's base plate needed to be approximately 700 mm deep for the screen's centre of gravity to lie directly over it (considering the screen's highest point when catering to an elderly male on a wheelchair, as that is where the system's centre of gravity is the most critical). However, this would result in the stand having a very deep base plate, which would occupy a lot of space in an aged-care facility bedroom (*Figure 5.17*).

Therefore, the base plate depth needed to be decreased by increasing the stand's anti-clockwise moment. Viable options are shown in Figure *5.18*.

Figures 5.19a, *5.19b* and *5.19c* detail the revised stand with a reduced base plate depth (third angle projection drawing with dimensions, exploded view and rendered orthographic views of stand).

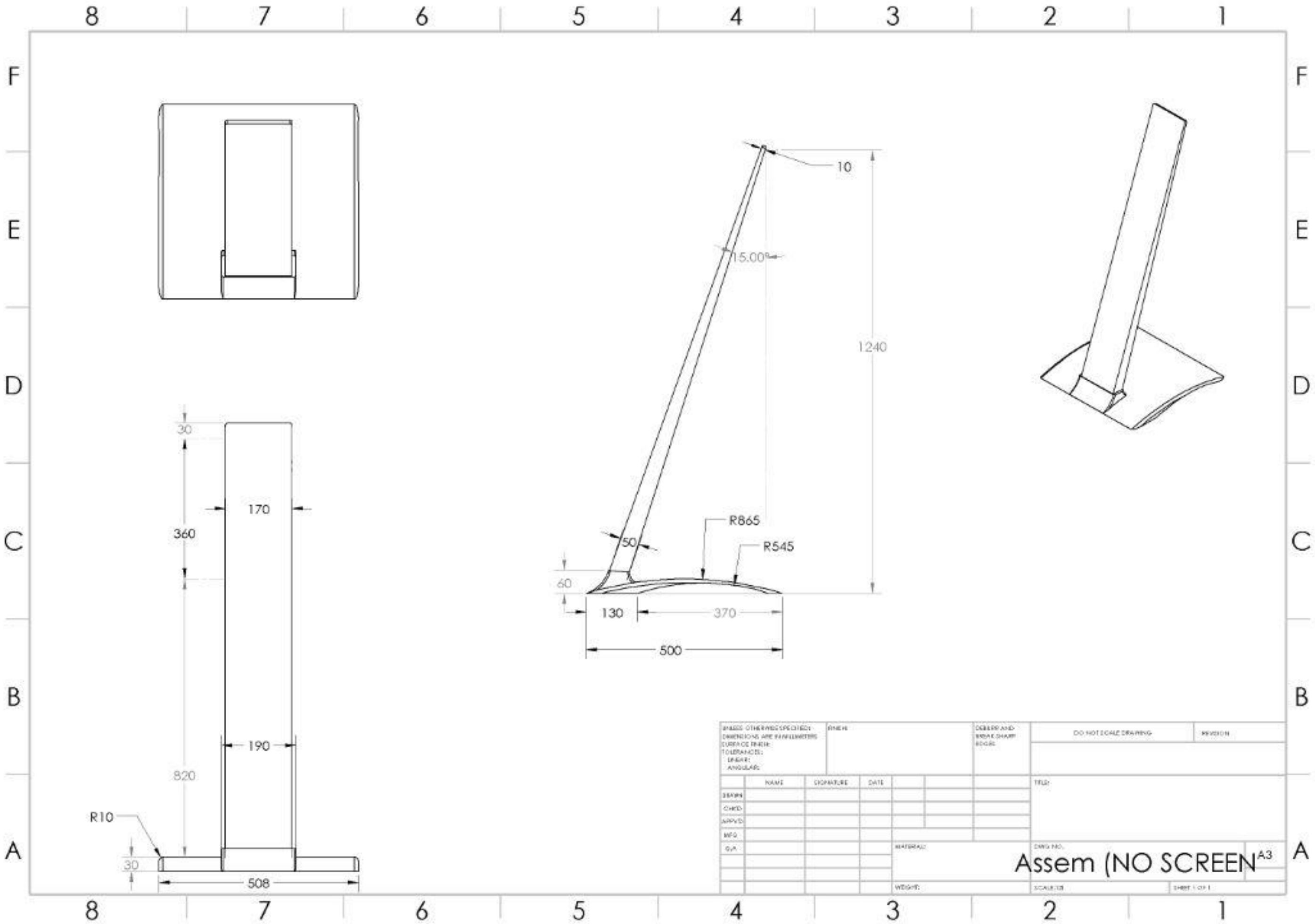


Figure 5.19a ***Revised stand design***

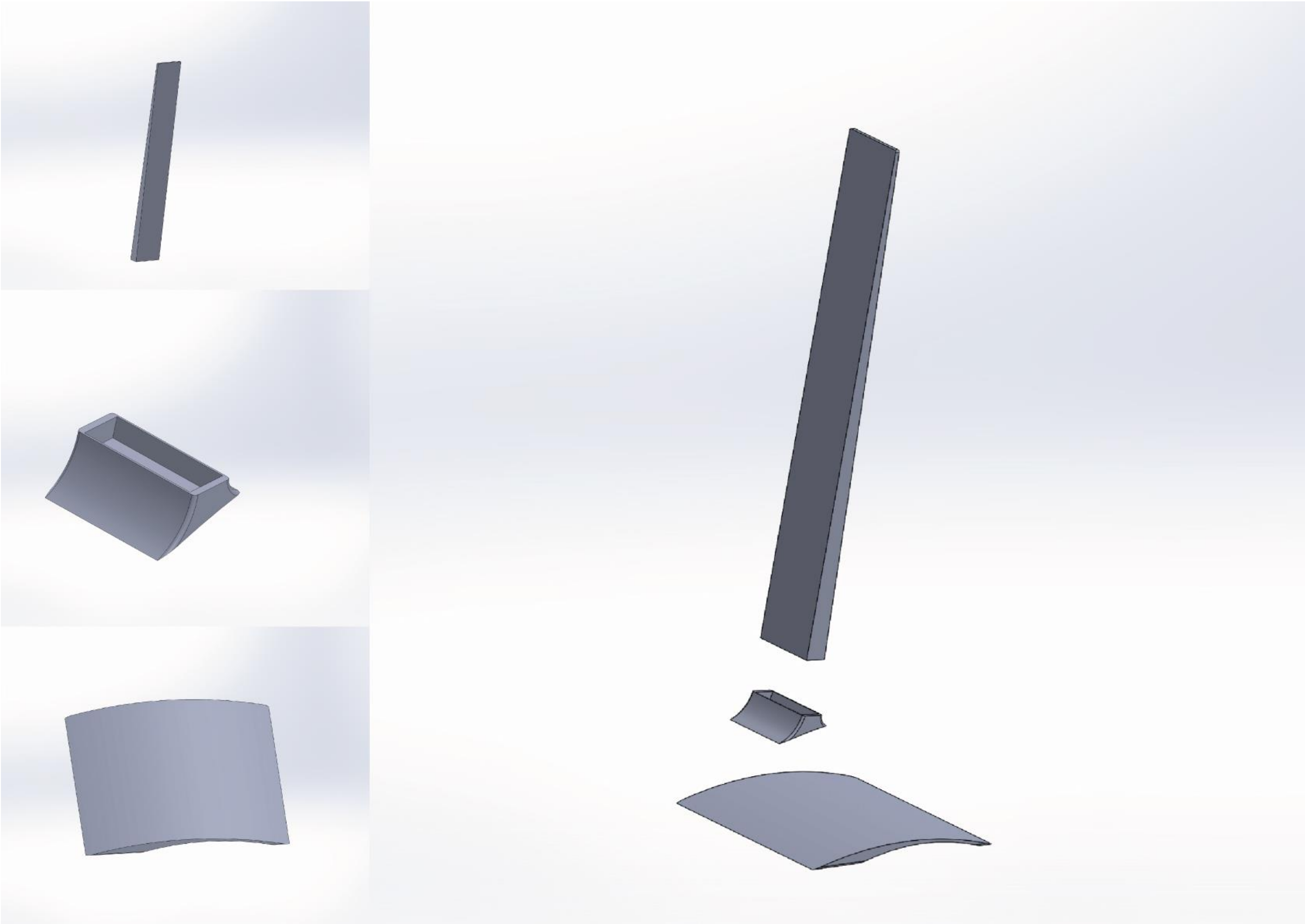


Figure 5.19b ***Revised stand design***

Figure 5.19c ***Revised stand design***

When it came to placement of the multimedia system in an aged-care facility bedroom, the RC suggested that it be near a wall as shown in *Figure 5.20*. In this position, any wires from the screen could run towards the stand’s base and directly to a power outlet while being concealed and reducing the risk of tripping. Moreover, in case a resident were to fall onto the stand, the wall behind would prevent it from tipping over.

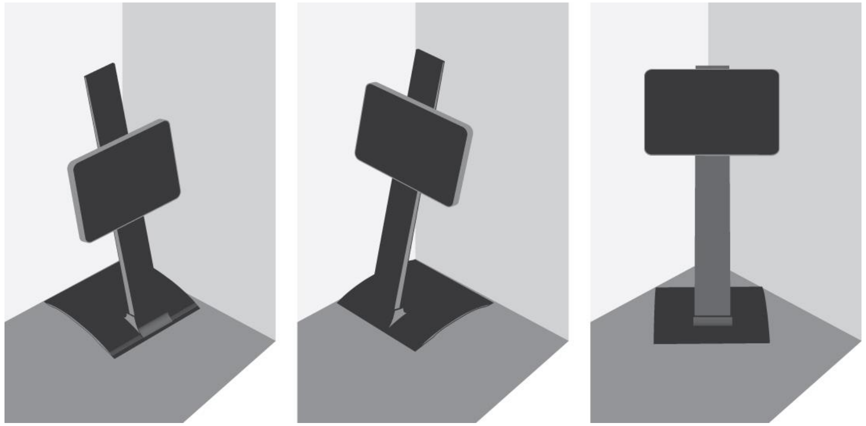


Figure 5.20 ***Recommended system placement***

5.3.4 The Tactile Buttons

Tactile buttons that corresponded to digital buttons provided more selection methods, resulting in a higher degree of autonomous use (*Section 4.10.3, page 63*). The usability sessions used low-fidelity elastomer-membrane buttons moulded from silicone (*Figure 5.21*).

Figure 5.21 ***Tactile buttons used during usability sessions***

Elastomer-membrane buttons, while successful, are not suitable for repetitive use as the material is prone to long-term wear. Therefore a more durable option was necessary, one designed to cater to both the able-bodied and the physically impaired elderly populations.

In a push-button study by Rahman et al. (1998), 36 older adults were categorised into three groups: those who were able-bodied, those who had arthritis and those who had tremors (such as in Parkinson's disease). Each group of 12 had male and female participants. In total there were 16 males and 20 females, aged between 51 and 91 (with a mean age of 70). The aim of the study was to develop a set of guidelines that would enable each of the three groups to use push-buttons comfortably, by testing a variety of force–travel combinations.

The study reported the following:

- All participants were able to operate push-buttons with their fingers within a force range of 0.36–5.2 N and a travel range of 0.2–7.1 mm.
- For continuous push and hold, the button should not have a force of more than 2.0 N. This implied that the currently recommended ranges of force 2.8–11.0 N and travel 3–6 mm were not ideal for the elderly population when a continuous push was required (Cushman and Rosenburg 1991).
- The able-bodied group had a preference to buttons with a low force-travel combination (force: 0.30–0.50 N; travel: 0.2–8.0 mm) or a medium force-travel combination (1.0–2.0 N; up to 0.8 mm).
- The arthritis group preferred buttons that required a low force (0.3–0.50 N) and a travel range of 0.2–4.0 mm, as well as a force–travel combination with gradual force build-up to high travel (7 mm).
- The tremor group had preferences for a number of force–travel combinations: low force with high travel (0.48 N, 3.9 mm), medium force with low travel (1.88 N, 0.5 mm) and high force with low travel (3.96 N, 0.8 mm). In summary, the group preferred buttons which stabilised their fingers, facilitating more precise control. (Rahman et al. 1998)

The results proposed that a force range of 0.30–0.48 N and a travel range of 0.2–3.9 mm would cater to all three groups. This, therefore, became the force–travel combination for the multimedia system's tactile buttons. *Figure 5.22a, b* and *c* present some visual syntheses for push-buttons.

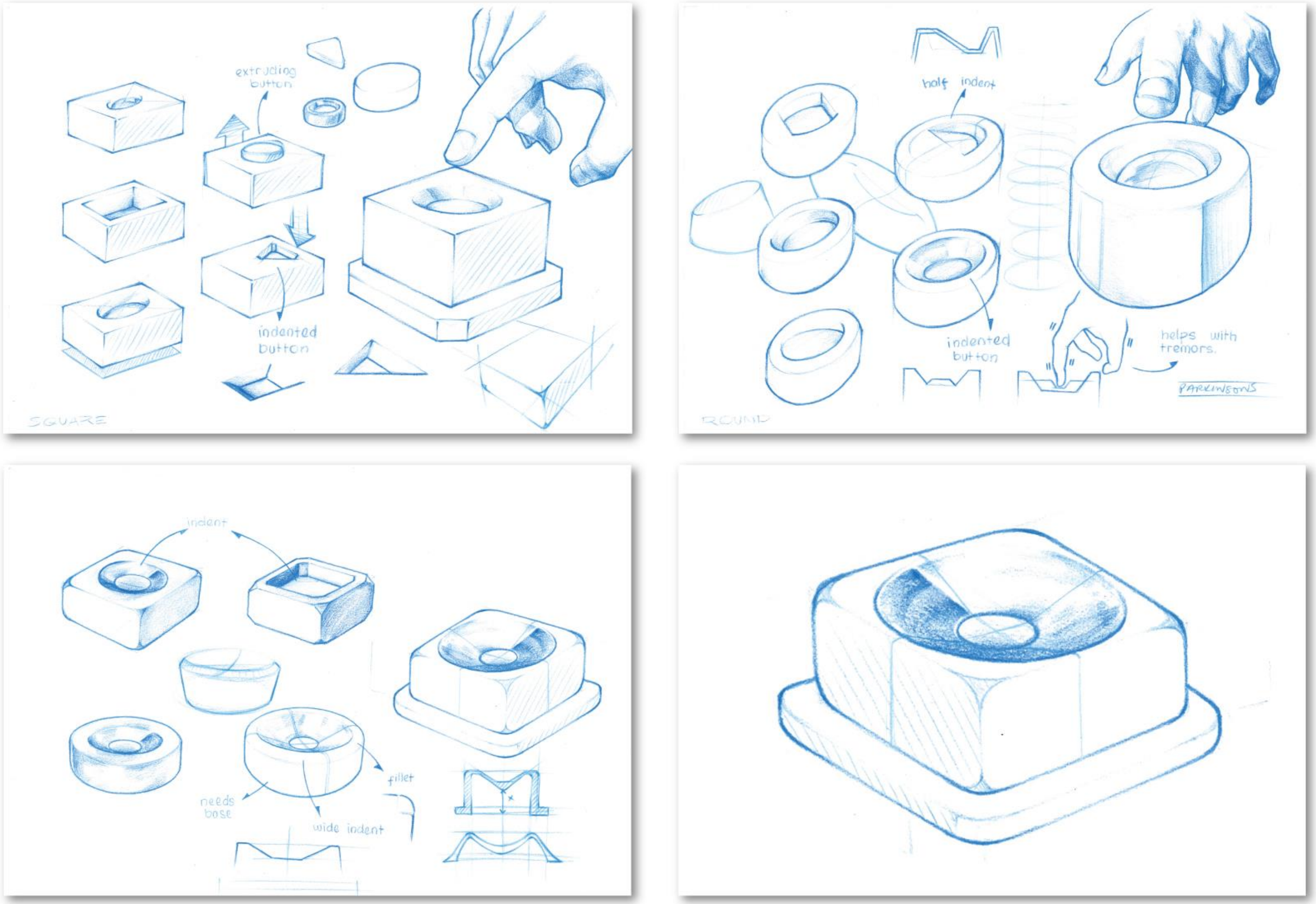


Figure 5.22a Visual synthesis of button design

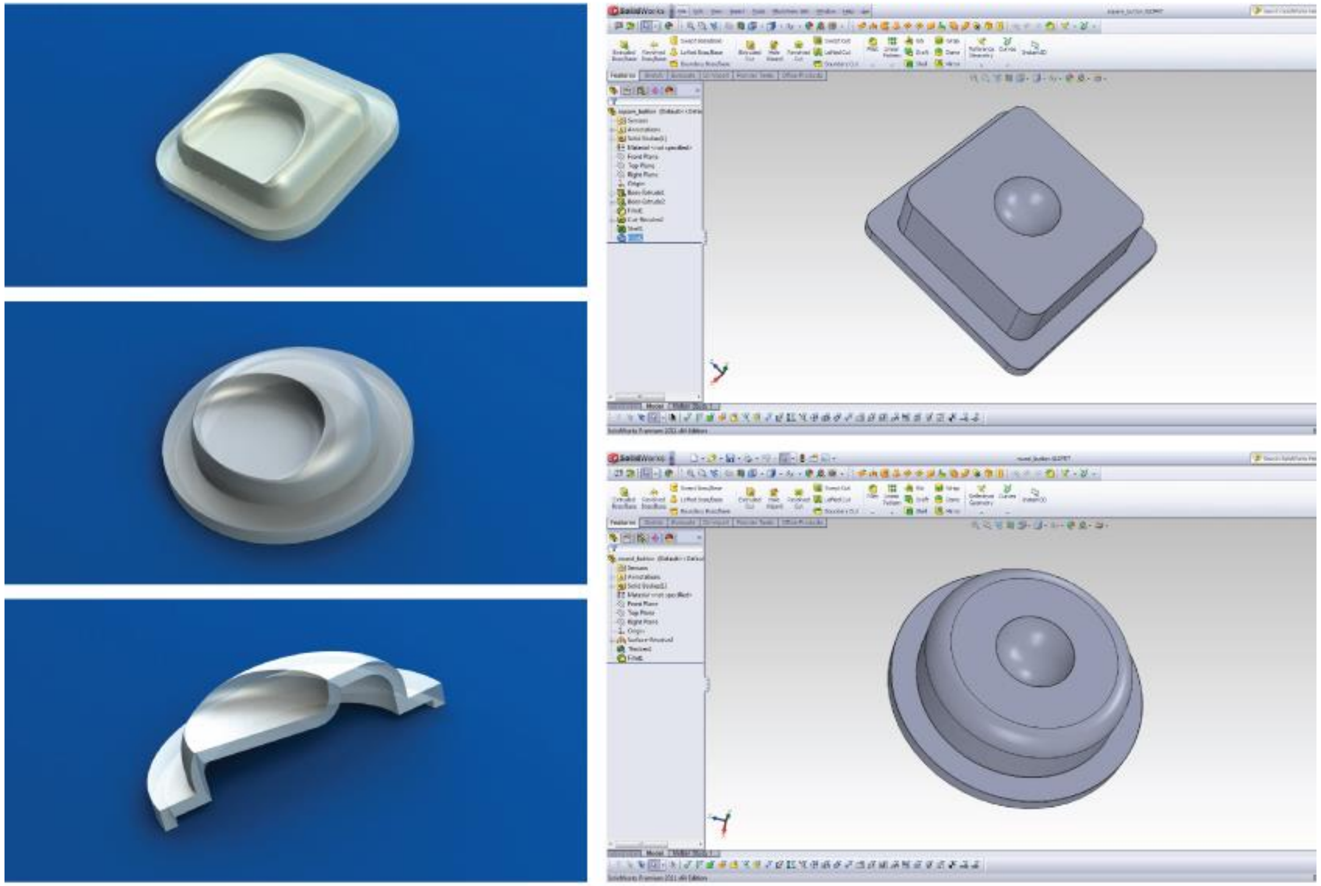


Figure 5.22b ***Visual synthesis of button design***

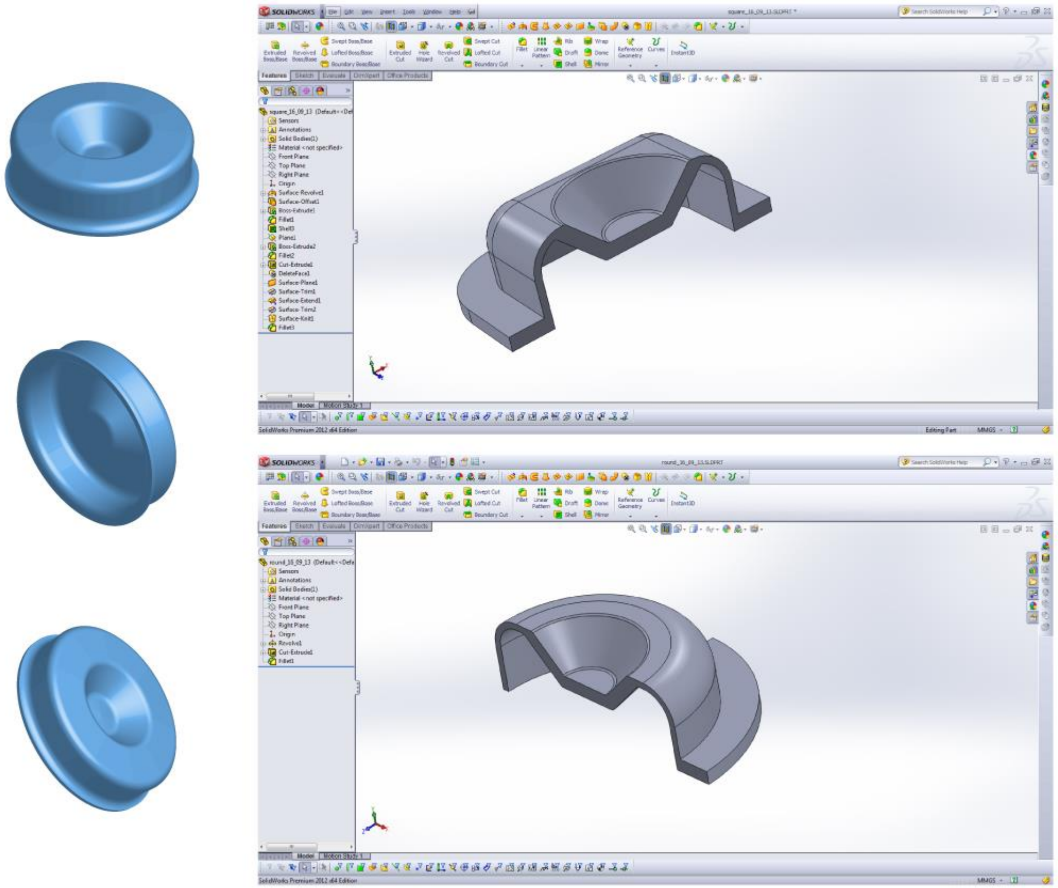


Figure 5.22c ***Visual synthesis of button design***

Given the success of silicone buttons in the usability tests, the multimedia system adopted a 30 mm diameter for circular buttons and a 28 mm edge for square buttons. To provide more control to individuals with Parkinson's disease or other tremors, a finger indentation tapering in diameter from 24 mm to 10 mm (6 mm deep) was incorporated into the button design (Tilley 2002).

The design parameters in *Chapter 4* (*page 65*) reported a need for sufficient auditory amplification. As auditory levels might vary among individuals, the provision of a volume knob in the multimedia system could enhance user comfort. For optimum comfort, a diameter range of 12.7–38 mm, with a torque lower than 0.037 Nm (Newton-metres), should be considered for rotary knobs (Tilley).

Figures 5.23a, b and *c* show the desired outcome and dimensions of rounded-square and circular buttons in a range of materials.

Figure 5.23a ***Desired button design and material study***

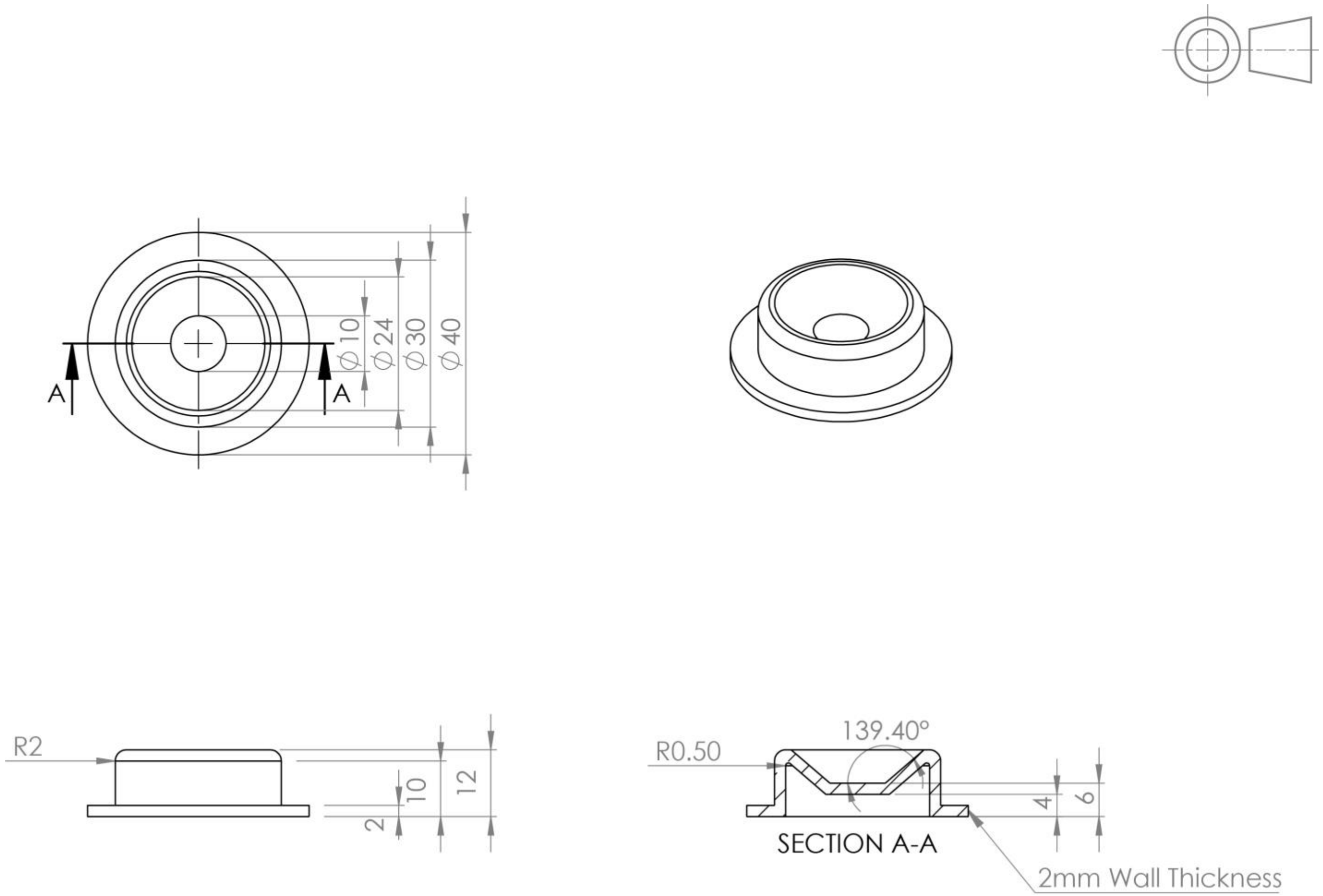


Figure 5.23b ***Desired button dimensions***

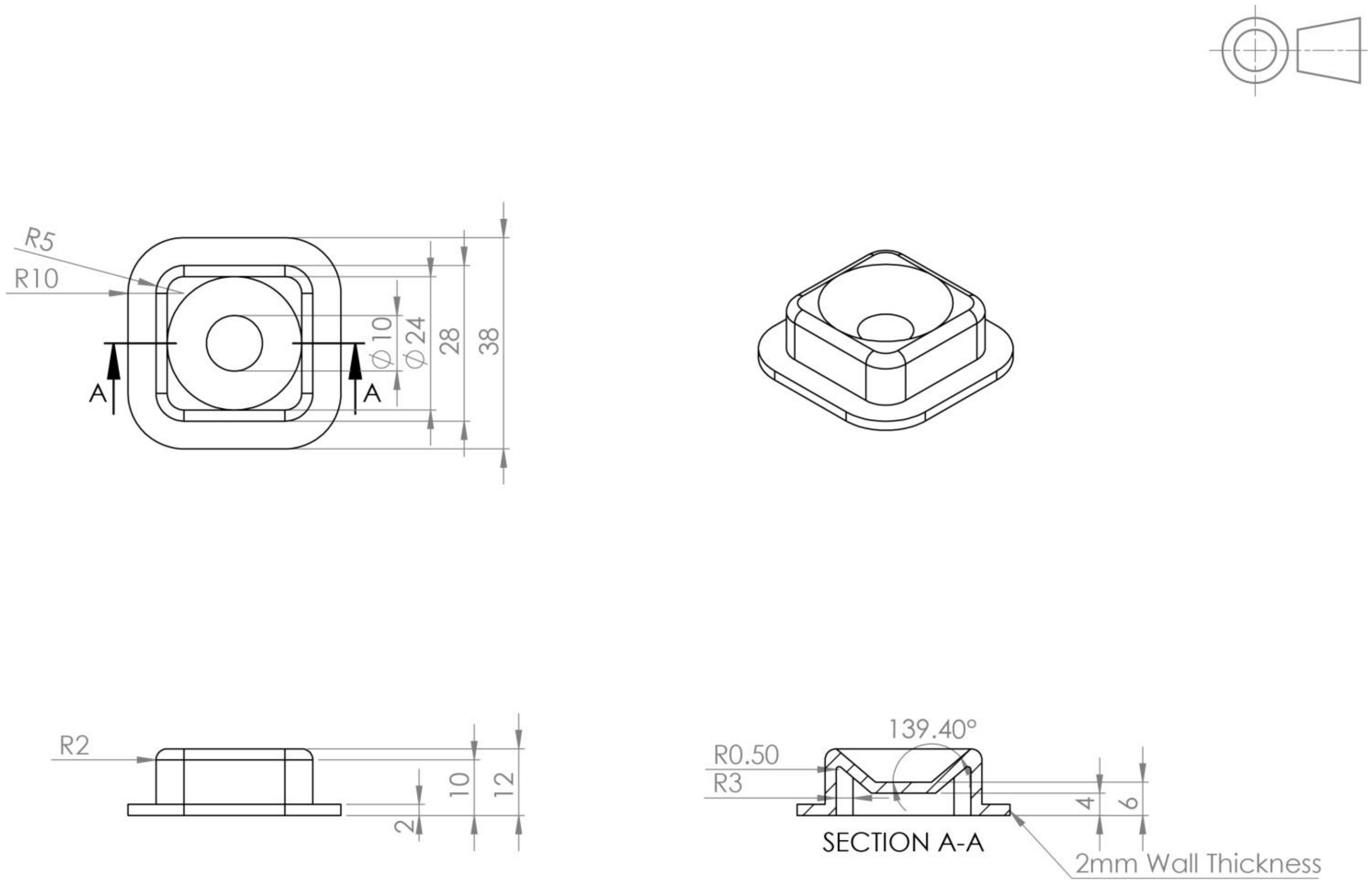


Figure 5.23c ***Desired button dimensions***

5.4 The Information Architecture

The findings in *Chapter 4* resulted in the following parameters which guided the development of the information architecture:

	the information architecture – needs
the literature review	*personalised photo-videos (with supporting personalised music and a pan/zoom feature)*
	to maintain flow
	representational icons
	personalised music
	pre-recorded family video-messages
	to provide more options to users (for all media to have associated photographs and titles)
age-related impairments	*sufficient auditory amplification*
	sufficient screen illumination
	large visual detail
touchscreen tablets	
the usability tests	*personalised movies*
	for symbols to have correlating text
	for all selections to be positioned horizontally at the base of the screen
	specially considered IA that vary in complexity
	icons that are familiar
	a Pause, Back or Stop button that is easily noticeable and recognised

Table 5.3 ***Parameters for the development of the information architecture***

To provide engagement, it was crucial that the multimedia system's information architecture provided and maintained flow when used by people with dementia. While the research demonstrated better efficacy of personalised media over generic media in addressing common symptoms of dementia, the key challenge in obtaining flow lay in the design of the information architecture.

The research narrowed in on the following media types that would be employed in the multimedia system:

- personalised music
- personalised photo-videos (with personalised music)
- pre-recorded family video-messages
- favourite movies

5.4.1 Hierarchy

When designing the information architecture, it was important for its hierarchy (also referred to as 'taxonomy') to have the right balance between depth and breadth. Depth refers to the number of steps in the information architecture, while breadth refers to the number of options at each level. When considering breadth, it is important to ensure that information overload on users is avoided; content is grouped and organised where possible; and designs are subjected to rigorous testing (Rosenfeld and Morville 2002). This is demonstrated in *Figure 5.24* using a hierarchical flow chart based on the selections made in the information architecture iconic model in *Chapter 4* (*Session 5, page 59*).

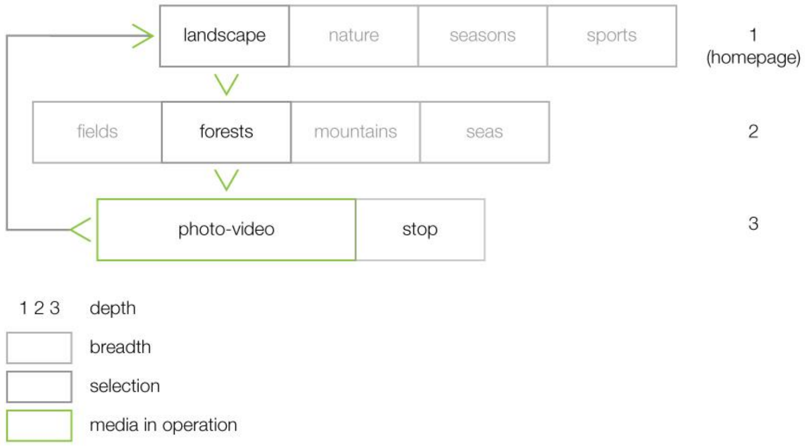


Figure 5.24 ***Information architecture hierarchical flow chart***

Chapter 4 concluded by identifying the need for information architecture that varied in complexity to cater to the various levels of dementia. It was apparent that some individuals with mild dementia were able to navigate through information architecture of greater depth, while others with mild or moderate dementia were only able to get as deep as one level. While the information architecture was not tested on people with severe dementia, it could only be assumed that they, too, would require a maximum depth of one. This hypothesis, however, required verification (*Chapter 6*).

People with dementia could therefore benefit from a multimedia system that would provide both hierarchies – 'narrow and deep' and 'broad and shallow'. As the name suggests, a narrow and deep hierarchy provides users with a minimal number of selections on a homepage (as few as one) and requires several steps to access its deepest content. A broad and shallow hierarchy provides users with a greater number of selections on a homepage and requires very few steps (as few as one) to access its deepest content (Rosenfeld and Morville).

Based on the results from *Chapter 4*, a narrow and deep hierarchy may better cater to people with high MMSE scores (mild dementia) who would have more control and options available to them, while a broad and shallow hierarchy may better cater to people with medium and low MMSE scores (moderate and severe dementia) where the deepest content would be just one click away.

It could be argued that only a broad and shallow hierarchy should be provided to all people with dementia, that being highly likely to provide autonomous use to individuals at mild and moderate stages. However, to people with mild dementia a hierarchy such as this may not provide sufficient challenge and therefore not enough flow. This confirmed the importance of the need for the two hierarchies. For purposes of the research, the narrow and deep hierarchy was called 'level 1 architecture' and the broad and shallow 'level 2 architecture'.

5.4.2 *The Level 1 Architecture*

The level 1 architecture catered to people with mild dementia. It provided a top-down approach where users could discover content by navigating through the depth of hierarchy at their convenience. The research suggested that people with dementia did not cope well with multiple sources of information (Astell et al. 2008). Given that the multimedia system aimed to present four media types (a breadth of four), level 1 architecture limited its breadth to a maximum of four selections at any depth. In this way, users may be able to navigate through greater depth without a reduction in flow. However, it was important to monitor depth for each user to ensure that flow was not lost before the media was accessed. *Figure 5.25* displays an example of the architecture from the four media types (homepage) to media output/format (media operation). The levels between the homepage and media operation are hereafter referred to as 'folder' 'sub-folder' and 'file', these determining the architecture depth (four levels in this example).

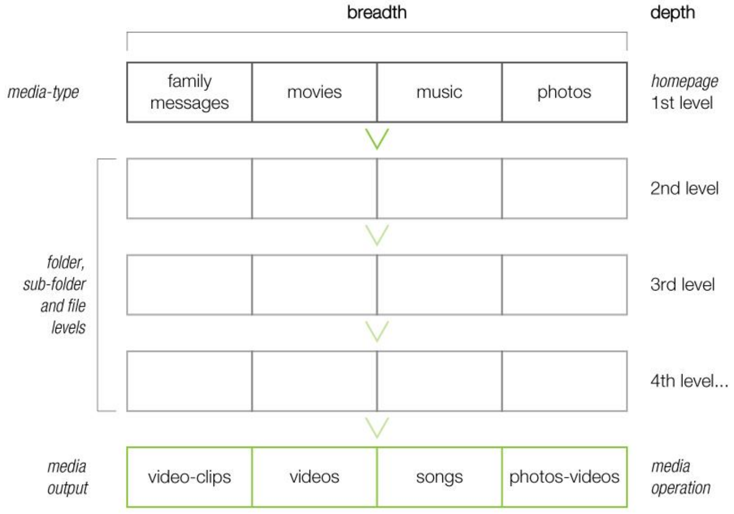


Figure 5.25 ***The level 1 architecture***

As shown in *Figure 5.25*, four media types were presented on the homepage. On selection, users were directed to the next level of the hierarchy (folder), followed by its subsequent levels (sub-folder and file), before media operation.

Some media types could require all four levels, while others required fewer levels before media operation; the difference lay in the manner in which the media was categorised. The example in *Figure 5.26* used a folder, sub-folder and files before music operation; the folder presented four artists, the sub-folder presented the selected artist's albums (Elvis Presley) and the files were the individual songs from the selected album (Blue Hawaii).

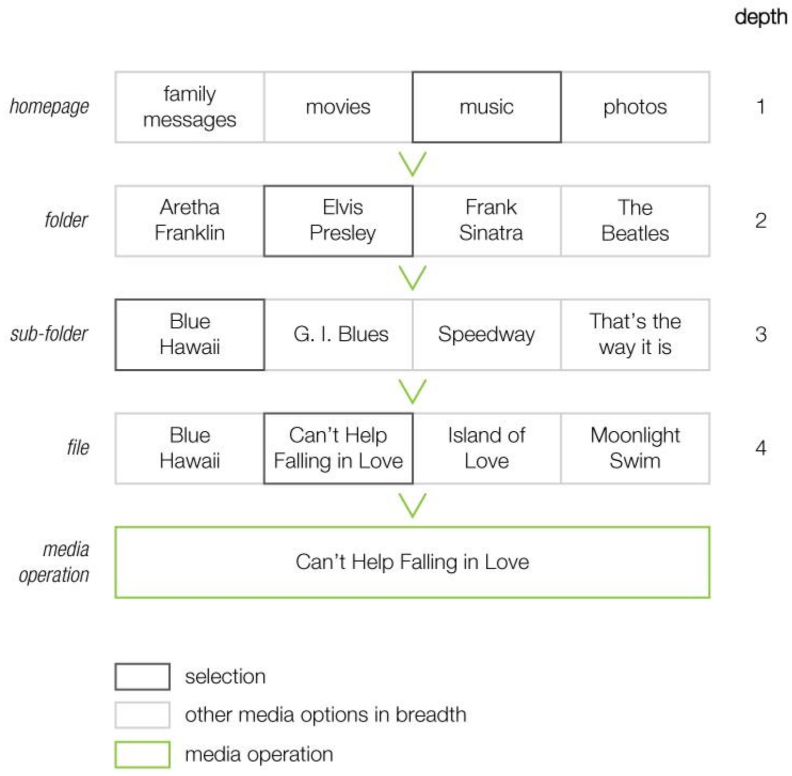


Figure 5.26 ***Categorisation of media (example 1)***

In the example in *Figure 5.27*, the sub-folder level was not applicable and was therefore removed. On selecting the artist, users were presented with individual songs by the artist.

In the example in *Figure 5.28*, the file level was not applicable and was therefore removed. On selecting the artist, users were presented with the artist's albums which, on selection, played the songs within the album.

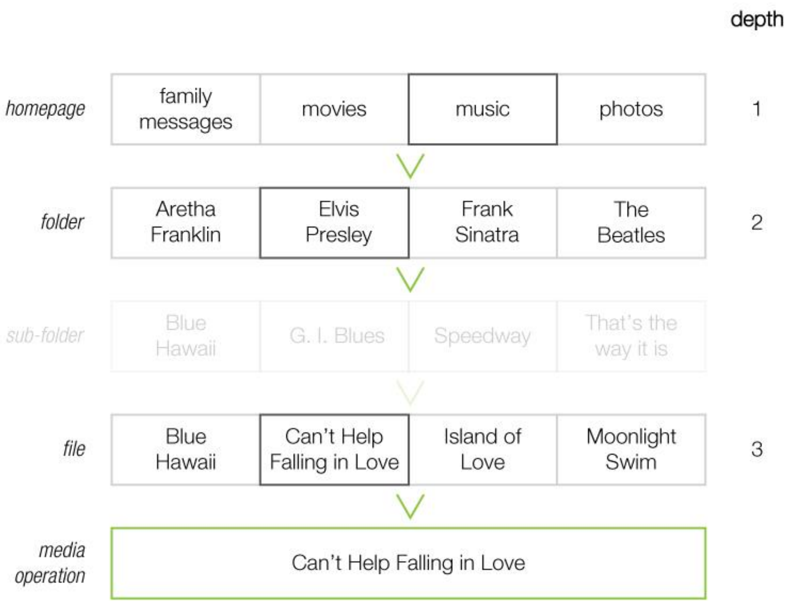


Figure 5.27 ***Categorisation of media (example 2)***

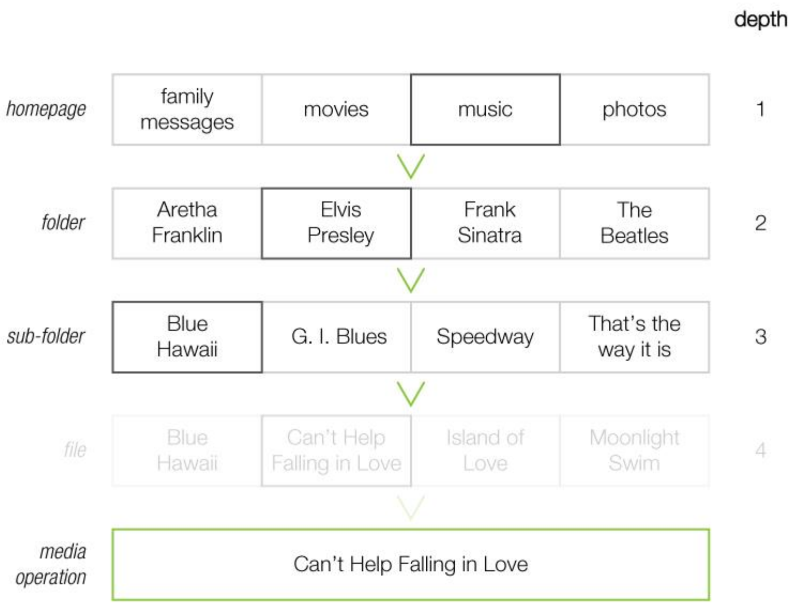


Figure 5.28 ***Categorisation of media (example 3)***

The flexibility of the level 1 architecture provided users with the option of navigating through as few as two levels before media operation:

- homepage and folder
- homepage and sub-folder
- homepage and file

For people with mild dementia who may be able to navigate through more than the four levels of the hierarchy, the level 1 architecture could provide them with additional media at folder, sub-folder or file level by incorporating a 'More' option. However, to maintain breadth size and to ensure users were not faced with multiple sources of information on a single page, the 'More' option would sit in the place occupied by the fourth media breadth option at any depth (thereby reducing the number of available media options to three). *Figure 5.29* displays how this works.

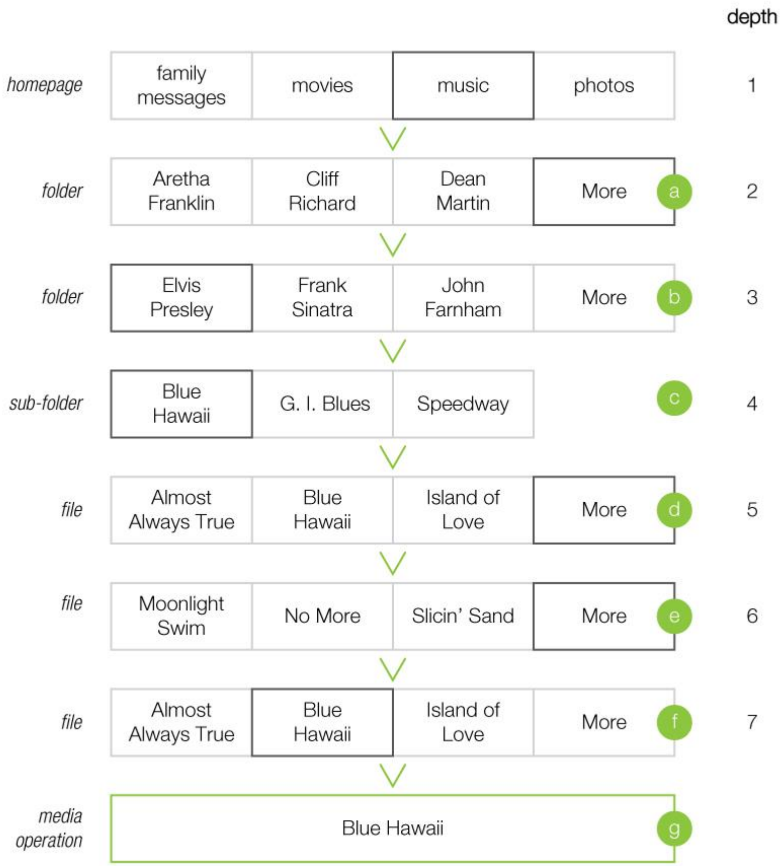


Figure 5.29 ***Inclusion of a 'More' option***

Figure 5.30 demonstrates how the inclusion of a ‘More’ option provided users with additional media choices, resulting in a hierarchy with much more depth. The navigation process from the homepage to media operation is now described.

a Once ‘Music’ is selected, a user is presented with three artists and the ‘More’ option. This informs the user that more artists are available for selection.
The ‘More’ option is selected.

b Three new artists and the ‘More’ option are presented.
‘Elvis Presley’ is selected.

c Three albums by Elvis Presley are presented. This demonstrates the hierarchy’s flexibility in accommodating fewer options when necessary. In this instance, the ‘More’ option is therefore not required.
‘Blue Hawaii’ is selected.

d Three songs from the album ‘Blue Hawaii’ and the ‘More’ option are presented.
The ‘More’ option is selected.

e Three new songs and the ‘More’ option are presented.
The ‘More’ option is selected.

f In this instance, as there are no new songs available, the ‘More’ option takes users back to the first song. This results in a polyhierarchical approach where the ‘More’ option acts as a ‘parent’ with more than one ‘child’ (function) (Rosenfeld and Morville 2002). It could be argued that in such a case, the ‘More’ option be renamed ‘Back’, but this will introduce yet another option which may confuse users. Moreover, users may find themselves on a page with two media options, a ‘Back’ option and a ‘More’ option.
‘Blue Hawaii’ is selected.

g The song ‘Blue Hawaii’ plays.

5.4.3 Level 1 Media Behaviour

Figure 5.32 presents the behaviour of the media during operation.

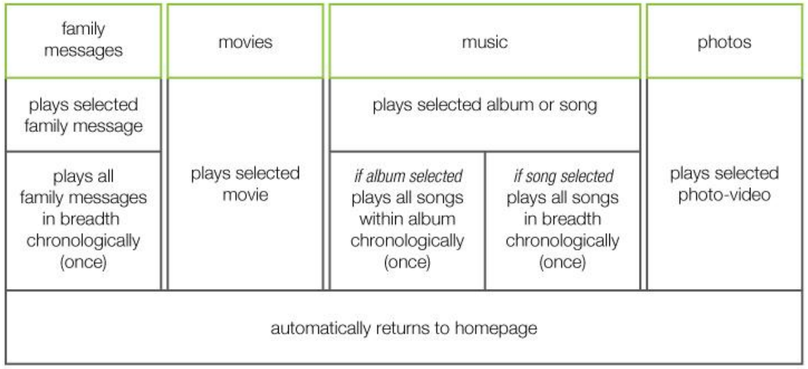


Figure 5.30: Media behaviour for the level 1 architecture

Due to probable long run-times of movies and photo-videos, the system reverts to the homepage immediately after a movie or photo-video has finished playing. Each photograph in a photo-video has a pan and zoom effect and is displayed for 15 seconds before gently fading into the next one.

5.4.4 The Level 2 Architecture

The Level 2 architecture used a broad and shallow hierarchy with the aim of catering to people with moderate and severe dementia (and to people with mild dementia who were unable to use the level 1 architecture). It used a bottom-up approach where users could access media instantly, without going through the folder, sub-folder and file levels between the homepage and media operation. This is shown in *Figure 5.31*.

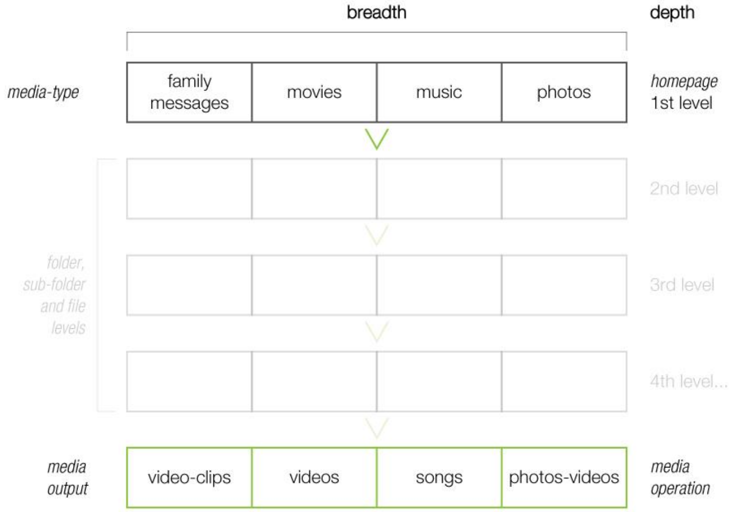


Figure 5.31 ***The level 2 architecture***

As shown in *Figure 5.31*, users were presented with the four media types on the homepage, similar to the homepage in level 1. However, on media selection, users were instantly rewarded with media operation. Given the design and purpose of the level 2 architecture, a 'More' option was not applicable. The difference between the level 1 and level 2 architectures is shown in *Figure 5.32* when music is selected.

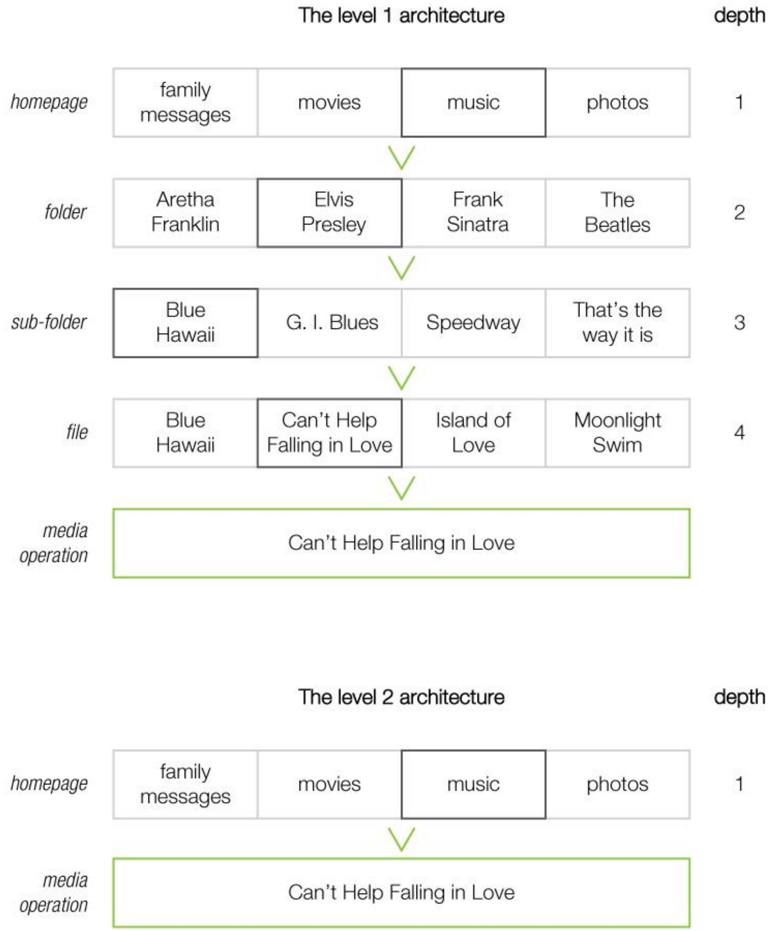


Figure 5.32 ***The level 1 vs. level 2 architecture example***

5.4.5 Level 2 *Media Behaviour*

Figure 5.33 presents the behaviour of the media during operation.

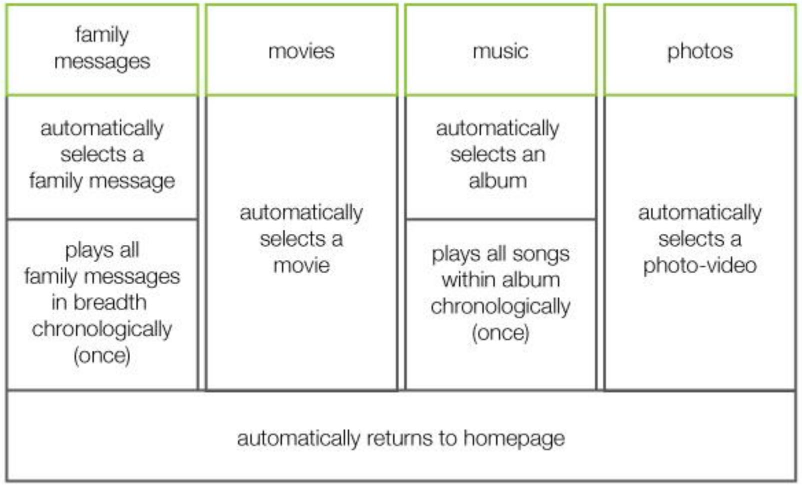


Figure 5.33 ***Media behaviour for the level 2 architecture***

The level 2 architecture did not provide selection options to a user after the homepage. Therefore, to ensure that the media was shuffled, the system always automatically selected the subsequent media files.

5.4.6 *The Secondary Architecture*

This chapter has discussed the design of dedicated architectures that aim to provide personalised media to people with dementia; the research does not concern itself with the design of an architecture through which media can be uploaded and edited onto the system; that feature has been referred to as the 'secondary architecture' in this research.

However, if this system were to be commercially available, one method of uploading and editing media, without 'reinventing the wheel', would be to use generic operating systems (or similar, such as Microsoft or Apple) that most technologically savvy users were familiar with; this could be a resident's spouse, caregiver or other family member, referred to as a 'secondary user' in this research. Media files would simply be uploaded onto the system using a USB and be categorised into appropriate folders or sub-folders.

The flexibility of a generic operating system would provide adaptability in the way folders, sub-folders or files were named, either in a particular language or to a user's preference (for example, using the word 'Films' instead of 'Movies').

5.5 *Media Controls*

Chapters 3 and *4* (*pages 32 and 58*) proposed that the multimedia system consider a 'Pause' option (Topo et al. 2004); its benefit would be for users to pause media at their convenience to go to the bathroom or leave their rooms for meals or activities. This would be particularly useful if a user was watching a movie with a typically long run-time. Without a 'Pause' option, users would return to their rooms to a movie that had already finished; it was highly unlikely they would watch it again from the beginning.

When a user wished to stop watching or listening to media, a 'Stop' option could be useful in taking the user back to the homepage in one step.

A ‘Back’ option would enable users to return to previous pages (on the level 1 architecture), but multiple selections might be required to return to the homepage, thereby complicating the architecture. Therefore, the ‘Back’ option was omitted, and the ‘Pause’ and ‘Stop’ options incorporated; whether these would be effective needed to be determined. *Figure 5.34* shows the placement of these media controls in the architectures.

To address problems such as loss of hearing and variances in media decibel levels (particularly for family messages which would be recorded using a range of devices and under different conditions), the multimedia system included a volume control. Like the media selection icons, the three media controls were positioned near the lower edge of the screen to provide easy access to individuals with reduced physical dexterity.

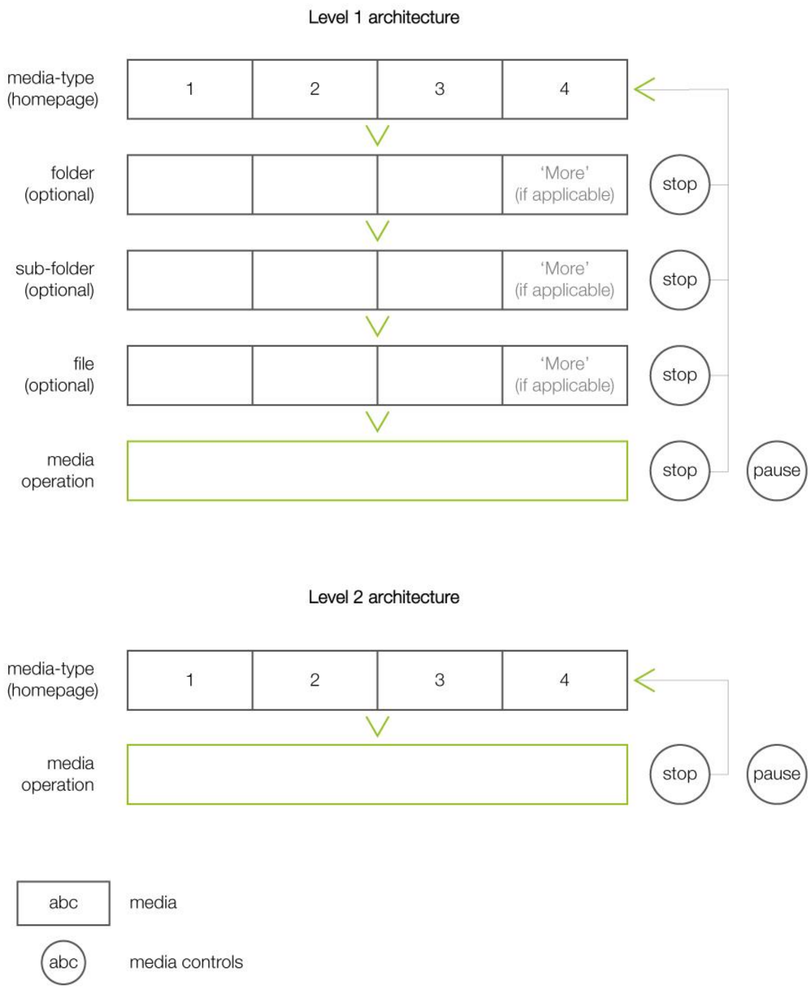


***Figure 5.34* Media controls in the two architectures**

5.6 The Interface Design

This section discusses the multimedia system's interface design from the homepage to media operation on architecture levels 1 and 2; these will now be referred to as the 'level 1 interface' and the 'level 2 interface'.

Given the success of the 23-inch infra-red touchscreen during the usability tests in *Chapter 4*, the research accepted this dimension as the multimedia system's touchscreen size. This is shown below with the rounded bezel that would enhance user safety (*Section 5.3.2, page 71*).

Figure 5.35 **The multimedia system screen (displaying part of its stand)**

5.6.1 The Layout

Individuals with dementia are prone to physical impairment (*Chapter 4.3, page 46*). This demonstrates the importance of all selections to be aligned horizontally and placed towards the lower half of the screen's base for easy and comfortable access. *Figure 5.36* shows the defined area within which the media selections and controls (both digital and tactile) should be positioned.

Figure 5.36 **Defined area for media selections and controls**

To ensure consistency in the design of the architecture, the screen provided designated areas for all media selections, controls and displays presented to users at any level. Based on previous sections in this chapter, these were:

- four media selections (homepage, folder, sub-folder and file levels)
- optional ‘More’ selection (folder, sub-folder and file levels)
- ‘Stop’ option (folder, sub-folder and file levels, and during media operation)
- ‘Pause’ option (during media operation)
- time and date (homepage)
- media operation
- tactile buttons

For older people with physical impairment, designers should consider spacing adjacent selections between 6.35 mm and 12.7 mm apart for enhanced accuracy; zero spacing reported the lowest accuracy and preference among participants (Jin et al. 2007).

Media selections were the dominant elements of the information architecture and were therefore positioned at the bottom-centre of the screen. The ‘Pause’ and ‘Stop’ controls (sub-dominant elements) sat at either end of the media selections, and the time and date (subordinate element) were placed towards the top of the screen (as in the usability tests in *Chapter 4)* as they did not require to be accessed. *Figures 5.37a* and *b* display the multimedia system’s visual hierarchy and designated areas within which the elements may be positioned. A spacing of 9.5 mm (mid-way between 6.35 and 12.7) between media selections and an aspect ratio of 4:3 for media operation were employed.

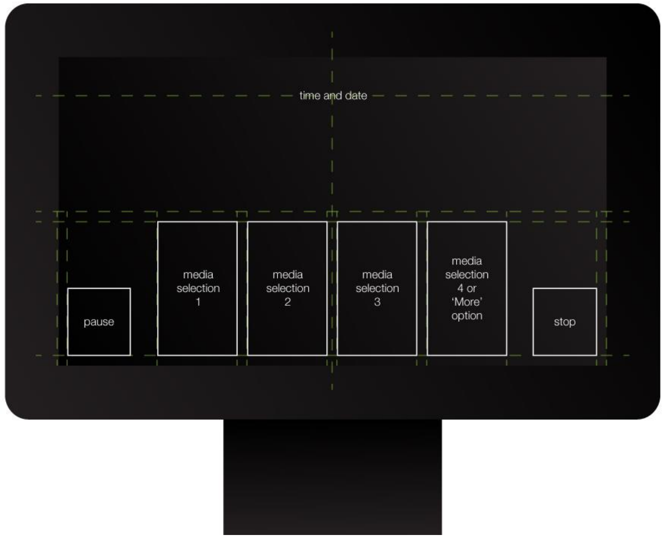


Figure 5.37a ***Visual hierarchy***

Figure 5.37b ***Designated areas for media selection, controls and operation***

The research demonstrated the importance of incorporating tactile buttons that corresponded to the digital media selections on the screen (*Section 4.10.3, page 63*); these, too, were positioned towards the base of the screen. To distinguish between media selections and controls, buttons of different shape were used; rounded-square buttons corresponded to media selections and circular buttons to media controls.

A volume knob with a diameter of 38 mm and a torque lower than 0.037 Nm was positioned below the media selection and control tactile buttons (Tilley 2002). This is shown in *Figure 5.38.*

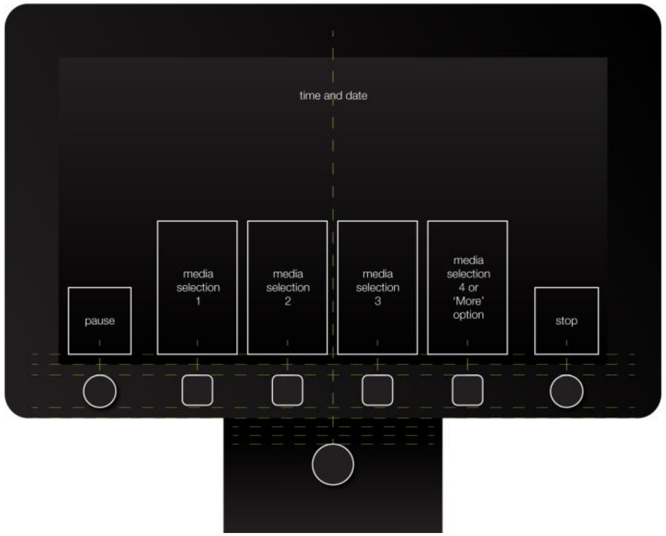


Figure 5.38 ***Placement of tactile buttons***

The media selection and control tactile buttons were manufactured using a translucent material that glowed due to a hard-wired back-lit assembly. This allowed for a button to be blanked out if there were fewer than four media selections on the screen (for example, when a user did not have enough media uploaded in a particular media category), thereby not distracting from valid, illuminated options.

5.6.2 *The Homepage*

The multimedia system's homepage consisted of:

- the four selected media types (family messages, movies, music and photographs)
- the time and date

The system aimed to provide personalised media to people with dementia. Therefore, to enhance personalisation and provide a sense of ownership to users, the media names included the prefix 'My': 'My Family' (for family messages), 'My Movies', 'My Music' and 'My Photographs'.

The homepage, being the first level of the information architecture depth, did not require any media controls. Therefore, the tactile buttons were not illuminated. This is presented in *Figure 5.39*.

Where a user's multimedia system did not have a particular media type (for example 'Movies'), that media type was not presented on the homepage, nor was its tactile button illuminated (*Figure 5.40*). This was employed throughout the information architecture wherever media selections were unavailable.

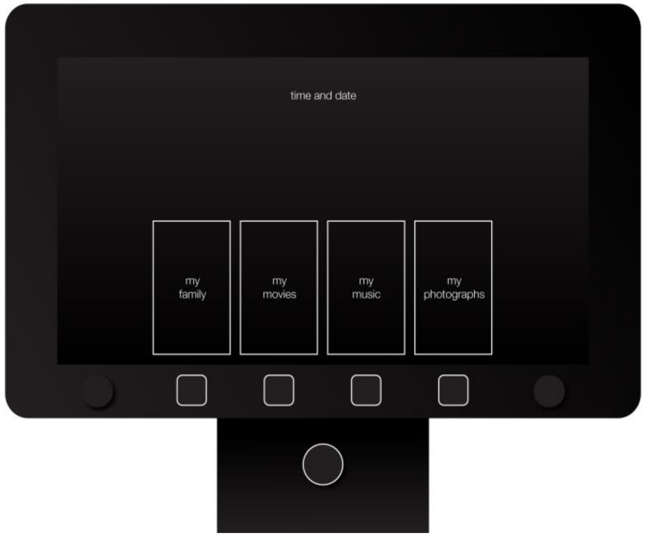


Figure 5.39 ***Information on the homepage***

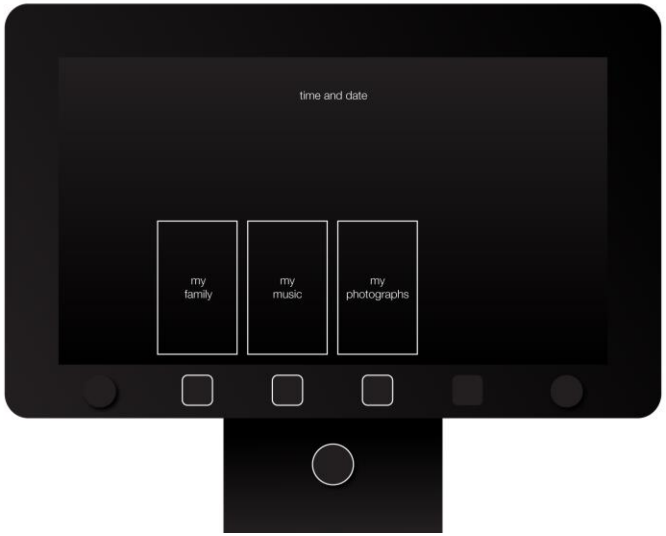


Figure 5.40 ***Adapting the interface to available media types on the homepage***

5.6.3 The Media Selections *Vector-based styling*

Astell et al. (2008) reported that people with dementia were able to recognise vector-based representations of a music player (*Section 3.9, pages 37 and 38*), encouraging the use of this styling in the multimedia system. In the usability tests (*Chapter 4*), when asked to select media icons that best represented media types, all participants selected familiar and traditional representations that dated back approximately fifty years. Although the sample size was small, the results supported the theory that long-term memories were better preserved than short-term ones (Astell et al. 2008; Rentz 1995). Therefore, traditional representations should be considered when selecting media icons for the four media types. *Figure 5.41* shows the preferred icons selected during the usability tests (*Chapter 4*). Two icons are shown for ‘music’ as these were both preferred by participants.

***Figure 5.41* Summary of vector-based icon results**

The icons needed to present the main elements of their respective media types, to make them more recognisable by people who may suffer from visual impairment. The icons in *Figure 5.41* were used as a departure point for the design of the media icons. In addition, icons for the ‘More’, ‘Stop’ and ‘Pause’ options would be developed. *Figure 5.42* presents visual synthesis resulting in desired outcomes.

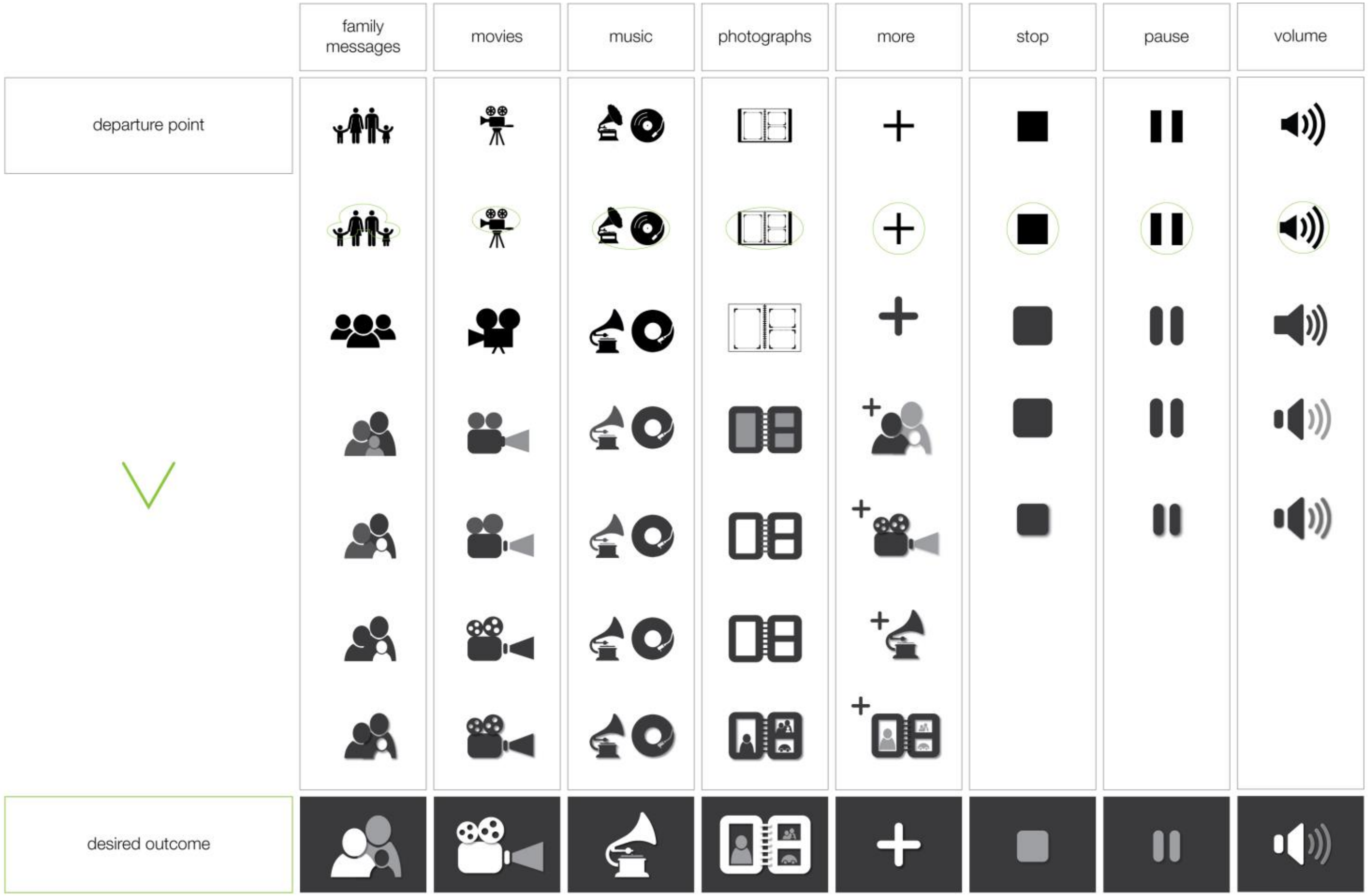


Figure 5.42 ***Visual synthesis of vector-based icons***

5.6.4 The Media Selections *Text*

The positive results of the PG intervention (*Section 3.5, page 31*) suggested that the combination of titles/text and associated photographs may have provided more options for a participant to better recognise a photo-video given the challenges of legibility of text (Topo et al. 2004). Therefore, all media selections consisted of a photograph/icon and its associated text.

According to Bernard et al. (2001), older people perceive sans serif fonts more easily than serif fonts. When presenting text to the elderly on a screen, a minimum font size of 14 points should be considered, as individual characters at this size are easier to perceive (Poulton 1955; Tullis et al. 1995). Based on this knowledge, the multimedia system employed a 30-point sans serif font (Helvetica Neue). *Figure 5.43* shows the combination of the media icons and their associated text.

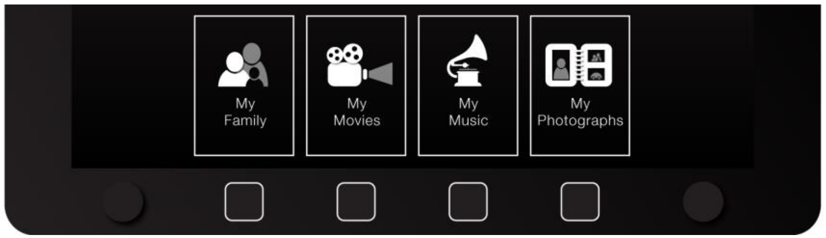


Figure 5.43 ***Combination of media icons and associated text***

5.6.5 The Media Selections *Colour*

Due to macular degeneration (*Section 4.3, page 46*), it is important that the media selections on the screen are clearly perceivable by users. *Figure 5.44* presents the media selections in achromatic colours to contrast them against the black background.

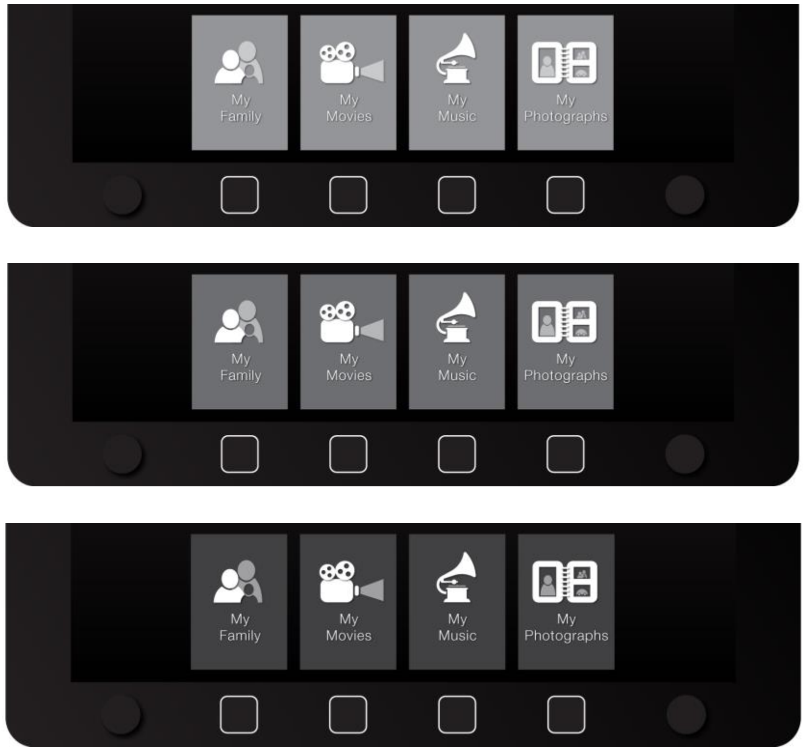


Figure 5.44 ***Media selections colour test***

While the media selections in *Figure 5.44* provide more contrast than those in *Figure 5.43*, there remains a lack in contrast between each media selection. *Figure 5.45* shows a digital colour-wheel where tetrad colours (four colours spaced evenly on a colour wheel) are explored and a desired range integrated in the media selections. Complementary colours are placed next to one another (blue-orange, green, pink), dividing analogous ones (blue-green, orange, pink).

Figure 5.45 ***Media selections in a tetrad range of colours***

5.6.6 *The Homepage Interface*

Figure 5.46 presents the interface design of the homepage based on the visual hierarchy, icon development, review of typography and colour selections in the previous sections.

Figure 5.46 ***The homepage interface***

The time and date were presented using the format: time (12-hour), day, date, month and year. This layout was adjustable to suit a user's preference using the secondary interface. In addition, the homepage included the following:

- Animated voice prompts – a voice prompt guided a user through the information architecture of the multimedia system, with the intention of enhancing the overall user experience (for users without hearing impairment). The voice prompt read the following message (in a user's preferred language), 'Please make a selection from one of the options below', after which each media selection flashed one after the other, acting as a visual reminder (Alm et al. 2009). According to Nass and Yen (2012), the human brain prefers a female voice over a male voice; it is also easier to find a female voice that people prefer than a male voice. Therefore, the multimedia system used a female voice for its voice prompts. The voice prompt repeated itself every half an hour if no selections were made on the homepage.
- Media selection feedback – according to a study by Koskinen (2008), despite the type of technology used, it is important to receive feedback on successful registration of tactile action. Therefore, a 'click' sound was generated every time a selection was made.

5.6.7 *The Folder, Sub-Folder and File Levels*

The multimedia system's folder, sub-folder and file levels consisted of the following elements/features:

- Four media selections – the media selections used the same layout as that of the homepage; however, the icons were replaced by photographs relating directly to their folder, sub-folder or file levels (as in the usability tests in *Chapter 4*). To provide users with optimal engagement, a media file was not accepted on the secondary interface (of any media type) unless an associated image was uploaded alongside it.
- Page title – the title of the page appeared in place of the time and date to remind users where they were in the information architecture.
- 'More' option (where necessary) – where there were more than four media options for a particular media type, the 'More' option presented itself as the fourth media selection.
- 'Stop' option – the 'Stop' option was illuminated, taking users back to the homepage when selected.
- Animated voice prompts – these were played once on landing on the page.
- Media selection feedback – same as homepage.
- 30-second selection period – if no media selections were made within 30 seconds, the system reverted to the homepage.

Figure 5.47 presents the interface design using an example of the 'My Movies' option being selected. The movies displayed were selected from the public domain database. Rather than colour-coding each media-type (for example, blue for 'My Family'), each depth used the four colours within its breadth to provide contrast and to allow any page to act as a homepage in a scenario where users forgot where they were (*Section 3.9*, *page 36*).

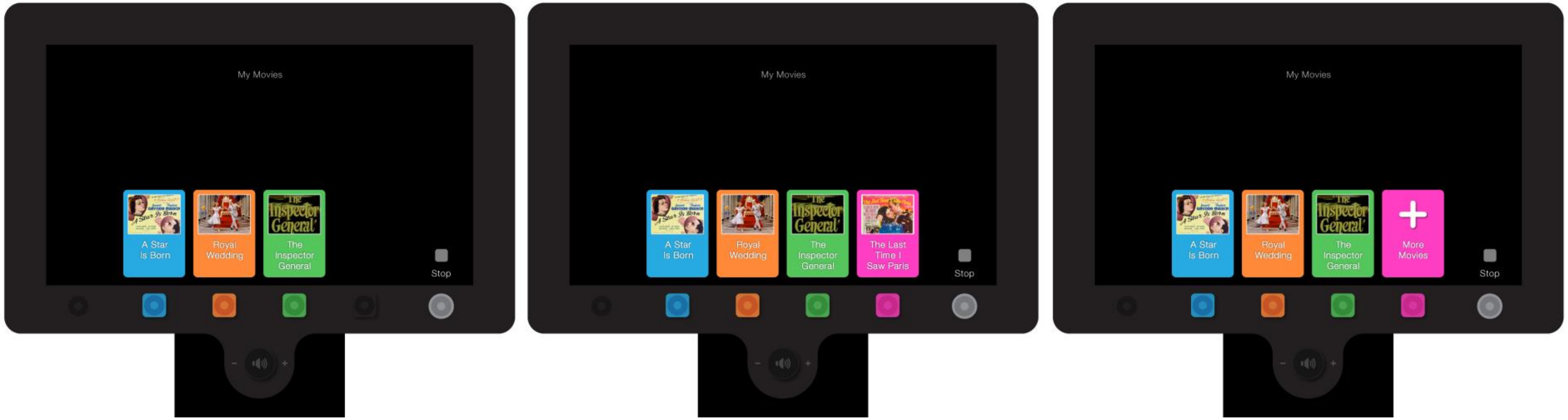


Figure 5.47 ***The folder, sub-folder and file level interfaces***

On the first screen above, three movie files are presented, suggesting only three movie files have been uploaded on the system. Therefore, the area where a fourth media selection would typically appear is blanked out and its corresponding tactile button not illuminated. On the centre screen, four movie files are available, suggesting only four movie files have been uploaded on the system.

Finally, on the third screen, the appearance of the 'More' option suggests that a user has more than four movie files available on the system. *Figure 5.48* shows the information architecture behaviour when the 'More' option is selected repeatedly, assuming five movies are available on the system.

Figure 5.48 ***The 'More' option in operation***

5.6.8 Media Operation

This section presents the interface design for the four media types during media operation. It was at this depth of the information architecture that the 'Pause' option was accessible. Pausing a media file led to the following:

- The media became translucent.
- The 'Pause' icon changed to a 'Play' icon.
- The 'Play' button flashed to act as a visual reminder.

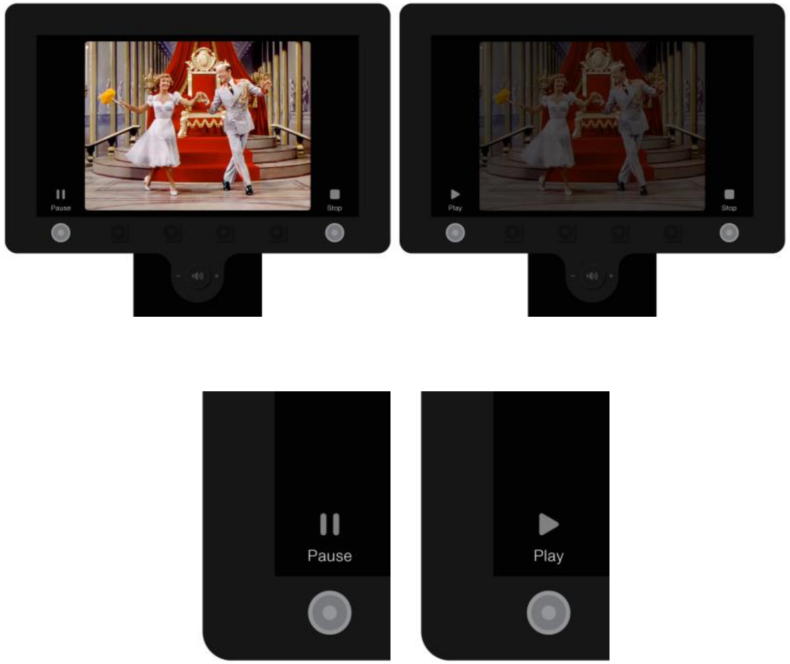


Figure 5.49 ***The 'Pause' option behaviour***

Figure 5.50 shows the interface during media operation on the level 1 and 2 information architectures.

Figure 5.50 ***An example of a family message on the level 1 and level 2 information architectures***

A family message was presented within the designated media operation area (4:3 aspect ratio), allowing for the media controls beside it to be clearly visible (*Figure 5.50*). The level 1 interface had a tab system where another media file within its breadth may be selected from any one of the illuminated media selections. This minimised the operational media file to a ‘preview mode’ for 10 seconds, reverting to full-screen mode if a new selection was not made (*Figure 5.51*). On making a new selection, the media file began playing in full-screen mode. On the level 2 interface, a user was taken back to the homepage if a non-illuminated option was selected; the media selections acted as an extension of the ‘Stop’ button.

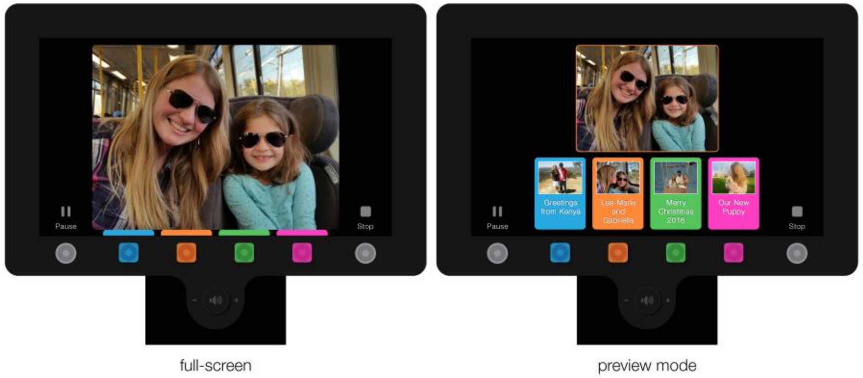


Figure 5.51 ***The level 1 preview mode***

Figure 5.52 shows the interface during movie operation on the level 1 and 2 information architectures. The multimedia system had the same layout as that of family messages.

Figure 5.52 ***Movie operation interface***

Figure 5.53 shows the interface during music operation on the level 1 and 2 information architectures.

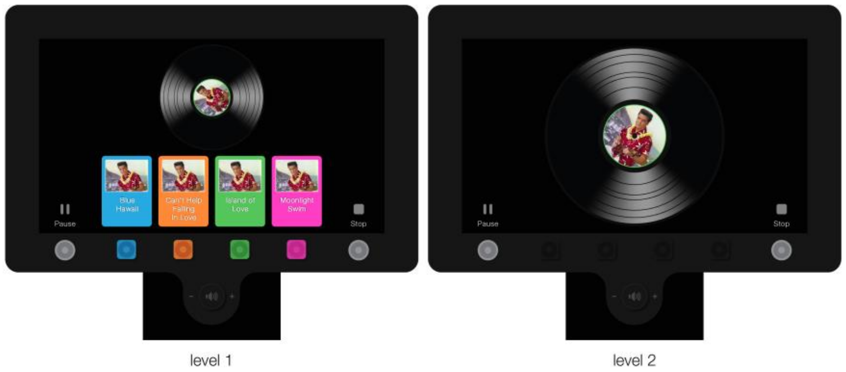


Figure 5.53 ***Music operation interface***

During music operation, the system presented a combination of audio and visual components to users if a file was purely aural (no accompanying video-clip). The visual component was a spinning record with the artist's/album's image cropped onto it to create a sense of where the music was coming from (Astell et al. 2008). The level 1 interface also presented the other media selections, while the level 2 interface did not.

Figure 5.54 shows the interface during a photo-video on the level 1 and 2 information architectures.

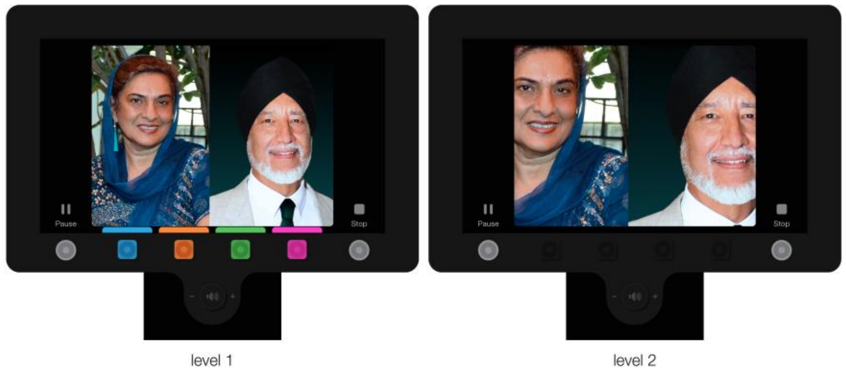


Figure 5.54 ***Photo-video interface***

The photo-video interface had the same layout as that of family messages and movies. As in the Picture Gramophone study by Yasuda et al. (2006) (*Section 3.5, page 31*), each photograph in a photo-video was displayed for 15 seconds before gently fading into the next one. It had a pan and zoom effect as shown in *Figure 5.56* above.

Chapter 3 suggested that the multimedia system should use personalised music to accompany photo-videos, with the aim of further enhancing the reminiscence experience. Each photo-video was therefore paired with a randomly chosen song from a user's music database.

5.9 *The Multimedia System Simulation*

This section shows the development process of a multimedia system simulation that was tested on individuals with dementia at aged-care facilities. The tests are detailed in *Chapter 6*. *Figure 5.55* shows an image of a desired screen with its tactile buttons and volume control. The multimedia system simulation, however, used the infra-red touchscreen like the one in the usability tests (*Chapter 4*) as it was readily available. The physical size of an infra-red touchscreen would obviate the need for a separate CPU as the circuitry could be incorporated into its casing. However, for the simulation, the full-size case was retained as a separate unit to permit rapid changes to be made to the prototype during testing and development.

Figure 5.55 ***Desired multimedia system screen***

Tangible mock-ups or prototypes are limited representations of design concepts that allow users to touch, hold and interact with the designs (Bødker and Buur 2002). They provide the opportunity for designers to choose between alternatives, test the technical aspects of an idea, clarify requirements and test usability. Compared to sketched or digital models, tangible mock-ups are more effective as their three-dimensional form is perceptible by more senses. Low-fidelity prototypes are inexpensive and faster to produce, using soft materials like cardboard and wood. High-fidelity prototypes are expensive as they are made of the same material as the final product (Preece et al. 2002). This method ensures that the physical dimension and its individual components conform to the design specification (such as the overall dimensions, weight and structural integrity), resulting in enhanced usability by residents in aged-care facility environments.

Low-fidelity prototypes (*Section 2.1.4*, *page 23*) were developed based on the specification in *Section 5.3.3* (*page 89*) using foam-core board and medium-density fibreboard (MDF). The prototypes included space for accommodating the CPU, as shown in *Figure 5.56*.

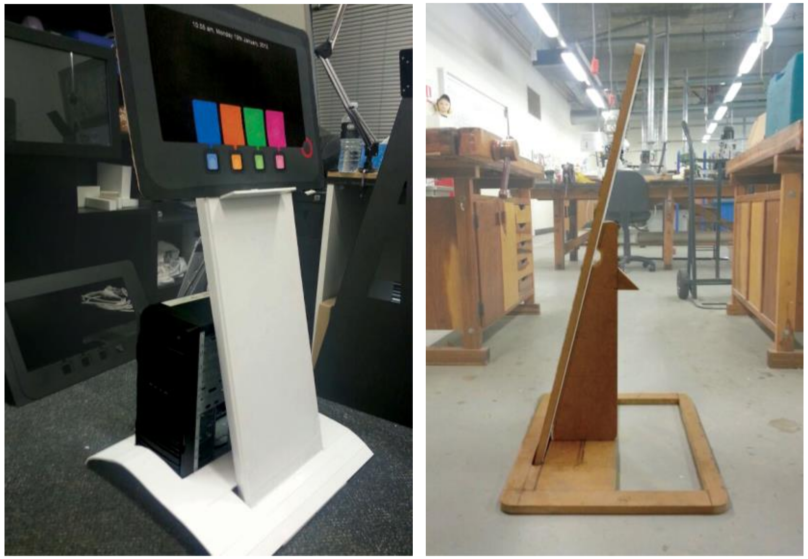


Figure 5.56 ***Low-fidelity prototypes***

After a process of iteration, high-fidelity prototypes were developed; a steel plane was laser-cut, folded, welded and powder-coated to form the stand for the physical dimension. This is shown in *Figure 5.57*.

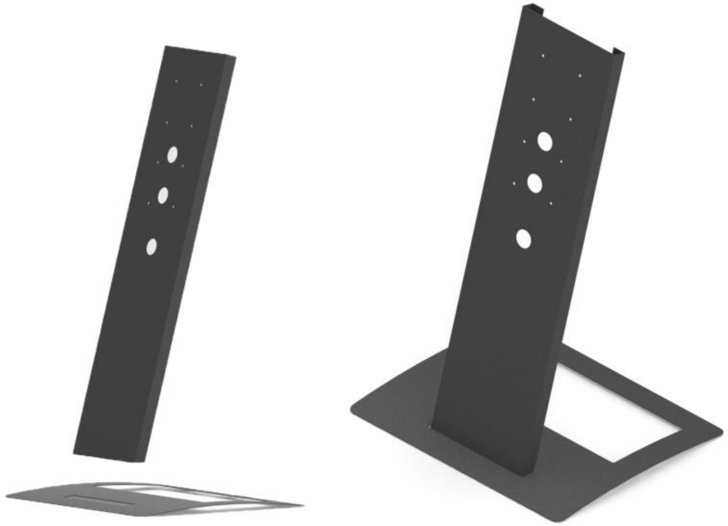


Figure 5.57 ***High-fidelity prototypes***

As in *Chapter 4*, elastomer-membrane buttons were developed for the simulation, but with a more durable and translucent silicone. This allowed the buttons to be back-lit by light from the screen, rather than building an independent back-light assembly. Moreover, the physical buttons inherited the characteristics of on-screen touch whereby blanked-out selections were not displayed and did not distract from valid illuminated options. The buttons had a force range of 0.30–0.48 N and a travel range of 0.2–3.9 mm based on results from the force-travel review (*Section 5.3.4, page 93*). The buttons were placed in an inexpensive laser-cut plastic frame suspended above the infra-red screen. *Figure 5.58* shows the simulation that was developed for the tests.

Figure 5.58 ***The multimedia system simulation***

The prototype software was developed in PHP running primarily in a full-screen instance of Google Chrome. Video playback was provided by the HTML5 standard player, with JavaScript manipulating onscreen elements such as animations and interactivity. A programmer developed the software based on the RC's specification.

The multimedia system was put to test at two Melbourne-based aged-care facilities. This is now detailed in *Chapter 6*.

Chapter Six The Field Tests

Chapter Overview

Chapter 6 details tests on the usability of the design outcome on residents with mild, moderate or severe dementia at two aged-care facilities. This was the second and final phase of the exploratory sequential mixed methods approach used in the research. The chapter concludes by evaluating the test results and identifying their limitations.

The tests were funded by, and conducted under the auspices of, the Dementia Collaborative Research Centre (DCRC). To authenticate the efficacy of the design outcome the tests were run by psychologists from the Department of Psychiatry (School of Clinical Sciences at Monash Health – Faculty of Medicine, Nursing and Health Sciences) at Monash University, using social and clinical research methods, in particular a randomised cross-over design (Hulley et al. 2013).

The tests resulted in the following publications, led by Dr. Tanya Davison (Department of Psychiatry) and co-authored by the research candidate:

Davison, T. E., Nayer, K., Coxon, S., de Bono, A., Eppingstall, B., Jeon Y., van der Ploeg, E. S. and O'Connor, D. 2016
A personalised multimedia device to treat agitated behaviour and improve mood in people with dementia: A pilot study
Journal of Geriatric Nursing. Elsevier, Volume 37, Issue 1, Pages 25–29

Davison, T. E., O'Connor, D. W., Nayer, K. S, Coxon, S. C., de Bono, A. and Jeon, Y. 2015
Pilot evaluation of the effectiveness and feasibility of a personalised multimedia device for aged care residents with dementia
Final report to the Dementia Collaborative Research Centres
Melbourne: Monash University

—
For the purpose of these tests, the multimedia system is named 'Memory Box'.

6.1 *The Aim of the Tests*

The previous chapters assisted in the development of the design outcome (multimedia system) through different stages of the research. This chapter documents the testing of the system over an eight-week period on residents with mild, moderate or severe dementia at two Melbourne-based aged-care facilities.

The aim of the tests was three-fold, as listed below in order of priority:

- To determine the feasibility of Memory Box in providing a high degree of autonomy to people with mild, moderate or severe dementia
- To alleviate rates of depression, anxiety, agitation and carer burden by using Memory Box, with the assumption that it would improve the overall quality of life of residents and caregivers during the test period
- To determine residents' satisfaction levels when using Memory Box routinely, establish usability patterns and recognise the level of support required by caregivers and family members to enhance the experience

It was anticipated that if these aims were met, Memory Box may have potential in alleviating boredom, loneliness and loss of self-reliance in people with dementia at aged-care facilities, that being the overall research aim.

6.2 *The Test Criteria*

There were a number of conditions for participation in these tests. Inclusion criteria were: a minimum age of 60 years; a chart diagnosis of dementia; one or more agitated behaviours that occurred daily or almost daily at times other than during nursing interventions; and availability of a family member to assist in sourcing personalised media for uploading onto Memory Box.

Exclusion criteria were: lack of comprehension of English; a severe medical condition likely to compromise participation in the study; and known aggressive or unintentional dangerous behaviour or inappropriate handling of materials which could compromise the safety of the user or the device.

6.3 *The Method*

The tests made use of social and clinical research methods (Bryman 2016; Hulley et al. 2013) (*Section 2.1.3, page 22*) and were therefore conducted by two psychologists experienced in the area. The following method was used:

- Obtain ethics approval.
- Select a sample group using a screening process based on the inclusion and exclusion criteria.
- Collect data before, during and after tests.
- Use a randomised cross-over design.
- Evaluate results.
- Identify limitations.

Ethics approval was obtained from the Monash University Research Ethics Committee and Dementia Collaborative Research Centre (DCRC) (reference: CF10/3129 – 2010001679). Senior members of staff from the aged-care facilities assisted in the sample selection process by identifying potential participants through a discussion of the inclusion and exclusion criteria with the psychologists. A screening process verified the presence of at least mild cognitive impairment and agitated behaviour in participants, using a Clinical Dementia Rating Scale (CDR) and a Cohen-Mansfield Agitation Inventory (CMAI) (Cohen-Mansfield et al. 1989; Hughes et al. 1982). A CDR is an instrument commonly used in clinical research to assess six areas of cognitive and functional impairment in people with dementia (Hughes et al. 1982). In this research it ensured that all participants had at least mild cognitive impairment – a criterion for participation in the tests. A CMAI measures the frequency with which a person with dementia demonstrates a list of 29 agitated behaviours over a one-week period (Cohen-Mansfield et al. 1989). It was used in this research to ensure that all participants displayed some form of agitation – another criterion for participation.

Participants' family members were provided with a detailed description of the study in order to obtain their consent for their relative's participation. The psychologists collected data before, during and after the tests. Prior to commencement, levels of depression, anxiety, agitation, caregiver burden and quality of life were measured at baseline. Symptoms of depression were evaluated using the Cornell Scale (Alexopoulos et al. 1988); symptoms of anxiety using the Rating Anxiety in Dementia scale (RAID) (Shankar et al. 1999); caregiver burden using the staff-rated Burden Interview (Sourial et al. 2001); and quality of life using Quality of Life in Alzheimer's Disease (QOL–AD) (Logsdon et al. 2002).

Test data was collected through observation and questionnaires (Bryman 2016). At the end of the tests, data on patterns of use was collected from the Memory Boxes (automatically logged data), while feasibility data on the satisfaction of Memory Box when used routinely was collected through caregiver and family member interviews (Bryman). More information on these tests is available in *Appendix C* (*page 188*).

The MMSE is a 30-point questionnaire used for measuring cognitive impairment (Folstein et al. 1975; Pangman et al. 2000). It was used to categorise participants by impairment level to determine what level of interface (level 1 or 2) to test on them (*Chapter 5.4.2, page 101*).

A randomised cross-over design was used to provide two interventions, one after the other, to a group of participants while observations were made, and data collected by psychologists (Hulley et al. 2013). This was used to identify differences in participants' behaviour when using Memory Box and over a social control intervention (the same conditions without the Memory Box intervention), each over a four-week period. A number generator was used to randomly assign the order in which each participant was to receive the Memory Box and the social control interventions.

A technique called spaced retrieval was employed as part of the Memory Box intervention (Hopper et al. 2001; Squire 2004; van der Ploeg et al. 2013). It tested recall of task accomplishment methods over increasing intervals (which helps people with dementia to learn and retain information) (Creighton et al. 2013). This procedure has also been effective on people with severe dementia (Hopper; Squire; van der Ploeg). The results were then evaluated and discussed, and limitations identified.

6.4 *Participants' Characteristics*

To ensure confidentiality, participants were once again referred to by identity numbers. For example, A3 was the third participant from the first aged-care facility and B4 the fourth participant from the second facility. A total of 16 residents (eight from each facility) aged between 76 and 96 years (mean age of 86.3) consented to participate in the tests, some having their families consent for them. Among the 16, there were 13 women and 3 men.

Results from the CDR and MMSE indicated moderate dementia overall; three with mild (19–23), nine with moderate (10–18) and one with severe (9 or less) impairment scores. A score of 24–30 indicates normal cognition (Folstein et al. 1975; Hughes et al. 1982). The participants had different types of dementia: Alzheimer's disease (AD), Vascular dementia (VaD), Lewy body dementia and unspecified and mixed types.

Participants with mild impairment were introduced to the level 1 interface. Those with moderate impairment were first monitored using the level 1 interface a few hours prior to the tests. If this proved challenging, the level 2 interface was used. The level 2 interface was automatically assigned to the remaining participant, who had severe impairment.

6.5 *The Interventions*

The social control intervention was carried out for half an hour once a week over four weeks. During these sessions one of the psychologists read from a newspaper and discussed current affairs. The aim of the intervention was to provide non-personalised social engagement with participants, that being contradictory to the aim of the Memory Box intervention.

Participants had access to individual Memory Boxes which were placed in their bedrooms a few hours before the tests began. The other psychologist introduced participants to their Memory Boxes and reminded them of the study at that stage. Based on feedback from caregivers, the Memory Boxes were programmed to automatically 'wake up' (switch on) at 8 a.m. and 'sleep' (switch off) at 8 p.m.

to ensure participants' sleep patterns were not disturbed. Caregivers or family members had the option of adjusting these times using a basic administrator interface (secondary interface) through which multimedia content was uploaded and edited, and logged data collected and analysed at various stages through the interventions.

Prior to the intervention, the Memory Boxes were adjusted to suit the heights of seated participants and uploaded with media personalised for them (family messages, movies, music and photographs). All media before and during the intervention was uploaded and managed by the RC using a Windows operating system.

Structured record sheets designed for the study were used to retrieve information on participants' media preferences. The participants themselves or their family members provided this information to the psychologists. The sheets contained prompts for favourite music, key people and events in the participants' lives. The music was purchased and uploaded to the Memory Boxes. Photographs collected from participants or family members were then scanned and uploaded. While it was envisaged that Memory Box would contain a participant's favourite movies, this was prevented to a large extent by Australian copyright legislation. Only movies in the public domain could be uploaded. From approximately 284 movies in the public domain, only 70 with an overall 'happy' story-line were selected.

Participants were presented with a list of these very old movies (with their synopses) for selection. The caption 'My Movies' was replaced by 'Old Movies' on the Memory Box. Details of the copyright legislation and the list of movies selected for the Memory Box intervention are available in *Appendix C* (*page 189*). Family members were encouraged to create as many brief video-messages as possible for uploading onto the Memory Box. There were large variations in the number, length and quality of video-messages submitted by family members.

Owing to the different sizes and layouts of rooms at aged-care facilities (*Chapter 5, page 74*), each Memory Box was positioned carefully to ensure easy and safe access by participants when seated on commonly used chairs. For safety reasons, rubberised corners were placed onto the edges of the generic screens, with all wires securely contained in conduits concealed behind the stands.

Before the tests, the psychologists met with caregivers and guided them on ways of encouraging and supporting participants to operate the Memory Boxes during the testing period, rather than making the selections for them. They were also shown how to identify problems that might occur when the psychologists were not at the facility. Family members were provided with face-to-face or telephone support whenever required.

6.6 *Usability Sessions*

While participants had continuous access to their Memory Boxes, a psychologist conducted 30- to 60-minute sessions with them each week for the duration of the study to observe how well they used the Memory Box. In attempting to provide users with a positive Memory Box experience, the spaced retrieval method was employed (Hopper et al. 2001; Squire 2004; van der Ploeg et al. 2013). During sessions, the psychologist asked a participant to access a particular media type. If the participant was able to accomplish the task, the next task was requested after a five-minute interval.

If participants continued to achieve the set tasks, each interval period was increased as shown in *Table 6.1*. However, if a participant failed to achieve a task at any point, the psychologist demonstrated how to achieve the task and the participant was asked to try again until successful. At this point, the recall interval period dropped back to five minutes. This technique was used for all four media types as well as for the 'Volume' and 'Stop' buttons.

	intro 1–5 mins	5 mins	7.5 mins	10 mins	13.5 mins	17 mins	22 mins	27 mins	comments
music									
photos									
movies									
messages									

Table 6.1 ***Table using the spaced retrieval method***

6.7 *Results from Facility A*

At facility A, only six of the initial eight participants completed the four-week testing period. *Table 6.2* shows the participants and their MMSE scores. Data collected from participants A3 and A4 was not used in the final analyses, on the assumption that their attrition was unrelated to the Memory Box trial. However, they were still allowed to use their Memory Boxes for the remaining period of the study with help from caregivers and family members.

Two caregivers claimed that A3, while bedridden, stared at her Memory Box for hours watching her favourite photographs, and that her eyes opened wide when her favourite music played (Davison et al. 2015). Two weeks into the tests, participant A4 asked for her Memory Box to be removed from her room as it took up too much space. During the two weeks of use, the logged data on her Memory Box showed that she used it for approximately three hours each day (Davison).

facility A		
ID no.	MMSE score	notes
A1	17 (moderate)	
A2	12 (moderate)	
A3	N/A	participant was bedridden
A4	20 (mild)	2 week participation only
A5	19 (mild)	impairment level exacerbated to moderate during the tests
A6	6 (severe)	
A7	17 (moderate)	
A8	23 (mild)	

Table 6.2 ***Participants from facility A***

Data on daily use of the Memory Boxes over the testing period was automatically logged onto Memory Box. Variables included the number of selections made per day by each participant (i.e. the number of times a digital or physical button was pressed) and the average time for which a participant used the Memory Box per day and per week. This data was available to caregivers and family members by accessing the administrator interface. *Table 6.3* illustrates data collected from the Memory Boxes during the tests at facility A.

facility A				daily average use (based on 11-hour days)	
ID no.	MMSE score	interface level	favourite media	hours	percent
A1	17 (moderate)	1	music	2.56	23.27
A2	12 (moderate)	2	photos	1.41	12.81
A3	N/A	2	photos	7.42	67.45
A4	20 (mild)	2	photos	3.06 (over 2 weeks use)	27.81 (over 2 weeks use)
A5	(change from mild to moderate)	changed from 1 to 2	photos	2.15	19.54
A6	6 (severe)	2	music	2.48	22.54
A7	17 (moderate)	1	music	3.49	31.72
A8	23 (mild)	1	photos	0.41	3.72

Table 6.3 ***Logged data from facility A***

Results from the logged data on each participant's Memory Box reported that the minimum time spent on Memory Box was 41 minutes a day, while the maximum time spent was 3 hours and 49 minutes (not including participants A3 and A4). Caregivers claimed that prior to testing, residents spent at least three hours a day in their bedrooms; at other times they were out for meals, at an activity such as Bingo or an exercise session, wandering around the facility or asleep in the facility lounge. However, during the testing period, caregivers reported noticeable changes in the participants' behaviour; they now spent between four and six hours in their rooms, much of it watching or listening to media on their Memory Boxes. Although these results are encouraging, they do not provide sufficient efficacy and have therefore been ignored.

The data demonstrates that within the four media types, participants showed a preference for music and photographs. *Table 6.3* shows that during the testing period, the impairment level of A5 declined from mild to moderate and the interface from level 1 to level 2.

The primary aim of the tests was to determine whether Memory Box could provide a high degree of autonomous use to individuals with mild, moderate or severe dementia. According to the psychologist's reports, all six participants at facility A were able to achieve set tasks by the end of the sessions which tested autonomous navigation through the interfaces. *Table 6.4* illustrates this.

facility A	autonomous use			
ID no.	wk 1	wk 2	wk 3	wk 4
A1	Y	Y	Y	Y
A2	Y	Y	Y	Y
A5	Y	Y	Y	Y
A6	Y	Y	Y	Y
A7	Y	Y	Y	Y
A8	Y	Y	Y	Y

Y indicates 'yes'
N indicates 'no'

Table 6.4 ***Results of autonomous use – facility A***

Finally, the tests aimed to determine satisfaction levels of individuals in residential care when using Memory Box routinely. These were evaluated through semi-structured interviews with participants, caregivers and family members. Caregivers and family members were also asked questions on the participants' levels of autonomy and their perceived levels of pleasure while using Memory Box, with the psychologist recording observations. Level of engagement was rated between 1 (resistant to using Memory Box) and 5 (fully engaged with Memory Box). Perceived level of pleasure was rated from 1 (displeasure) to 5 (considerable pleasure) (Likert scale). *Table 6.5* illustrates the scores.

Overall, the results demonstrated that the participants' satisfaction levels were above average, particularly in 'engagement'. Although every participant was shown how to operate the digital buttons on the touchscreen, three of the six preferred using the physical buttons. Participants' comments included, 'It feels so nice and easy'; 'When you push it, it just comes back easily'; 'I like the way they glow especially when it gets dark'; and, 'The dip in the button is very helpful and guides my fingers'.

Some participants' scores reported displeasure and engagement, simultaneously, which according to the psychologist was due to technical issues with their Memory Boxes, such as the screens 'freezing'.

facility A	engagement (1–5)				pleasure (1–5)			
ID no.	wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4
A1	5	5	5	5	5	5	5	1
A2	5	4	3	4	5	3	1	3
A5	5	5	5	5	5	5	5	4
A6	3	5	5	5	5	1	1	5
A7	5	5	5	5	4	5	5	5
A8	5	4	4	4	1	4	3	4
	1 indicates resistance 5 indicates fully engaged				1 indicates displeasure 5 indicates pleasure			

Table 6.5 ***Results of engagement and pleasure – facility A***

6.7.1 Revisions

After completion of the tests at facility A, there was a four-week period (clinically referred to as a 'wash-over period') for making revisions that would enhance the performance of Memory Box before commencement of tests at facility B. Revisions were based on suggestions from the psychologist who observed the way participants used their Memory Boxes.

The Memory Box logs displayed that some participants waited for up to 40 minutes before selecting media from the homepage. Based on this, a feature called 'Auto Play' was added to both interfaces, so that in the absence of a selection, 'Auto Play' would take control of the system in 5 to 30 minutes (the interval was set by a caregiver or family member on the secondary interface) and play a random selection from a participant's media, encouraging use of the Memory Box.

6.8 Results from Facility B

At the end of the four-week testing period at facility B, only five of eight participants completed the tests. *Table 6.6* shows their MMSE scores. B1 passed away before the tests began; B4 suffered a fall during week 3 and was unable to continue with the study; and B8 refused to go ahead with the tests for personal reasons. On B4's recovery, her Memory Box was switched back on but no further data was collected.

facility B		
ID no.	MMSE score	notes
B1	N/A	participant passed away prior to the tests
B2	17 (moderate)	
B3	10 (moderate)	
B4	12 (moderate)	got sick 2 weeks within the testing period
B5	18 (moderate)	
B6	11 (moderate)	
B7	15 (moderate)	
B8	N/A	participant did not continue with the tests

Table 6.6 ***Participants from facility B***

Table 6.7 illustrates data collected from the Memory Boxes during tests at facility B.

facility B				daily average use excluding autoplay (based on 11 hour days)		autoplay (daily average)
ID no.	MMSE score	interface level	favourite media	hours	percent	hours
B2	17 (moderate)	1	music	5.03	45.72	3.25
B3	10 (moderate)	2	photos	1.59	14.45	3.21
B4	12 (moderate)	1	music	4.42 (over 2 weeks use)	40.18 (over 2 weeks use)	4.36
B5	18 (moderate)	1	music	4	36.36	3.45
B6	11 (moderate)	1	photos	2.12	19.27	5.4
B7	15 (moderate)	1	photos	4.09	37.18	2.4

Table 6.7 ***Overall results from facility B***

Results from data logged on each participant's Memory Box reported that the minimum time spent using Memory Box was 2 hours a day, while the maximum time spent was 5.4 hours. This was independent of the media triggered by the 'Auto Play' feature.

The data for facility B demonstrates that from the four media types, participants showed preference for music and photographs. Of the five participants with moderate impairment, four used the level 1 interface and one used level 2. According to the psychologist's reports, all five participants at facility B were able to achieve set tasks by the end of the sessions which tested autonomous navigation through the interfaces (*Table 6.8*).

facility B	autonomous use			
ID no.	wk 1	wk 2	wk 3	wk 4
B2	Y	Y	Y	Y
B3	Y	Y	Y	Y
B5	Y	Y	Y	Y
B6	Y	Y	Y	Y
B7	Y	Y	Y	Y

Y indicates 'yes'
N indicates 'no'

Table 6.8 ***Results of autonomous use – facility B***

Table 6.9 illustrates the satisfaction levels of individuals in residential care when using Memory Box routinely.

Overall, the participants' results demonstrated that the satisfaction levels of using Memory Box were above average, particularly in the category of 'pleasure'. Three of the five participants preferred the use of the physical buttons to the digital ones.

facility B	engagement (1–5)				pleasure (1–5)			
ID no.	wk 1	wk 2	wk 3	wk 4	wk 1	wk 2	wk 3	wk 4
B2	5	5	5	5	5	5	5	1
B3	3	3	3	3	2	3	4	4
B5	5	5	5	5	5	5	5	4
B6	4	3	3	3	4	4	4	3
B7	5	5	5	5	1	4	4	4

1 indicates fully engaged
5 indicates resistive

1 indicates pleasure
5 indicates displeasure

Table 6.9 ***Results of engagement and pleasure – facility B***

6.9 *Overall Intervention Results*

The results of the Memory Box intervention reported that all eleven participants who had either mild, moderate or severe dementia were able to use Memory Box with a high degree of autonomy via its adaptable interfaces (*Tables 6.4* and *6.8, pages 134* and *137*); all individuals with mild and some with moderate dementia were able to use the level 1 interface. In addition:

- Symptoms of depression on the Cornell Scale (Alexopoulos et al. 1988) decreased significantly during the Memory Box intervention.
- Symptoms of anxiety on the RAID (Shankar et al. 1999) also decreased significantly.
- While scores on the CMAI (Cohen-Mansfield et al. 1989) reported a fall in agitation, they were non-significant.
- Quality of life on the QOL–AD (Logsdon et al. 2002) rated by participants, caregivers and family members, all increased slightly during the Memory Box intervention.
- Scores on the staff-rated Burden Interview (Sourial et al. 2001) decreased during the Memory Box intervention.
  (Davison et al. 2015)
  (These details are available in *Appendix C, pages 188–190*).

With the social control intervention, there were no statistically significant differences before and after the intervention, with the exception of QOL–AD as rated by caregivers which decreased during the social control intervention. There was a small decrease in scores on the CMAI, RAID, and staff-rated Burden Interview, but these changes were insignificant (*see Appendix C, page 190*).

6.9.1 *Feasibility of Memory Box*

While eight of the eleven participants (72.7%) claimed the ability to operate Memory Box autonomously, family members and caregivers of six participants (54.5%) shared their view citing the severity of cognitive impairment as the reason for the inability of those unable to use the device without some assistance. These participants had a lower MMSE score (mean score of 12.8) than those who were able to use it without any assistance (mean score of 19.0).

On ease of access of the media on Memory Box, 'no difficulty' was reported by six participants' family members (54.5%), four experienced 'slight difficulty' (36.4%) and one found it 'quite difficult' (9.1%). Family members commented that they could not spare enough time to prepare the media. This was in spite of their pledge of sourcing personalised media being a prerequisite to participation in the trial.

6.9.2 *Participant Reports*

On a scale of 1 to 5, participants rated their experience of Memory Box between 2 (slightly enjoyable) and 5 (extremely enjoyable). Their mean score of 3.3 indicated that overall, Memory Box was considered 'quite' to 'very' enjoyable. Eight participants (72.7%) said they would recommend Memory Box to others, one participant would not recommend it and two were undecided. On preference of media during the trial, music was rated the highest and photographs second. Participant interviews are available in *Appendix C* (*page 191*).

6.9.3 *Family Reports*

Family members' ratings of participants' experience of Memory Box ranged from 3 (quite enjoyable) to 5 (extremely enjoyable). The mean score of 3.9 placed their overall rating in the 'very enjoyable' category. All participants indicated willingness to recommend use of Memory Box to other residents. Family interviews can be found in *Appendix C* (*page 191*).

6.9.4 *Caregiver Reports*

Ratings by caregivers of participants' enjoyment of Memory Box ranged between 2 (only slightly enjoyable) and 5 (extremely enjoyable), with the mean score of 3.4 falling in the 'quite' to 'very' enjoyable category. Staff interviews can be found in *Appendix C* (*page 192*).

6.9.5 *Psychologist Observations*

The degree of participants' interaction with Memory Box during the trial period was also monitored by the psychologist and RC, who observed and logged their levels of pleasure while accessing media. Average ratings over the four sessions varied between 3 (mixed pleasure and displeasure) and 5 (considerable pleasure). The mean score of 4.2 fell between 'pleasure' and 'considerable pleasure'. Levels of engagement ranged from 3 (moderately) to 5 (fully) engaged. The mean score of 4.5 translated to an overall level of 'fairly engaged' to 'fully engaged'. Viewing family photographs and singing along to music were reported to cause excitement in the residents. Among the residents was a former pianist who moved her fingers in synchronisation while listening to a piano recital of her own composition.

6.9.6 *Patterns of Use during the Memory Box Trial*

The Memory Boxes automatically logged their run time in hours. Units recorded a daily run time of between 25 minutes and 5 hours, giving a mean of 2.6 hours. The log did not necessarily represent active engagement; for example, during continuous slide shows when the participant may have been watching the slideshow and moved away from Memory Box or left the room. A more accurate usage pattern was provided by the log of manual selections which, in this study, was between 6 and 26 selections per day with a mean of 14.7 selections.

Additional data on estimates of usage by participants was obtained from family members and caregivers. The scores ranged between 1 (only when visited by the psychologist and RC) and 5 (several times per day). The mean score of 3.5 indicated 'daily' or 'almost daily' use of Memory Box. Estimates from family members ranged between 3 (several days each week) and 5 (several times per day), the mean score of 4.1 showing a perception of usage on a daily basis. The caregivers' estimates ranged between 1 (only when visited by the research team) and 5 (several times per day). The mean score of 3.0 pointed to their perception that the residents used the device several days each week.

6.10 Discussion

The purpose of this study was:

- to determine the feasibility of Memory Box in providing a high degree of autonomy to people with mild, moderate or severe dementia.
- to alleviate rates of depression, anxiety, agitation and carer burden when using Memory Box, with the assumption that this would improve the overall quality of life in residents and caregivers during the testing period.

In addition, the study looked at determining residents' satisfaction levels when using Memory Box routinely, establishing usability patterns and recognising the level of support required from caregivers and family members to enhance the overall Memory Box experience.

Among the limitations of the research, the most notable was the small sample size and large health-related attrition, resulting in a 31% drop-out (five out of sixteen participants), leaving just eleven to complete the Memory Box and social control interventions. In spite of a supplementary feasibility study involving all participating residents and their family members, the small sample places limits on the conclusions about the efficacy of Memory Box.

On analysis of pre and post Memory Box outcome variables, a decrease in the levels of depression and anxiety during the intervention was detected. Post hoc analyses revealed this to be true for participants with lower cognitive impairment. Agitation levels, however, decreased only in residents with higher cognitive impairment. This leads to the inference that Memory Box may have a positive effect on symptoms of depression and anxiety in people with mild dementia, and on symptoms of agitation in people with moderate to severe dementia. No significant changes were detected in quality of life or in carer burden.

The positivity of outcomes was observed to be proportional to the degree of usage of Memory Box, suggesting the existence of some minimum degree of usage for any positive impact on residents' well-being.

As these data were preliminary and the sample sizes very small, the results need to be verified through further research. Comparison between intervention outcomes and outcomes of a social control condition could not establish significant statistical differences in mood, anxiety and agitation. This underpowered analysis may point to Memory Box not achieving better outcomes than social visitors. The technical support team worked to resolve a number of technical problems encountered during the trial, which may have reduced participants' engagement with the devices and limited the efficacy of the intervention in alleviating agitated or affective symptoms.

Residents with dementia found Memory Box to be enjoyable and pleasurable, and engaged well with it during training sessions, thereby indicating high levels of satisfaction with the experience. When Memory Boxes were placed in their rooms for four weeks, the residents with dementia were reported to use them on most days of the trial. Family members reported high levels of enjoyment and caregivers observed moderately high levels. The ability to access favourite music and photographs reportedly caused great delight in many residents. The content of Memory Box was not found interesting by two of the eleven participants, which may have resulted from the devices not being set up optimally for them.

These reports, however, were inconsistent with their family members' positive observations. One participant with mild dementia could already access media through devices like the tablet. It will require further research to determine if this sub-group of highly functioning residents with mild dementia would benefit from the addition of content like games and favourite television shows.

Many family members of residents with dementia were optimistic about Memory Box, expressing a desire to purchase the device if and when it became available. Residents commented mostly on the functionality of Memory Box, while their family members talked about its usability as well as its impact on the residents. They described it as normalising, motivating, engaging, providing companionship, and facilitating adjustment to the new environment. They reported that access to media, especially photographs and music, triggered pleasant memories and the ease of operating the system afforded the residents a sense of control. After the Memory Box trial, some family members perceived positive change in the residents' well-being and motivation. This perception could not be confirmed, as only data on cognitive impairment at baseline was collected. Residents and caregivers deemed Memory Box to be beneficial to residents who tended to stay in their rooms and may have been socially isolated. Those who were active outdoors during the day were deemed to find it less beneficial.

In addition to its primary aim of facilitating persons with dementia with easy access to personalised media, Memory Box provided some unexpected fringe benefits of a social nature. Participants felt that Memory Box enhanced their engagement with family members by providing new conversation topics and opportunities to reminisce. Several residents appeared to enjoy taking visitors through the media on their devices. Caregivers found that Memory Box allowed them to discuss personal histories and relationships with residents and become more familiar with them as individual people.

Owing to diverse levels of cognitive function in the group, the ease of operating Memory Box varied substantially among individual members. The researchers found that correctly matching interfaces to the individual cognitive capacities of residents enhanced usability. While data recorded on Memory Boxes indicated high usage, it was difficult to differentiate the number of daily media selections made by the residents themselves and those made by their families or caregivers. Further research is required in identifying residents' capacity for autonomous use of Memory Box and facilitating regular use by those who require some level of assistance.

Chapter Seven Conclusions

Chapter Overview

Chapter 7 reflects on the research and examines how effectively the design outcome has addressed its aims, based on the problem areas. It discusses the knowledge gaps identified during the research and how the outcome contributes to knowledge; the outcome is a multimedia system consisting of a dedicated physical dimension, and specially-considered information architecture that is personalised for use by individuals with dementia. This has shown potential in:

- providing a high degree of autonomous use to individuals at any stage of dementia
- reducing depression and anxiety in individuals with mild dementia
- reducing agitation in individuals with moderate or severe dementia
- adapting to the different impairment levels of dementia
- providing high levels of enjoyment to affected individuals, their family members and caregivers

(Davison et al. 2015)

Finally, the chapter presents the limitations of the research and future direction.

The research used a mixed methods approach, in particular exploratory sequential mixed methods through studio-based, social and clinical research.

7.1 *The Research Aim and Question*

The thesis began by discussing problem areas that provided purpose for this research (*Chapter 1, page 3*). The rapid increase in the rate of global ageing implies generally longer and healthier lifespans. However, as people get older they become more prone to chronic and degenerative diseases. One such ailment is dementia, the incidence of which is expected to rise from 35.6 million people in 2010 to 115.4 million in 2050 (Prince et al. 2013; World Population Ageing 2013). Dementia describes a collection of medical conditions caused by the loss of neurons in the brain (Prince). The most common symptoms are behavioural (such as aggression), psychological (such as hallucinations), and a decline in the ability to remember new information (Alzheimer's Association 2014; Finkel et al. 1996). As the symptoms exacerbate, family members find it increasingly difficult to handle and communicate with affected individuals (O'Connor et al. 1990). This often leads to their placement in aged-care facilities where professional help is available (Schultz and Williamson 1991). However, due to shortfalls in staffing levels, caregivers have busy schedules and are unable to provide residents with as much one-on-one attention as they would like (Cohen-Mansfield 2001). Individuals with dementia therefore spend much of their time in isolation (Alm et al. 2003). Medication is the primary method of treating the symptoms of dementia, despite frequent reports of the efficacy of placebo treatments (Ballard and O'Brien 1999). More than 40% of people with dementia at aged-care facilities are being prescribed unnecessary medication (Margallo-Lana et al. 2001), which leads to reduced well-being and quality of life and may expedite cognitive decline (Ballard et al. 2001; McShane et al. 1997). According to the Alzheimer's Society (2006), all medications used for treating the symptoms of dementia have adverse side effects, the prevention of which encourages the use of non-medicinal interventions (Douglas et al. 2004).

Based on these problems the research aimed to propose and develop a response to challenges posed by the common symptoms of dementia (*Section 1.2.3, page 9*) found in residents at aged-care facilities, in particular:

- loss of self-reliance, which may lead to depression
- boredom
- isolation and/or loneliness

(Alm et al. 2003; Cohen-Mansfield 2000a)

O'Connor et al. (2009) reported that non-medicinal therapies, in particular those tailored to participants' backgrounds, interests and skills, were effective in reducing some of the symptoms of dementia. Reminiscence therapy was most effective when using photographs (Astell et al. 2008; Bohlemeijer et al. 2007; Cappeliez et al. 2005; Cohen-Mansfield and Werner 1998; Dochterman and Bulechek 2003; Kuwahara et al. 2006; Sarne-Fleischmann and Tractinsky 2008; Woods et al. 2005); personalised music was more effective than randomly selected music (Clark et al. 1998; Gerdner 2000; Music and Memory 2010; Sherratt et al. 2004; Thomas et al. 1997); video-taped simulated family presence was far more effective in reducing agitation than audiotaped simulated presence (Cohen-Mansfield and Werner 1997); a combination of therapies was more effective than any one therapy by itself (Remington 2002); and one-on-one interaction was more effective in reducing verbal agitation than personalised music or simulated presence.

These encouraging reports led to the design outcome – a multimedia system consisting of a dedicated physical dimension with specially considered information architecture. Its purpose was to provide reminiscence, personalised music, simulated presence and autonomous use to individuals at any stage of dementia. Thus, the research question was:

***How can a personalised multimedia system be designed to enhance the quality of life of individuals with dementia and provide them with a high degree of autonomous use, while adapting itself easily to the deteriorating stages of their condition from mild to moderate to severe*?**

Figure 7.1 shows the problem areas and their association, resulting in the design hypothesis.

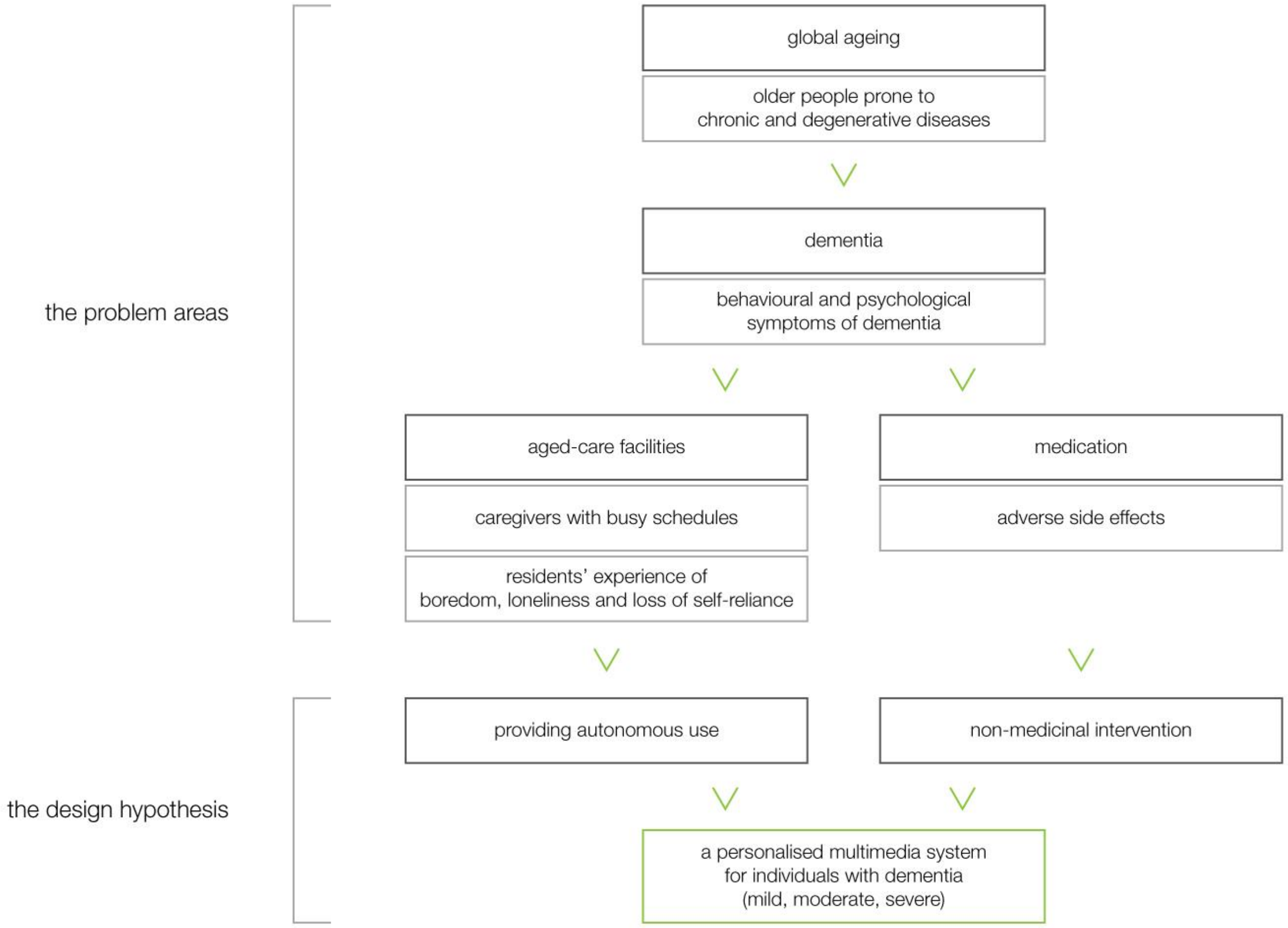


Figure 7.1 ***Framing the problems and identifying the design hypothesis***

7.2 *The Knowledge Gaps*

Based on the research question, the literature review (*Chapter 3, page 26*) aimed to identify state-of-the-art media interventions that utilised personalised media, provided a high degree of autonomy to individuals at any stage of dementia and adapted to the deterioration in their level of impairment. Seven interventions were reviewed, of which two were the most relevant; Project CIRCA and the Interactive Reminiscence Aid demonstrated that touchscreen technology had potential in providing a degree of autonomy to people with cognitive impairment (Alm et al. 2001, 2003, 2004). This warranted its use in the multimedia system.

However, despite reports of the two interventions providing a degree of autonomy to individuals with dementia, it was unclear to what impairment levels of dementia (mild, moderate or severe), and what exact degree of autonomy the interventions afforded. There was no suggestion of whether either of the interventions could provide continuing autonomous use throughout the process of deterioration in the degree of dementia from mild to moderate to severe. The progressive and irreversible decline in the degree of dementia leads to corresponding decline in the ability to perform even the most routine tasks. Moreover, the interventions focused on their software component and not on the design of dedicated hardware or associated features such as physical adjustability. Further trials were therefore necessary to determine the degree of autonomy at each level of dementia, and whether the autonomy could be maintained across the exacerbation in impairment.

The next stage of research was a review of literature on physical and perceptual impairments in people with dementia, and prototype testing at an aged-care facility. These assisted in the collation of design parameters (*Table 7.1*), which guided the development of the multimedia system (*Chapter 5, page 64*). The system was tested on 11 residents with mild, moderate or severe dementia for a period of four weeks each (*Chapter 6, page 124*).

	the physical dimension – needs	the information architecture – needs
the literature review	*a large screen* *touchscreen technology* *dedicated hardware*	*personalised photo-videos (with supporting personalised music and a pan/zoom feature)* *to maintain flow* *representational icons* *personalised music* *pre-recorded family video-messages* *to provide more options to users (for all media to have associated photographs and titles)*
age-related impairments	*a freestanding physical dimension* *for users to be seated while using such a system*	*sufficient auditory amplification* *sufficient screen illumination* *large visual detail*
touchscreen tablets	*a non-obtrusive physical dimension* *a self-charging system*	
the usability tests	*individualised units* *a compact physical dimension* *an alternative to capacitive touchscreens* *physical adjustability* *corresponding tactile and digital selections* *infra-red (or comparable) touchscreen technology*	*personalised movies* *for symbols to have correlating text* *for all selections to be positioned horizontally at the base of the screen* *specially considered IA that vary in complexity* *icons that are familiar* *a Pause, Back or Stop button that is easily noticeable and recognised*

Table 7.1 **The design parameters**

7.3 *The Multimedia System Intervention Results*

The purpose of this study was to determine the feasibility of the system in providing a high degree of autonomy to people with mild, moderate or severe dementia, and to alleviate rates of depression, anxiety, agitation and carer burden through the use of the multimedia system, with the assumption that this would improve the overall quality of life in residents and caregivers during the testing period. In addition, the study looked at determining residents' satisfaction levels when using the system routinely, establishing usability patterns and recognising the level of support required from caregivers and family members to enhance the overall system experience.

The results reported that all 11 participants who had mild, moderate or severe dementia were able to use the system with a high degree of autonomy via its adaptable interfaces (*Tables 6.4, page 134* and *6.8, page 137*). Moreover, symptoms of depression on the Cornell Scale (Alexopoulos et al. 1988) decreased significantly during the intervention; symptoms of anxiety on the Rating Anxiety in Dementia scale (RAID) (Shankar et al. 1999) also decreased significantly. While scores on the Cohen-Mansfield Agitation Inventory (CMAI) (Cohen-Mansfield et al. 1989) reported a fall in agitation, they were non-significant; quality of life on the Quality of Life in Alzheimer's Disease (QOL–AD) (Logsdon et al. 2002) rated by participants, caregivers and family members, all increased slightly during the intervention; and scores on the staff-rated Burden Interview (Sourial et al. 2001) decreased during the intervention.

7.4 The Contribution to Research in the Field

This research resulted in the design of a multimedia system that demonstrated potential in providing a high degree of autonomy and self-reliance to people with dementia at aged-care facilities. It also led to the defining of a comprehensive set of specifications that should be incorporated in the design of such a system for optimum use by this cohort. These specifications apply to the system's hardware and information architecture and are summarised below:

Dedicated Hardware

- The multimedia system should consist of hardware that is compact, non-obtrusive and physically adjustable to cater for the 95th percentile of elderly people when seated.
- Large screens should be used to provide an enhanced experience for this cohort, who are prone to age-related physical and perceptual impairments.
- Touchscreens with infra-red or comparable technology should be used to address challenges related to tactile agnosia.
- The system should include both tactile and digital buttons that correspond with one another for more user options.
- Tactile buttons should have a force–travel combination of 0.30–0.48 N and 0.2–3.9 mm respectively. This should cater to able-bodied people as well as to people with arthritis and tremors.

Adaptable Information Architecture

- The multimedia system should provide specially considered information architectures that vary in complexity to cater to individuals with mild, moderate or severe dementia.
- Individuals with a high MMSE score should use an information architecture with a top-down approach and a narrow and deep hierarchy.
- Individuals with a low MMSE score should use an information architecture with a bottom-up approach and a broad and shallow hierarchy.
- Individuals with a medium MMSE score should first attempt to use an information architecture with a top-down approach and a narrow and deep hierarchy. If flow is not achieved, they should use an information architecture with a bottom-up approach and a broad and shallow hierarchy.
- Matching the correct information architecture to an individual's impairment level is vital in order to achieve flow.
- As individuals with dementia are prone to physical impairment, it is important for all media selections and controls to be aligned horizontally and close to the screen's base to allow easy and comfortable access.
- Long-term memories are better preserved than short-term memories (Astell et al. 2008; Rentz 1995). Therefore, using media icons with past familiarity to users should enhance usability.

7.5 *Limitations of the Research*

While the results of tests on the usability of the multimedia system were encouraging, there were a number of limitations during field tests that may have affected their efficacy, necessitating future trials. Perhaps the most notable limitation was the small sample size. Due to a high rate of health-related attrition, the dropout rate of 31% resulted in only 11 of the initial 16 participants completing the multimedia and social control interventions.

Data recorded on the multimedia systems reported high overall daily usage. However, despite instructions to caregivers and family members to refrain from making media selections, there was no way of confirming that the selections were made solely by the participants themselves. Given the short testing period, only one participant's impairment level deteriorated during the tests, requiring a change in information architecture from level 1 to level 2. While the change was successful, and the participant was once again able to use the system autonomously, there were not enough cases to determine whether the degree of autonomy could be maintained as the level of impairment deteriorated from mild to moderate to severe.

The multimedia system provided participants with physical and digital buttons that corresponded with one another. Six participants used the physical buttons while five used the digital ones. Further testing was necessary to determine whether this cohort preferred one to the other. While reports of the system's daily usage were encouraging during field tests (*Section 6.9.6, page 139*), there was an opportunity to consider the inclusion of sensors in the system that would detect motion (such as aggression) or sound (such as agitation). This could be used to draw a user's attention to the system when the user was in near proximity but not making media selections.

Finally, due to a number of technical difficulties encountered during the testing period (such as fluctuations in power and periods where the computers froze or did not cooperate), it is possible that participants' level of engagement with the system was reduced, limiting the efficacy of the intervention in alleviating agitated or emotional symptoms.

7.6 *Meeting the Research Aim*

Overall, the results of the research suggest that the multimedia system provided people with dementia with a degree of self-reliance and potential in alleviating boredom and isolation at aged-care facilities, thus meeting the research aim. In addition, there were anecdotal reports that caregivers learnt more about residents during the intervention, and family members felt closer to their relatives and more involved in their lives than prior to the intervention.

This innovative intervention represented a significant contribution to the research field by demonstrating that with such a system, the current generation of people with dementia could independently access their favourite media, attain a higher degree of self-reliance, and restore their own sense of joy and contentment as well as that of their family members and caregivers.

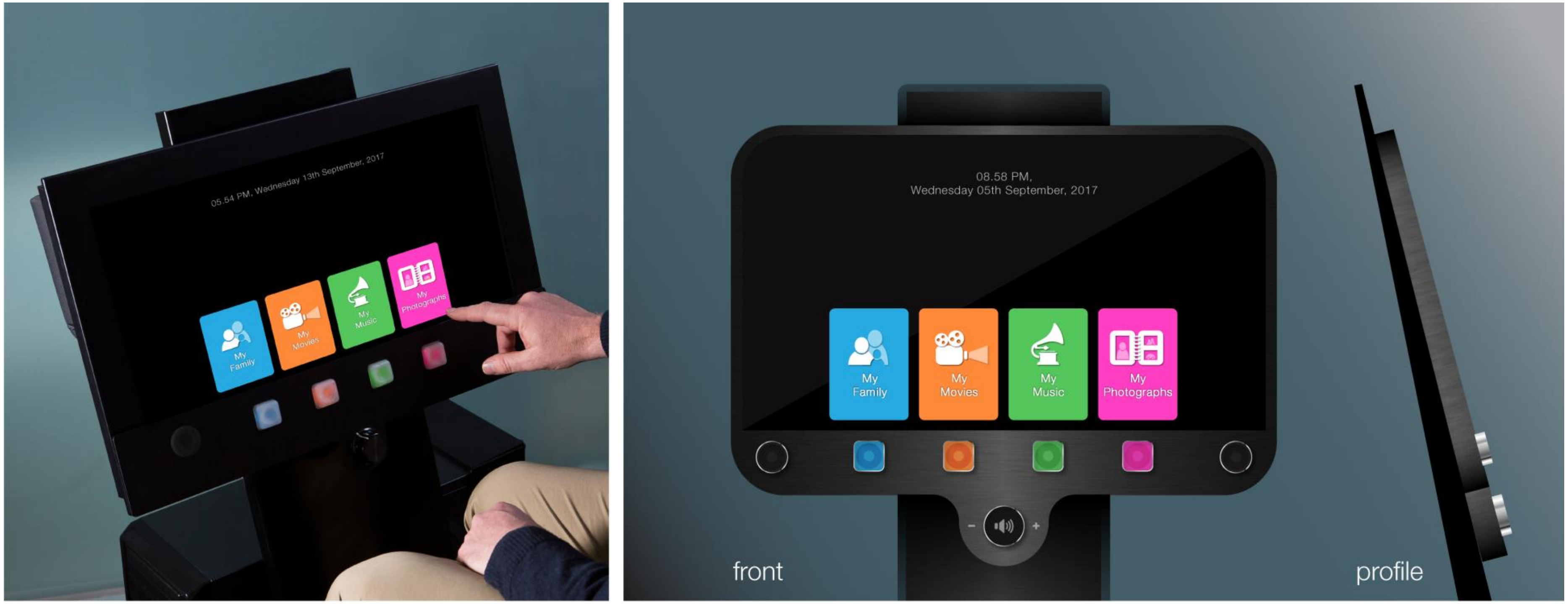
7.7 *Future Direction*

Dementia having a global prevalence provides an opportunity for the scope of this study to be extended to larger group sizes, for longer periods and across diverse regions of the world. This could confirm whether or not its findings are valid and may assist individuals with dementia worldwide to lead an improved quality of life. The many technical difficulties encountered during the field-tests warrant a technical support team that is available to assist during future tests.

Due to technological limitations, the infrared touchscreen in the multimedia system required a bezel and a large casing in which to house its LEDs (*Section 4.8.2, page 55*), glass panel and circuitry. This resulted in its bulky and relatively heavy form factor (*Figure 4.6, page 55*). There is therefore the opportunity to explore avenues in which its bezel and casing may be re-designed to achieve the following, which should improve the system's overall aesthetics:

- A reduced screen depth
- Rounded corners for enhanced safety
- The inclusion of a CPU and speakers
- A bezel that encases the tactile buttons and volume knob
- A backlit assembly for the tactile buttons

Figure 7.2 displays the touchscreen used during the field-tests and a concept of the desired infrared touchscreen with a re-designed bevel and casing (as *in Figure 5.55*).



current desired

Figure 7.2 ***Current vs. desired infrared touchscreen (on its stand)***

Finally, to expand on the potential of the multimedia system for wider impact and to make better use of the research outcomes, further testing should be considered into the system's adaptability for use at home by the geriatric population with the aim of maintaining independent living.

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Appendices

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Appendix A

Non-Medicinal Therapies for BPSD

standard therapies	alternative therapies	brief psychotherapies
behavioural therapy reality orientation validation therapy reminiscence therapy	art therapy music therapy activity therapy complementary therapy aromatherapy bright-light therapy multi-sensory approaches simulated presence	cognitive behavioural therapy interpersonal therapy

Table A1 ***Types of non-medicinal therapies for treating BPSD***
Douglas et al. 2004

Standard Therapies

This section highlights the four therapies shown in *Table A1*; behavioural therapy, reality orientation, validation therapy and reminiscence therapy.

Behavioural therapy involves gathering information based on signs of behaviour and the sequence of actions that lead to the behaviours in individuals with dementia. These findings result in the choice of interventions by therapists.

When designing an intervention, it is important to consider the following: an individual's preferences; changing the setting in which the behaviour occurs; and using strategies and schedules that may reduce the behaviour (Emerson 2001). There have only been a few studies of behavioural therapy in the context of dementia; more studies are therefore necessary to determine its efficacy (Burgio and Fisher 2000).

Reality orientation is the therapy most used for dealing with people with dementia. It uses semiotics such as signs, symbols and other memory aids to help those with loss of memory and disorientation to move from one point to another in their environment. Reality orientation has been found to increase people's verbal orientation (Morton and Bleathman 1988) but can also remind individuals of their deterioration (Goudie and Stokes 1989) which lowers their moods during the sessions (Baines et al. 1987). As with behavioural therapy, there are not enough studies to report its efficacy.

In response to the lack of efficacy of behavioural therapy and reality orientation, an intervention called validation therapy was developed. Validation therapy focuses on an individual's emotions rather than intellect. Emotions promote contentment which reduces negative effect and behavioural disturbance (Feil 1967; Hitch 1994). It has been suggested, however, that therapists could focus too deeply on an individual's method of communication (such as confused speech) which can result in therapists failing to recognise simple explanations such as pain or hunger. Despite the response to lack of efficacy in the previous therapies, Neal and Briggs (2002) evaluated a number of validation therapy studies and concluded that despite some positive results, there was still not enough data even from this intervention.

Overall, standard therapies have reported some positive results but there is not yet enough evidence to determine their success due to a limited number of studies.

Alternative Therapies

Alternative therapies are becoming more popular for treating BPSD but, as in the case of behavioural therapies, often still lack evidence of their effectiveness (Marshall and Hutchinson 2001). Alternative therapies include movement therapy, self-maintenance therapy, pet therapy (living and robotic) and memory training. This section provides a review of some of the more commonly used types of alternative therapy (*Table A1*).

Art therapy focuses on activities such as drawing and painting which allow individuals with dementia to express themselves through colour and theme (Killick and Allan 1999).

Activity therapy focuses on group recreational activities such as dance, sport and drama. Physical exercise has been shown to have a number of health benefits for people with dementia. These include a reduced number of falls, improved mental health and sleep (King et al. 1997) and an improvement in one's mood and confidence (Young and Dinan 1994). Alessi et al. (1999) found that exercise helped reduce day time agitation and night-time restlessness.

Complementary therapy includes a range of therapies such as massage, reflexology, reiki, therapeutic healing, herbal medicine and aromatherapy. The results from a survey about these therapies were reviewed by Wiles and Brooker (2003), who reported that most complementary therapies have not received a great deal of experimental investigation except for aromatherapy.

Aromatherapy is the fastest growing alternative therapy for BPSD (Burns et al. 2002). It has several advantages over the use of medication: it provides a degree of interaction between a person with dementia and a caregiver, and it provides sensory experience. Aromatherapy is better tolerated than sedative medication. The two main oils used in aromatherapy are lavender and Melissa balm. There are several methods of application such as inhalation, bathing, massage and application in cream form. These allow for targeting a wider range of behaviours; for example, inhalation can be effective on a person with restlessness. Aromatherapy has been shown to reduce agitation in people with dementia (Ballard et al. 2002).

Bright-light therapy is used for people with dementia who have recurring confusion or agitation in the late afternoon or early evening (referred to as 'sundown syndrome') (Haffmans et al. 2001). Both bright-light therapy and multi-sensory approaches have demonstrated positive outcomes for improving restlessness, in particular sleep disturbances.

Multi-sensory stimulation (MSS, formerly known as 'Snoezelen') uses sensory stimulation to treat BPSD. Typically, rooms are set up with visual, auditory, olfactory and tactile stimuli such as lights (commonly fibre optics, which are flexible), textures, smells and sounds that cater to an individual's preferences (Baillon et al. 2004; van Diepen 2002). MSS has been tested mainly on individuals with severe dementia and has shown some positive effects on agitation (van Diepen). Burns et al. (2000) reviewed the increasing use of MSS and concluded that there is potential within this area; however, the available evidence lacks scientific rigour.

Brief Psychotherapies

This section describes two types of therapy: cognitive behavioural therapy (CBT) and interpersonal therapy.

CBT is aimed at helping people change unhealthy thinking habits, feelings and behaviour. It is used to treat anxiety, depression, anger, eating disorders and other problems. Teri and Gallagher-Thompson (1991) reported positive findings on CBT for people with mild dementia and Kipling et al. (1999) found favourable results with individual or group CBT. Interpersonal therapy is used to examine an individual's distress within an interpersonal context (Weissman and Blom 2000). It uses a specific framework in which the individual's distress is conceptualised through one of four areas: interpersonal disputes; personality difficulties; grief; and life events. Interpersonal therapy has reported positively in treating older people but it has only recently been introduced to people with dementia (James and McCullough 2003).

Both CBT and interpersonal therapy have their limitations, especially with people with severe dementia. However, due to their simple conceptual models they have been found to help severe cognitive impairment in general (James and McCullogh).

Appendix B

dimension number	measure	M	SD	median	range	CV %
1	seated eye height	729	46	732	631-805	6.3
2	seated shoulder height	587	37	585	502-670	6.3
3	seated elbow height	232	35	235	168-297	15.2
4	upper limb length	784	74	789	644-987	9.4
5	elbow-fingertip length	422	30	418	365-487	7.2
6	buttock-knee length	549	38	547	443-610	6.9
7	knee height	515	31	513	462-580	6.0
8	floor-buttock height	416	25	421	372-468	6.1
9	toe height (wheelchair)	205	-	-	-	-
	age (years)	76	7	73	65-92	9.6
	weight (kg)	72	11	72	46-99	15.9
	hand length	184	10	184	164-200	5.3
	hand breadth	86	7	86	70-99	8.3

dimension number	measure	P5	P25	P50	P75	P95
1	seated eye height	632	693	732	766	799
2	seated shoulder height	522	561	585	608	667
3	seated elbow height	173	210	235	259	293
4	upper limb length	660	738	789	835	923
5	elbow-fingertip length	369	398	418	443	477
6	buttock-knee length	453	531	547	581	601
7	knee height	470	486	513	539	570
8	floor-buttock height	373	392	421	437	460
	weight (kg)	52	65	72	78	99
	hand length	165	178	184	191	200
	hand breadth	72	81	86	92	97

All linear dimensions are in mm

***Table B1* Descriptive statistics and percentile values of elderly Australian males (aged 65 years and over)**
Kothiyal and Tettey 2000; Tilley 2002

dimension number	measure	M	SD	median	range	CV %
1	seated eye height	676	42	679	570-782	6.3
2	seated shoulder height	531	35	533	456-632	6.7
3	seated elbow height	212	34	211	150-286	16.1
4	upper limb length	737	75	745	566-940	10.0
5	elbow-fingertip length	385	36	380	322-623	9.0
6	buttock-knee length	530	35	530	446-620	6.7
7	knee height	475	28	474	400-570	5.9
8	floor-buttock height	379	28	378	310-465	7.4
9	toe height (wheelchair)	205	-	-	-	-
	age (years)	77	8	77.5	65-92	10.0
	weight (kg)	61	13	59	39-105	21.4
	hand length	170	10	169	146-195	6.0
	hand breadth	79	5	78	70-99	6.0

dimension number	measure	P5	P25	P50	P75	P95
1	seated eye height	600	646	679	706	749
2	seated shoulder height	471	502	535	557	587
3	seated elbow height	154	182	211	237	275
4	upper limb length	614	679	745	785	847
5	elbow-fingertip length	337	362	380	400	442
6	buttock-knee length	475	504	529	558	589
7	knee height	432	452	474	491	521
8	floor-buttock height	330	362	378	397	430
	weight (kg)	45	51	58	70	85
	hand length	153	163	168	176	188
	hand breadth	71	76	78	81	87

All linear dimensions are in mm

Table B2 ***Descriptive statistics and percentile values of elderly Australian females (aged 65 years and over)***
Kothiyal and Tettey 2000; Tilley 2002

Appendix C

Depressive Symptoms

Depressive symptoms were evaluated using the Cornell Scale for Depression in Dementia (Alexopoulos et al. 1988) which is a commonly used instrument in residential aged-care settings. The instrument was administered during interviews to both the resident and caregiver; their final scores based on clinical judgement of the evaluator. The 19 items were rated from 0 (absent), 1 (mild or intermittent) or 2 (severe) over the past week, with total scores ranging from 0 to 21 points, demonstrating the severity of depressive symptoms. Previous research has endorsed this scale for use with aged-care residents with cognitive impairment, with indications of high sensitivity for a diagnosis of major depressive disorder (McCabe et al. 2006).

Anxiety Symptoms

Anxiety symptoms were evaluated using the RAID (Shankar et al. 1999) which is a 20-item screening measure used to assess anxiety symptoms in people with dementia. There are 5 sub-groups in the scale: worry; apprehension and vigilance; shortness of breath; phobias; and panic attacks. Each item is rated 0 (absent), 1 (mild or intermittent), 2 (moderate) or 3 (severe) with the total scores ranging from 0 to 60; higher scores indicate more severe anxiety. The RAID is completed using information from the participant, an interview with a caregiver and using medical records. The structured interview guide for this rating scale reported by Snow et al. (2012) was implemented in this study.

Caregiver Burden

Caregiver burden was assessed using a version of the Burden Interview (Zarit et al. 1980), modified for use with professional carers (Sourial et al. 2001). Responses to 13 items were on a five-point Likert scale, from 0 (never) to 4 (nearly always) with total scores ranging from 0 to 52. Two caregivers each completed the instrument and a mean score was calculated reporting that internal consistency was high in the present sample.

Quality of Life

Quality of life was evaluated using the QOL–AD (Logsdon et al. 2002) which uses a 15-item measure to administer participants and family members; it uses an interview format for participants and questionnaires for caregivers. Where a participant was unable to fill out the self-report (due to moderate impairment for example), only 11 areas in the 'informant' section which are of concern to people with dementia were used. These areas include physical health, energy, mood and living situation. The adaptation for individuals in residential aged-care settings described by Edelman et al. (2005) was used (Davison et al. 2015).

Levels of Cognitive Impairment

Levels of cognitive impairment were evaluated using the MMSE score at baseline (Folstein et al. 1975) which is a commonly used cognitive screening instrument. It comprises of 11 items divided into two sections.

The first section requires verbal responses and measures participants' orientation to time and place, memory recall and attention. The second section consists of reading and writing and evaluates the individual's language and comprehension abilities and visuo-spatial skills. The MMSE provides an overall score out of 30 (as discussed in *Chapter 2*) The following ranges were used in this research: 25–30 for normal cognition; 19–24 for mild cognitive impairment; 10–18 for moderate cognitive impairment; and 0–9 for severe cognitive impairment (Ward et al. 2002).

Technological Protection Measures in Australia

Australia's principal medium for transmission of commercial movies is DVDs. Memory Box plays videos in a format commonly known as MPEG–4, the principal format underlying the HTML5 interface it is built on. Preparing movies for playback by Memory Box in this format requires transcoding to this format. Almost without exception, commercial DVDs are packaged with TPMs; much precedent exists for the circumvention of such measures but in Australia this is illegal. Attempts were made to contact the copyright holders for permission to obtain unprotected copies; however, the avenues for this line of enquiry appeared to be pursuable only from the United States of America, where most of the copyright holders resided. Faced with few other options, the decision was made to simply eschew all copyrighted movies and peruse the public domain. Thus, all commercial films shipped with Memory Box were obtained freely and legally from the public domain. Curiously, a similar problem does not exist for music as in the two principal media for transmission of music (CDs and MP3s) TPMs are not implemented and transcoding of these media is permitted for personal use subject to the originally purchased transmission media being retained. This condition is not specific to audio, and in fact would apply to all videos were the circumvention of a TPM not necessary. Homemade media never contain protection of this kind and given that the copyright holders (the family members) were providing this media specifically for use with Memory Box, legal difficulties were not encountered (Copyright Amendment Act 2000 (Cth) Sch 1 [98]).

Movies from the Public Domain Available for Viewing on Memory Box

1. Wizard of Oz
2. The 39 Steps
3. His Girl Friday
4. The Phantom of The Opera
5. The Hunchback of Notre Dame
6. The Gold Rush
7. And then There Were None
8. Charade
9. A Farewell to Arms
10. Jungle Book
11. Popeye the Sailor
12. Father's Little Dividend
13. Road to Bali
14. Meet John Doe
15. The Flying Deuces
16. Little Lord Fauntleroy
17. Glorifying the American Girl
18. The Lady Vanishes
19. Jack and the Beanstalk
20. Zorro’s Black Whip
21. Dressed to Kill
22. Hercules
23. Popeye the Sailor Meets Ali Baba's Forty Thieves
24. A Star is Born
25. The Fast and the Furious
26. Dick Tracy
27. Sing a Song of Six Pants
28. Superman
29. Rain
30. Angel and the Badman
31. My Favorite Brunette
32. All This and Rabbit Stew
33. Abraham Lincoln
34. The Big Show
35. Disorder in the Court
36. The Inspector General
37. The Outlaw
38. The Red House
39. Suddenly
40. Penny Serenade
41. Fire Over England
42. The Last Time I Saw Paris
43. The New Adventures of Tarzan
44. Impact
45. A Shriek in the Night
46. Bull Drummond
47. The Hurricane Express
48. Algiers
49. The Stranger
50. The Royal Wedding
51. Happy Go Lucky
52. The Great Rupert
53. Zorro’s Fighting Legion
54. A Word to the Wives
55. Salt of the Earth
56. I Cover the Waterfront
57. Something to Sing About
58. Stamp Day for Superman
59. The Painted Hills
60. Malice in the Palace

61. Tarzan the Tiger
62. The Wabbit who came to Supper
63. Gulliver's Travels
64. Santa Fe Trail
65. Second Chorus
66. The Princess and the Pauper
67. Eternally Yours
68. Vengeance Valley
69. Captain Kid
70. The Circus

Social Control Intervention Scores

outcome measure	pre-control mean (SD)	post-control mean (SD)	post-control minus control score (SD)	*t*
CMAI	42.82 (9.51)	40.09 (9.19)	-2.73 (6.78)	-1.33
QOL-AD resident rated	43.09 (4.01)	42.09 (6.41)	-1.00 (4.84)	-0.69
QOL-AD staff rated	36.18 (8.23)	32.27 (7.93)	-3.91 (4.74)	-2.73*
QOL-AD family rated	39.09 (5.97)	39.45 (6.61)	0.36 (4.72)	0.26
Cornell Scale	5.18 (5.95)	5.36 (2.20)	0.18 (5.33)	0.11
RAID	7.55 (7.54)	4.64 (3.38)	-2.91 (6.33)	-1.52
Staff Burden Interview	8.09 (6.67)	5.91 (4.42)	-2.18 (5.84)	-1.24

Note ** $p < 0.01$, * $p < 0.05$

Table C1 ***Social control intervention scores***
Davison et al. 2015

Memory Box Intervention Scores

outcome measure	pre-Memory Box mean (SD)	post-Memory Box mean (SD)	post-Memory Box minus pre-Memory Box (SD)	*t*
CMAI	45.82 (19.39)	37.27 (9.86)	-8.55 (13.70)	-2.07
QOL-AD resident rated	42.36 (5.54)	43.09 (4.76)	0.73 (3.74)	0.64
QOL-AD staff rated	34.82 (6.37)	35.55 (8.14)	0.73 (5.04)	0.48
QOL-AD family rated	38.90 (6.49)	41.10 (7.25)	2.20 (4.44)	1.57
Cornell Scale	5.73 (3.10)	3.45 (2.54)	-2.28 (2.24)	-3.36**
RAID	6.64 (4.18)	3.18 (2.93)	-3.46 (4.03)	-2.84*
Staff Burden Interview	8.00 (5.93)	7.09 (3.96)	-0.91 (4.83)	-0.62

Note ** $p < 0.01$, * $p < 0.05$

Table C2 ***Memory Box intervention scores***
Davison et al. 2015

Participant Interviews

Listed below are some of the responses received during semi-structured interviews with participants.

80-year-old woman with moderate dementia:
"I'm mad on the music, that's my favourite … I love the whole thing … I just love it … I think it's fantastic ... I want to buy it."

86-year-old woman with severe dementia who showed a particular liking for the music function:
"I had all the music that I liked … I loved the music … Liked having it in the background … Like the radio … I'm sorry that it's going … I would have liked to keep it."

88-year-old woman with moderate dementia:
"It looks like TV … Works like TV … You find something different on it that you won't find on TV … It's handy to have if you want to look at photographs … Press a button and they come up."

89-year-old woman with severe dementia:
"It's good to have something to look at while performing other activities like knitting or drinking tea … Good if people popped in … I could share photographs with them and different things of interest … I would be interested in purchasing the device."

Another 88-year-old woman with moderate dementia:
"I'm glad there's Memory Box here … I like the music, and that when I push the button I can see my family … I wouldn't like it to suddenly disappear … Easy to push a button and have the song come on … I frequently sing out loud to the music … But I'm concerned about the noise disturbing other residents."

95-year-old woman with mild dementia:
"I found Memory Box easy to use … Anyone can operate it … Can get the selections … It's not complicated to select the media using the four buttons … I think it's wonderful."

82-year-old man with moderate dementia:
"I don't see the need for it …", but he also acknowledged, "I enjoy looking at photographs and listening to music."

91-year-old man with mild dementia:
"Very limited … It's restricted as it only has a limited amount of material … It didn't excite me much and wasn't worth having in my room for what I got out of it … I would rather have TV … The media available is insufficient to engage me … You've got to have something that someone wants to see."
This participant had used computers extensively in his previous career, and was highly competent in using existing technologies, for example Skype, and had an electronic photo frame in his room providing this type of media.

76-year-old woman with moderate dementia:
"I think it's a clever thing … I'm a bit in awe of it but know I have only four buttons to press … It's a good thing but I didn't use it often during the trial period … I haven't been in my room much."

Family Interviews

Listed below are some of the responses received during semi-structured interviews with family members.

Daughter of an 80-year-old woman with moderate dementia:
"Memory Box normalised her life and gave her control over her happiness … It's been like being at home and having access to what she would have done at home … It's a lifestyle companion … Memory Box facilitated more satisfying conversations with my mother … Memory Box is life giving … I saw definite improvement in her cognition, which I attribute to motivation and engagement with the apparatus."

Son of an 89-year-old woman with severe dementia:
"Memory Box is fabulous … All the personal information that she liked, photographs, music, there it was with the press of a button … I wouldn't mind one myself at home … There was a high level of engagement between her and the family members … When we visited Mum, we usually made comments about what was appearing on the screen; that was good."

Son of a 95-year-old woman with mild dementia who had been in the facility for three months:
"The intervention was good for Mum. It formed part of her adjustment to a new life … [The trial] came along at the perfect time for Mum."

Son of an 86-year-old woman with severe dementia:
"Mum loved watching [Memory Box] … it brought back good memories for her, although she did struggle with a few faces."

Son of an 88-year-old woman with moderate dementia:
"I loved the music and photographs … Mum loved it … I thought it was fabulous," but he expressed aesthetic concerns: "it's ugly, a metal robot, too big."

Wife of an 82-year-old man with moderate dementia:
"Memory Box gave him another way of filling his time … another thing to occupy himself … He loved the photographs of his sisters and being able to select from different media types … Having choices was good … What is the possibility of purchasing Memory Box?"

Son of a 95-year-old woman with mild dementia:
"The delight Mum took from [Memory Box] and with us having fun with it … The simplicity was the thing I liked the most … She showed visiting family members how to operate the device … I like the ability to switch between programs … She could switch from a show to music if someone came in."

Son of a 91-year-old man with mild dementia:
"He previously showed lack of interest in the selected media … You should see Dad's smile now when he talks about the photographs … When you look at his face, you can see him liking it … Dad hasn't got long left, and if dementia is taking hold then [Memory Box] may extend him further … I would like to enquire if I can purchase the device for my father."

Not all family members reported positive observations.

Daughter of an 85-year-old woman with moderate dementia:
"She didn't have the desire to use it."

Son of a 76-year-old woman with moderate dementia:
"She wasn't comfortable with it … She needed encouragement …
But she loved it when she was on it … She would say, 'remember this?'"

Staff Interviews

Listed below are some of the responses received during semi-structured interviews with members of staff at aged-care facilities.

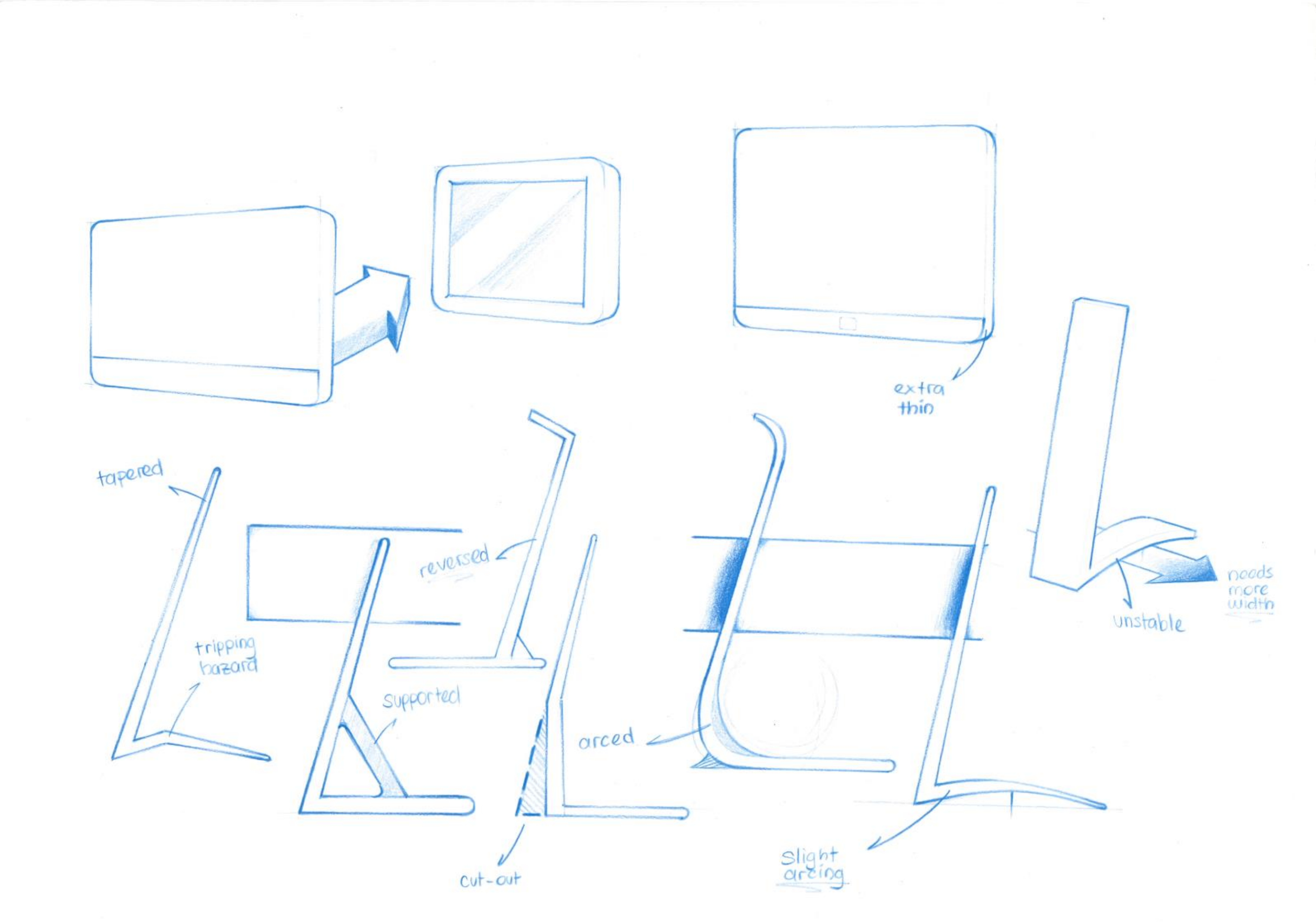
Lifestyle coordinator:
"One resident absolutely loved the music … Memory Box helped staff to engage with residents in reminiscence and conversation topics … But it was negatively perceived by one resident with visual impairment … She was upset that she didn't see the people … She didn't settle into it."

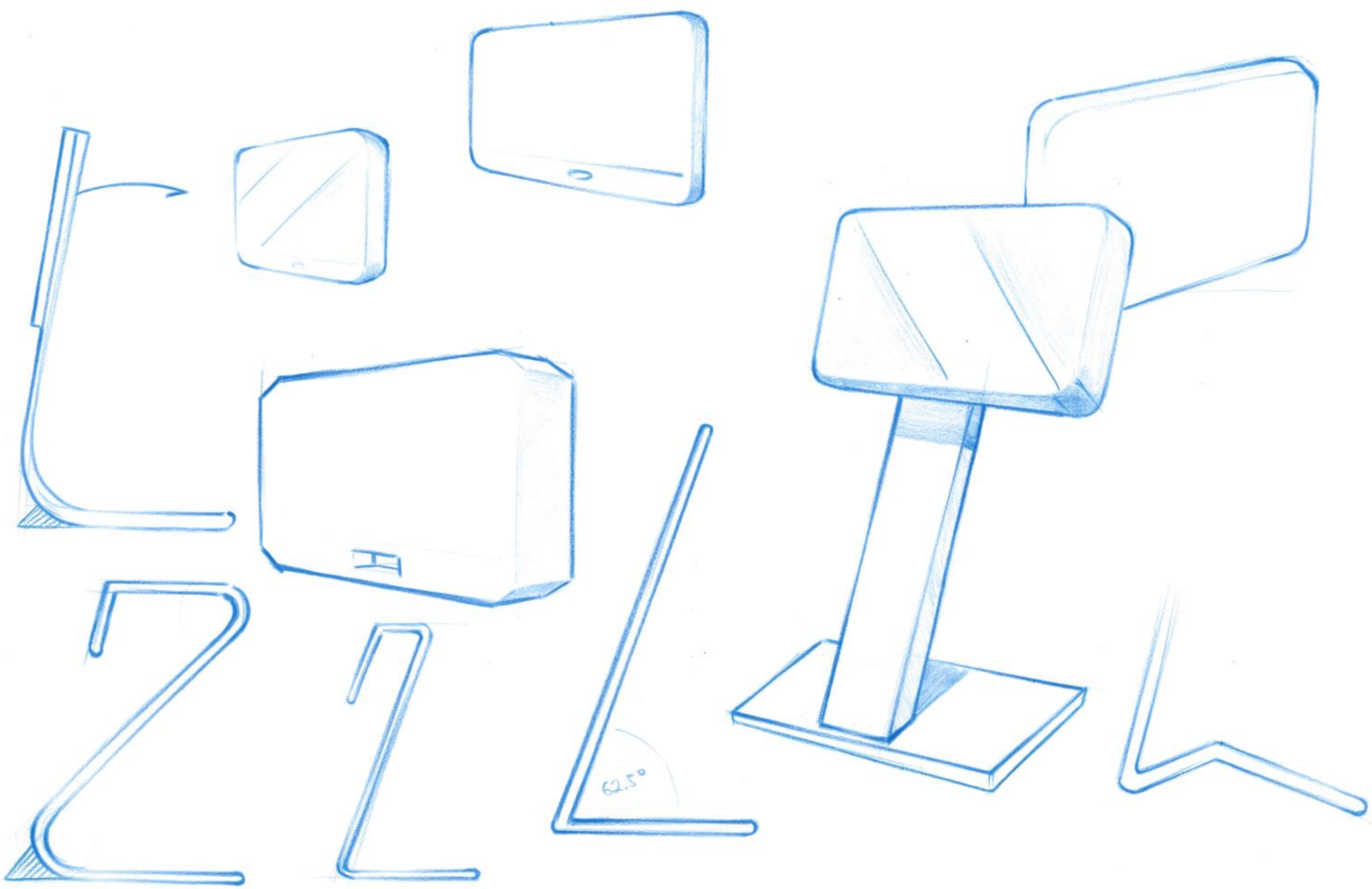
Diversional therapy trainee on placement at one facility:
"It's really good … I just wish they had it for more time … I enjoyed seeing them view their family… Seeing them light up when they saw family pictures … One resident particularly enjoyed watching old movies … Memory Box is really good for people with or without dementia if they are a bit down, and for those who don't leave their rooms and are isolated … Memory Box facilitated interaction between residents and staff members … They talked about the family pictures and messages."

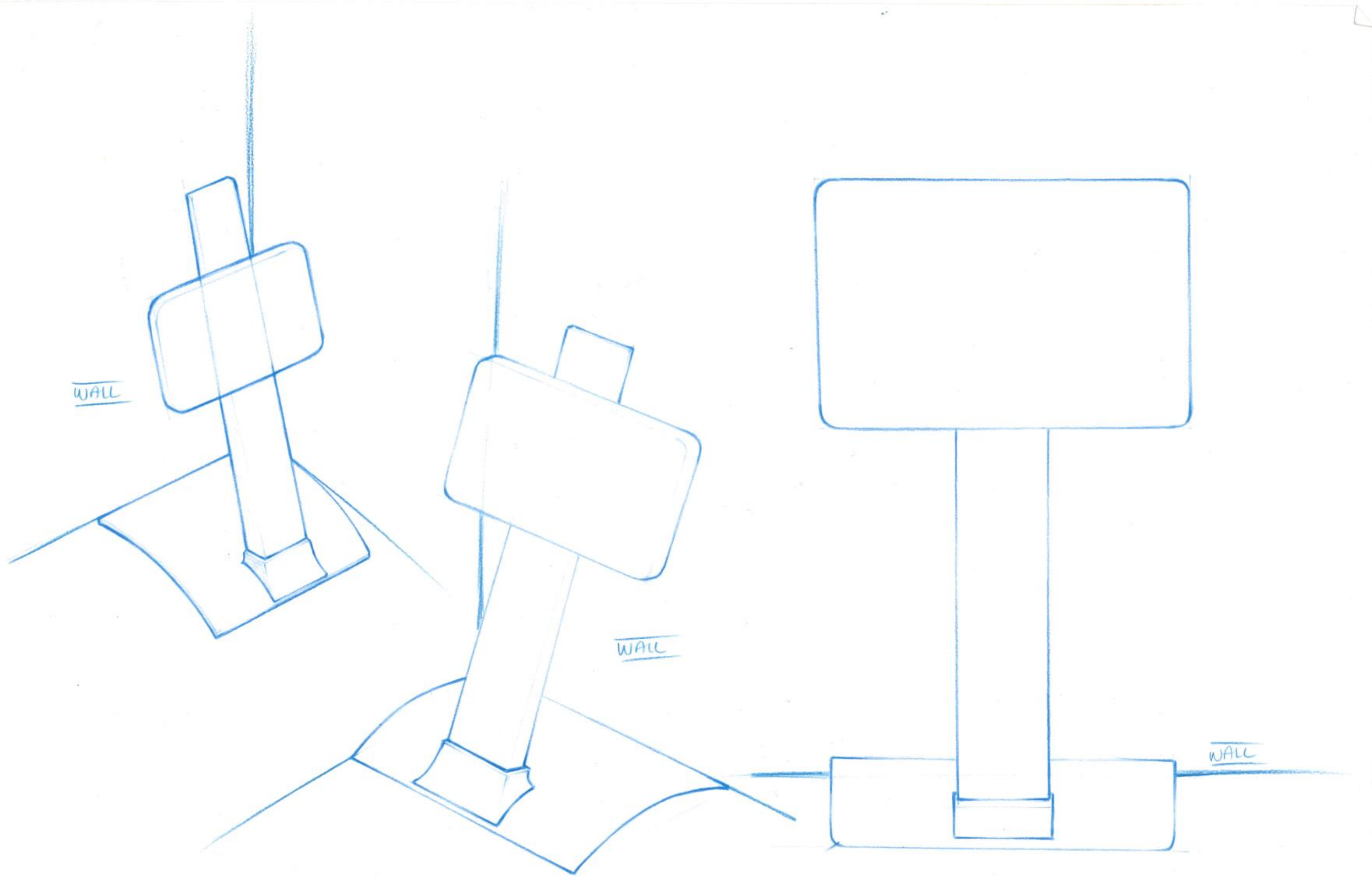
Personal care assistant:
"Memory Box is an interactive tool … especially for one-on-one with family …
I like its simplicity and the large screen … The device is personalised to the individual."

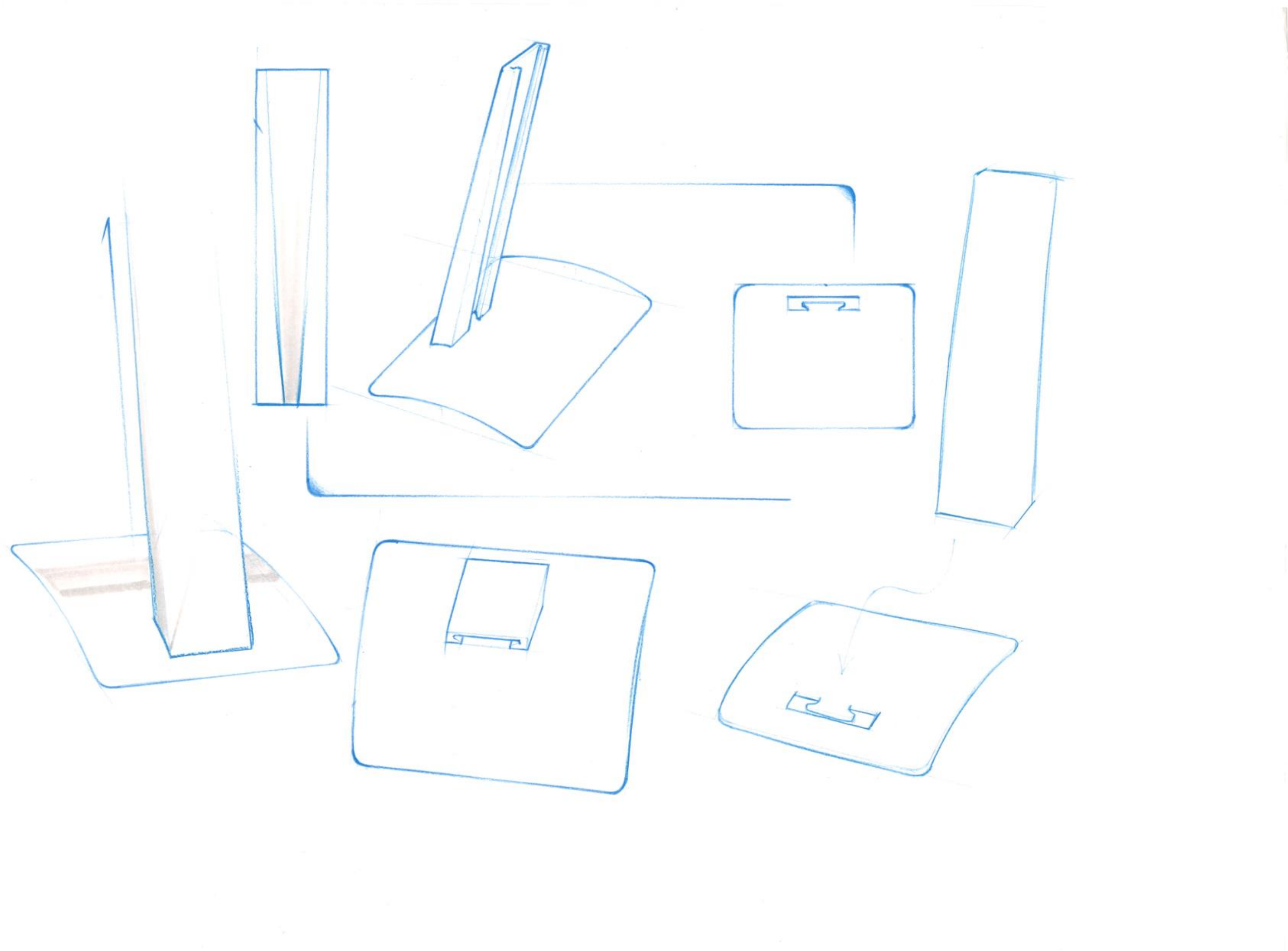
Appendix D

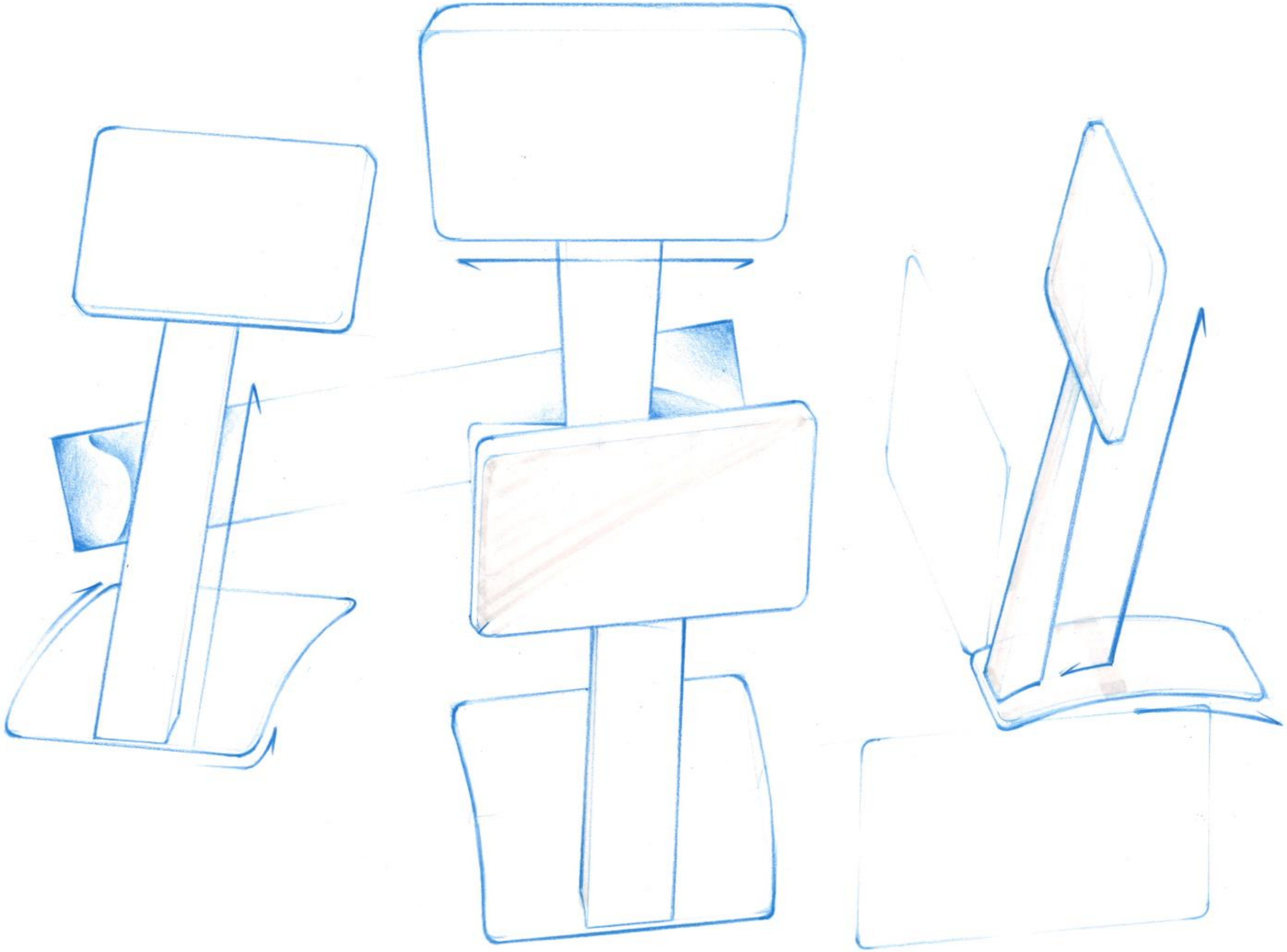
Sketches

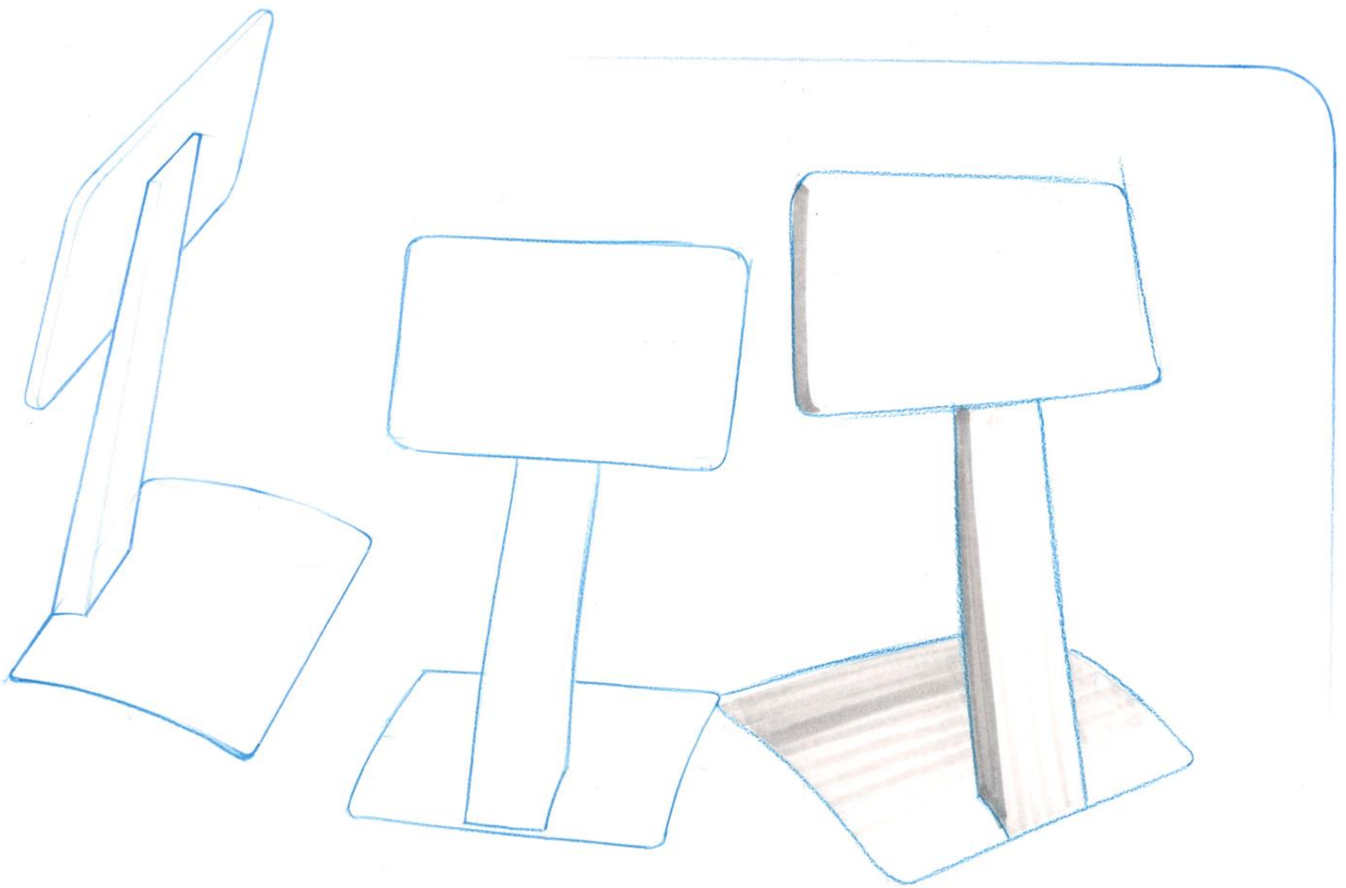


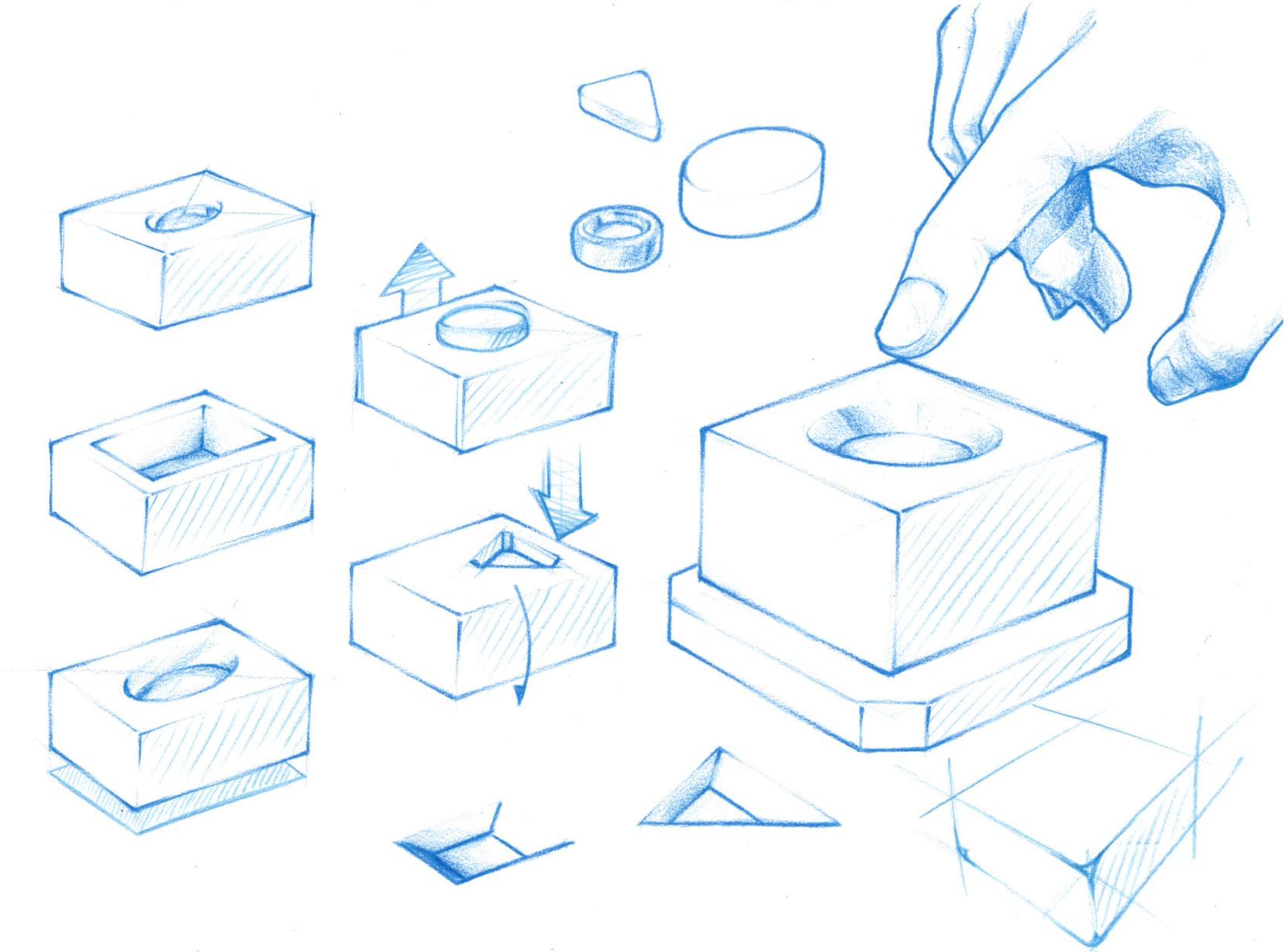

62.5°

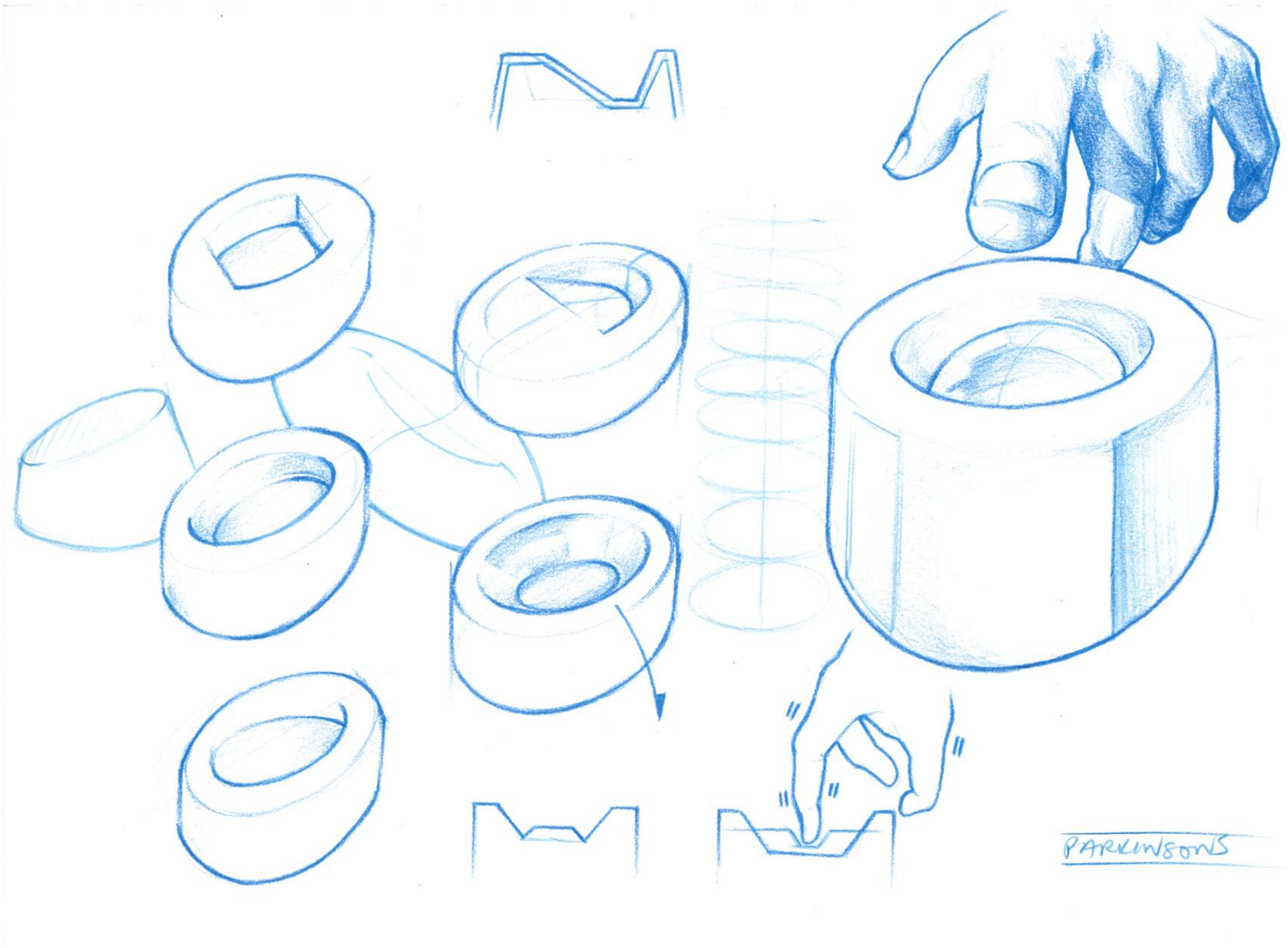

WALL
WALL
WALL

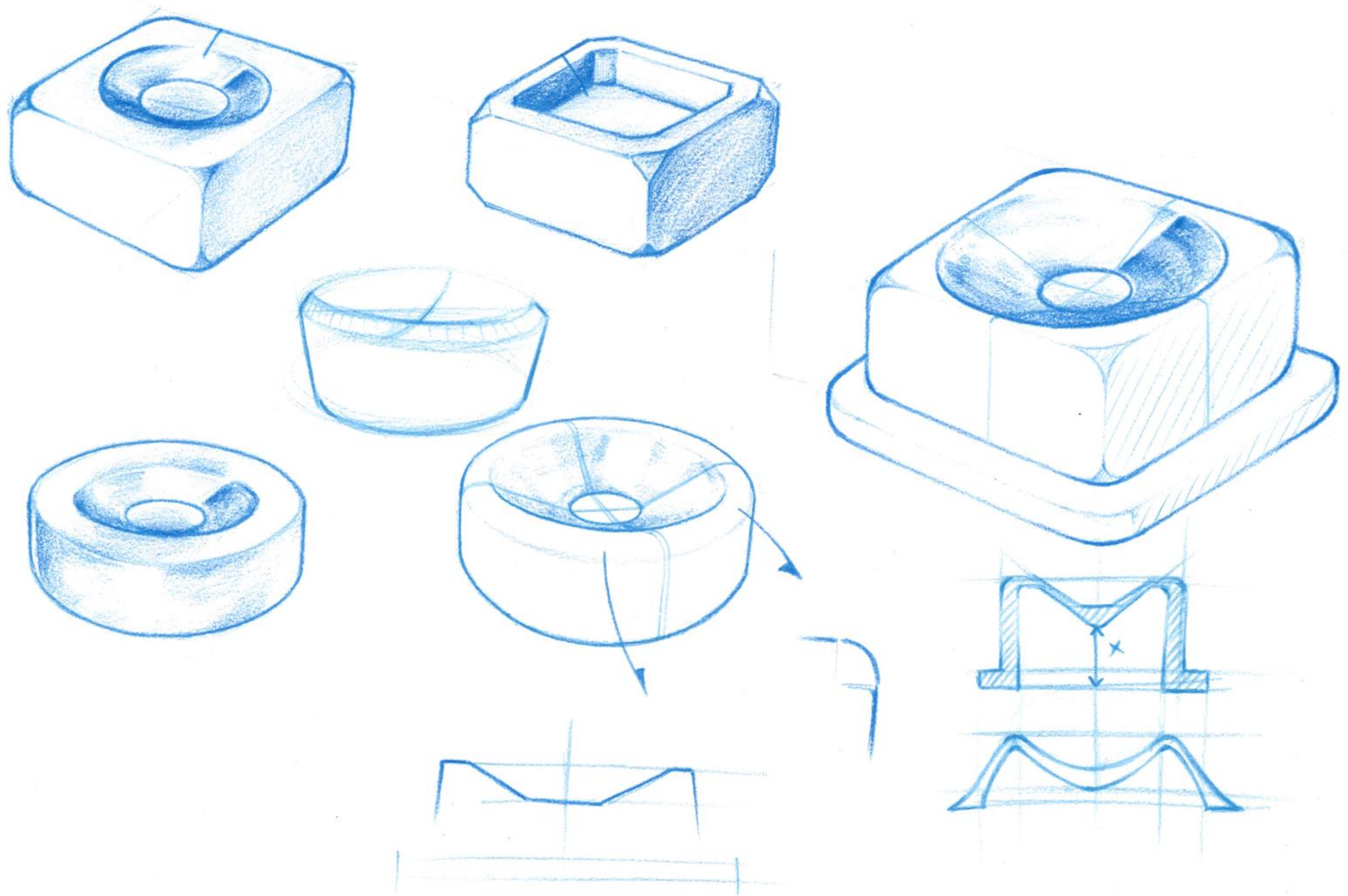




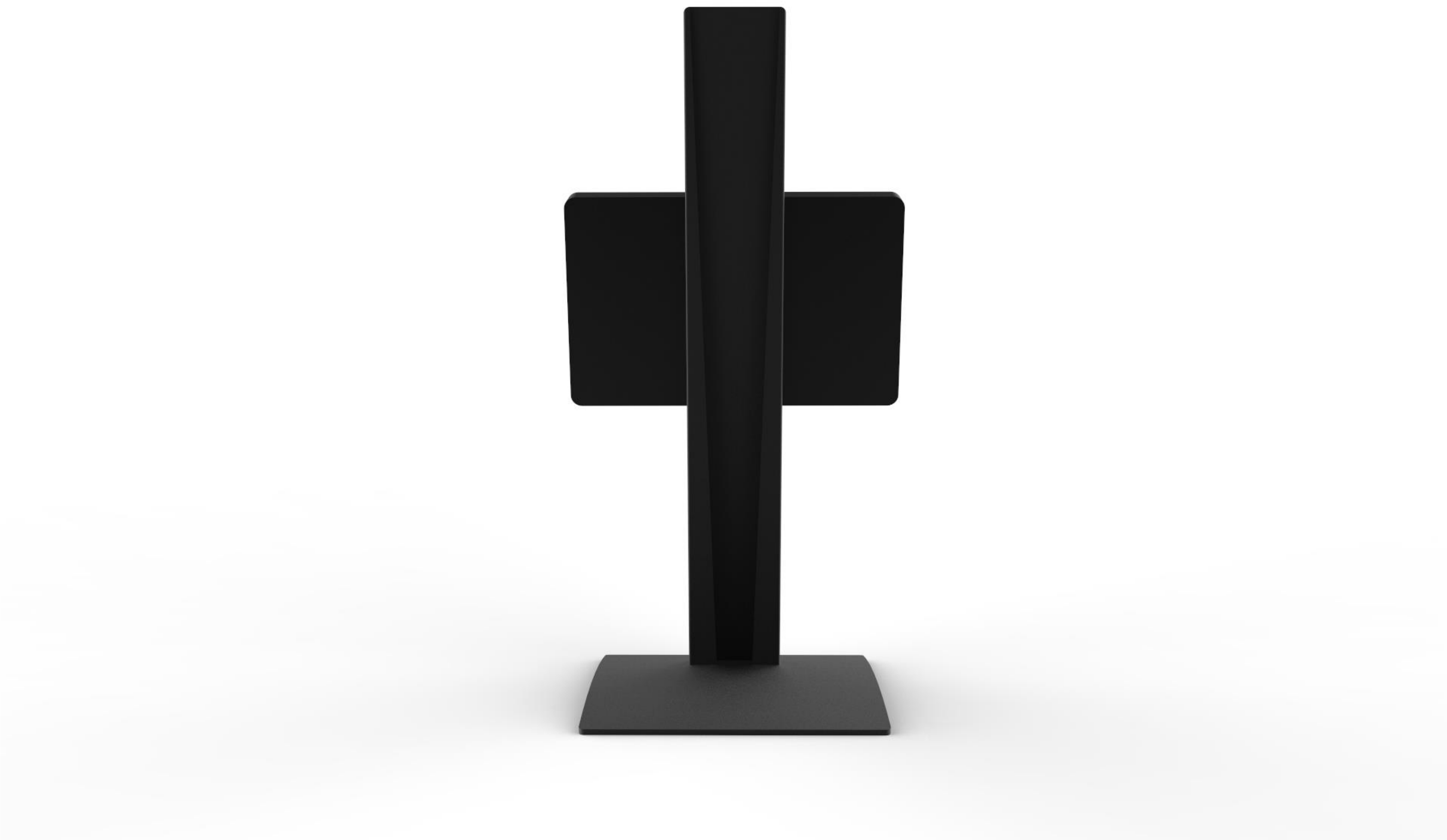


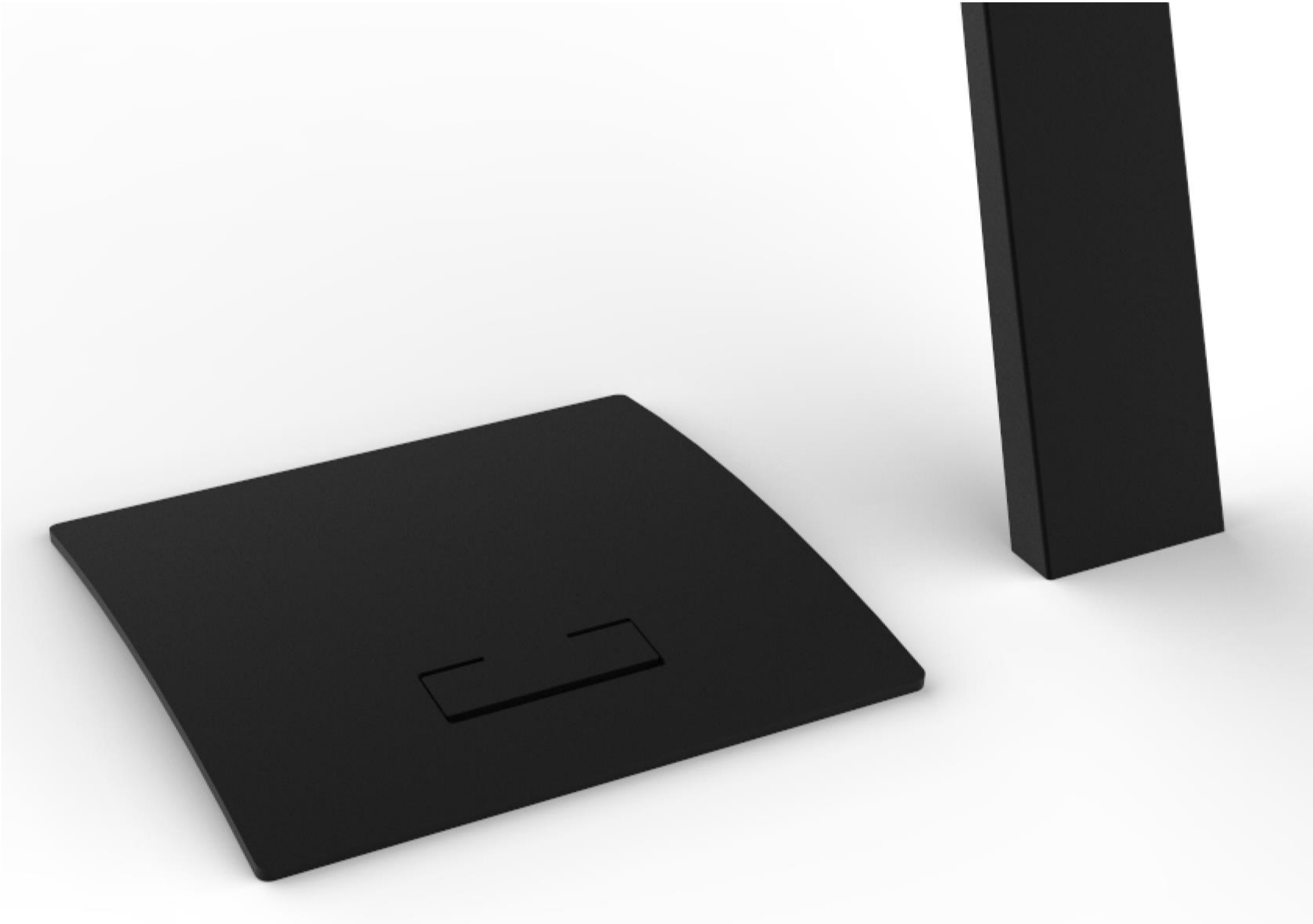


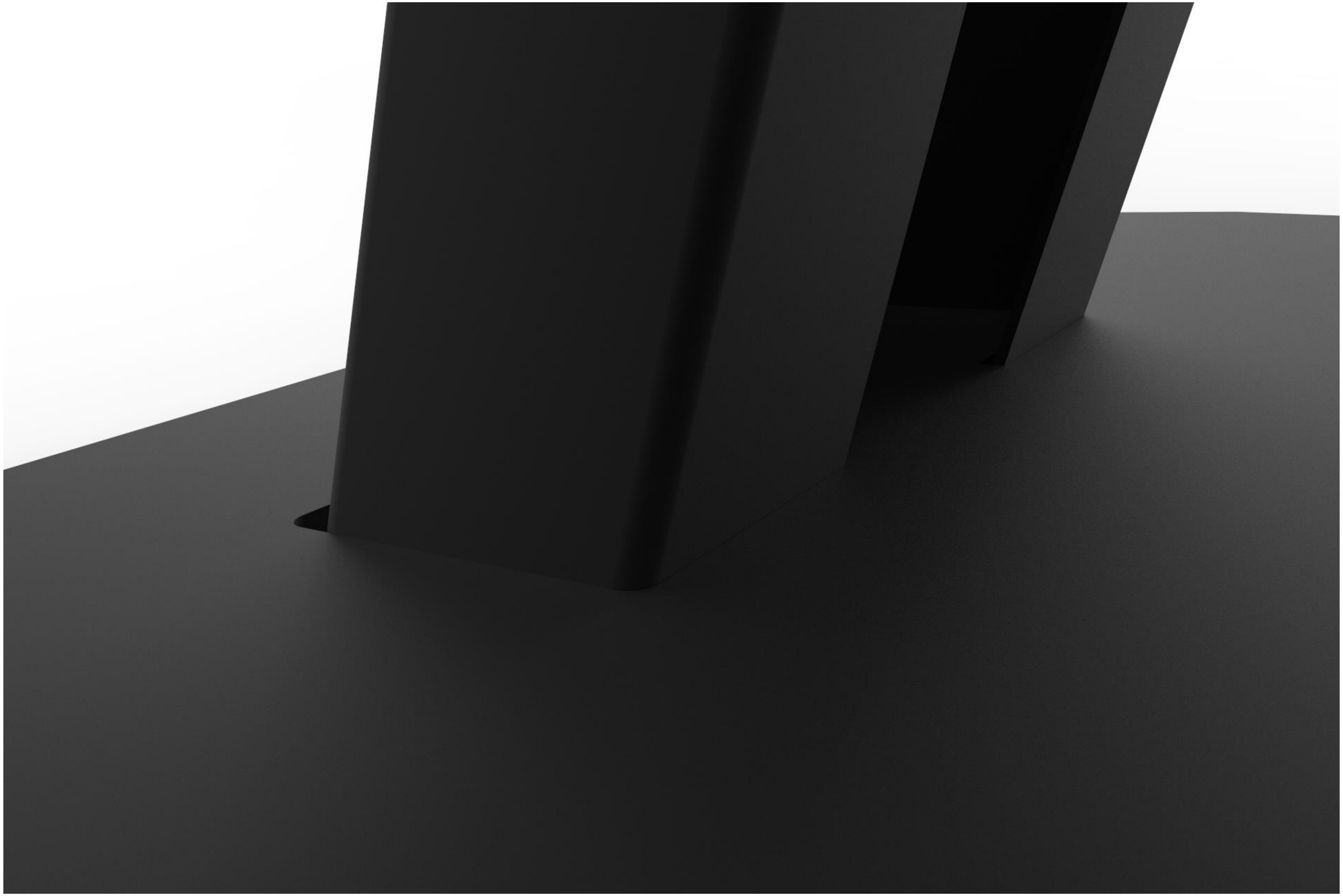

PARKINSONS



Multimedia System 3D Renders (final design)





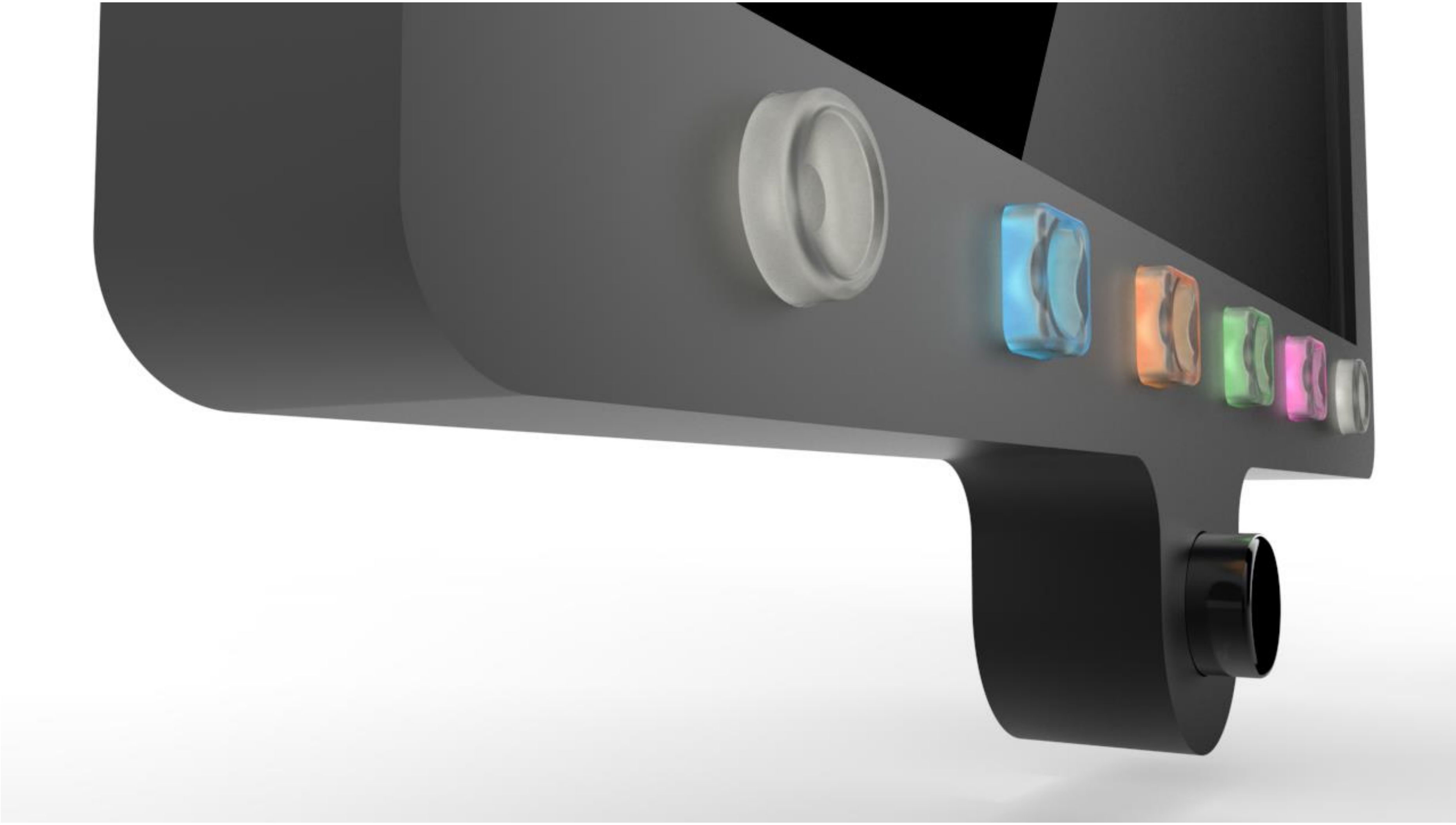


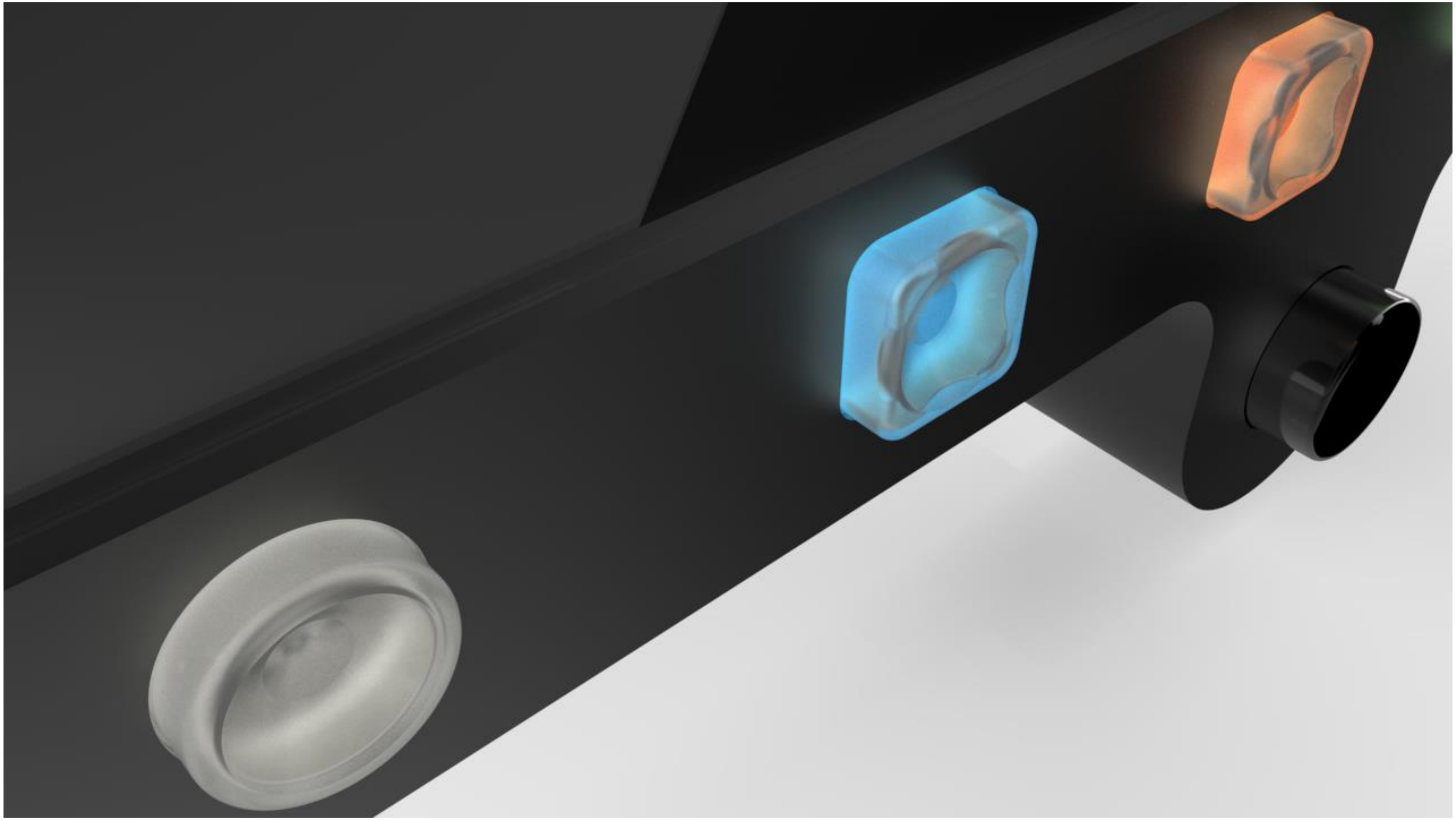

05.54 PM, Wednesday 13th September, 2017
My Family
My Movies
My Music
My Photographs

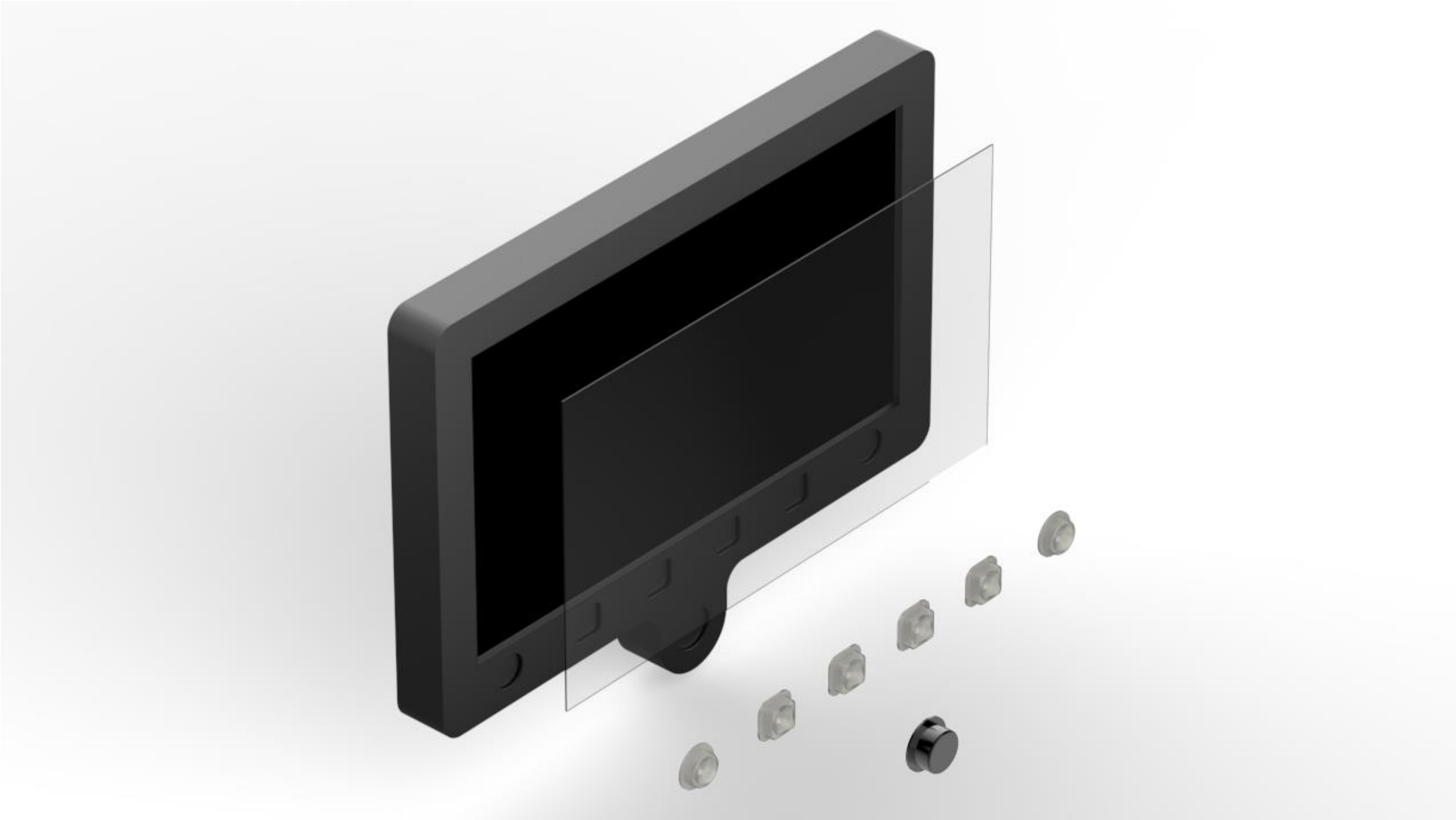

05.54 PM, Wednesday 13th September, 2017
My Family
My Movies
My Music
My Photographs

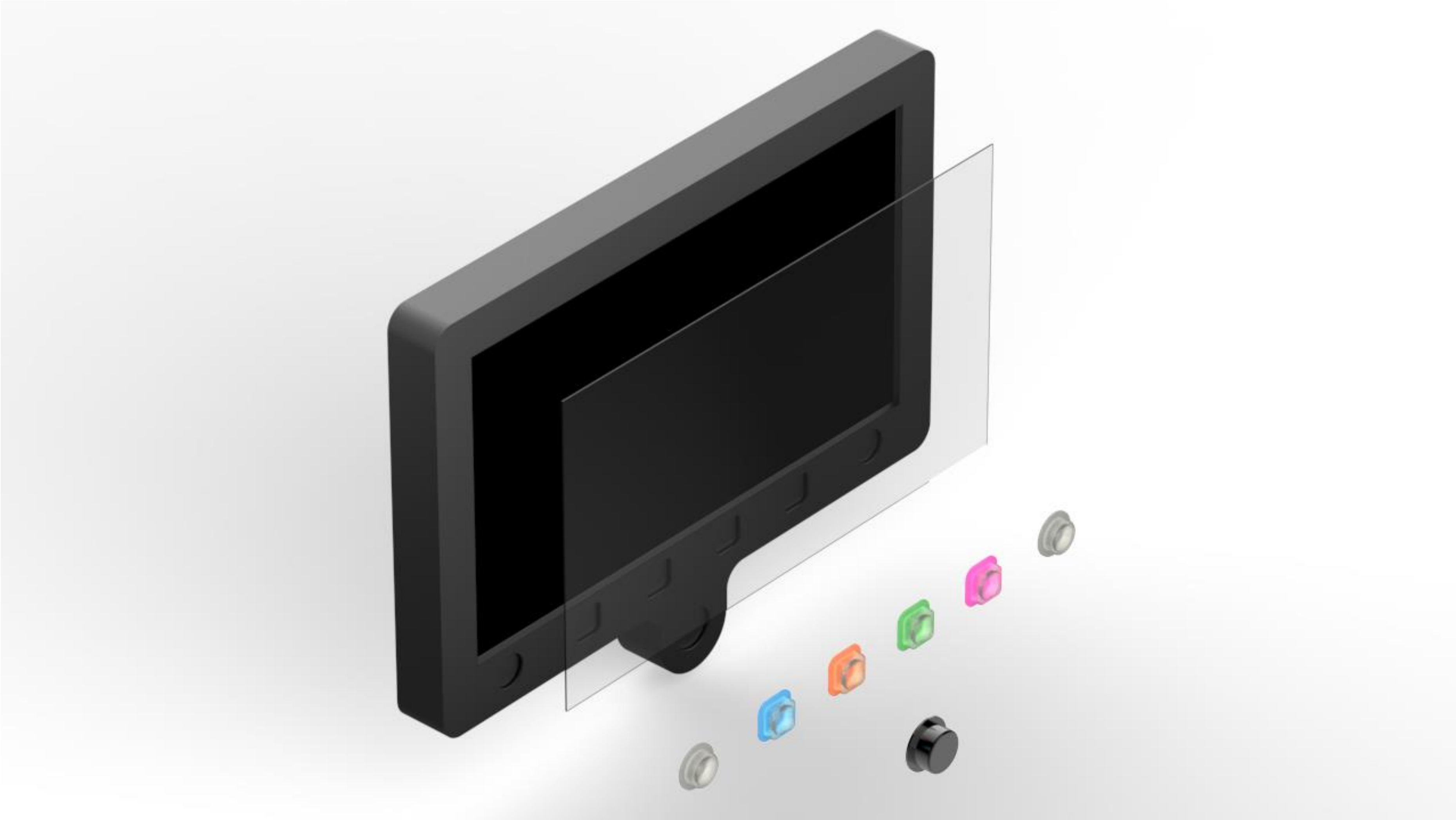

05.54 PM, Wednesday 13th September, 2017
My Family
My Movies
My Music
My Photographs


05.54 PM, Wednesday 13th September, 2017
My Family
My Movies
My Music
My Photographs









Multimedia System 3D Renders (initial concepts)

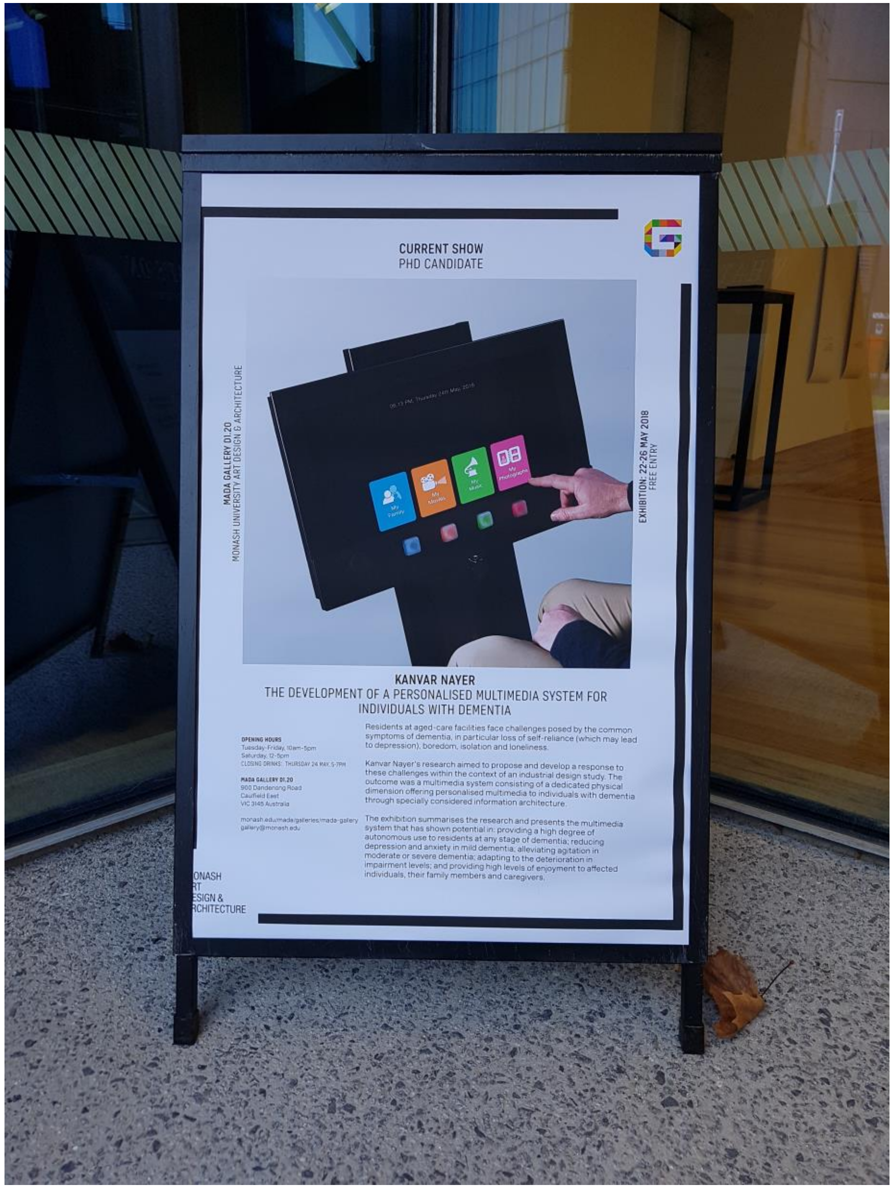

VIDEOS
MUSIC
PHOTOS
TALK


10:05AM, MONDAY 13 JANUARY, 2013
MUSIC
VIDEOS
PHOTOS
TALK

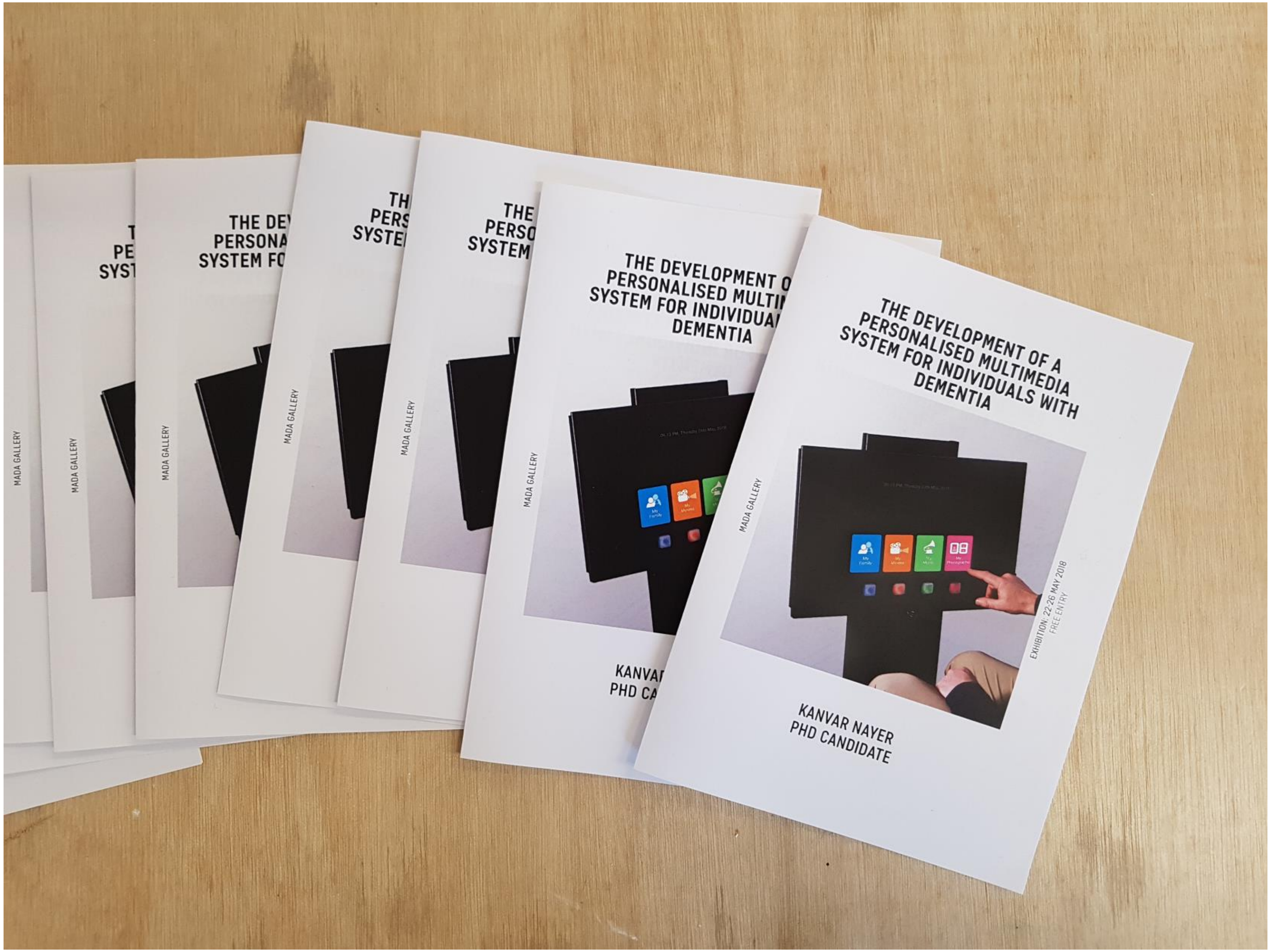

PAUSE
STOP

Appendix E

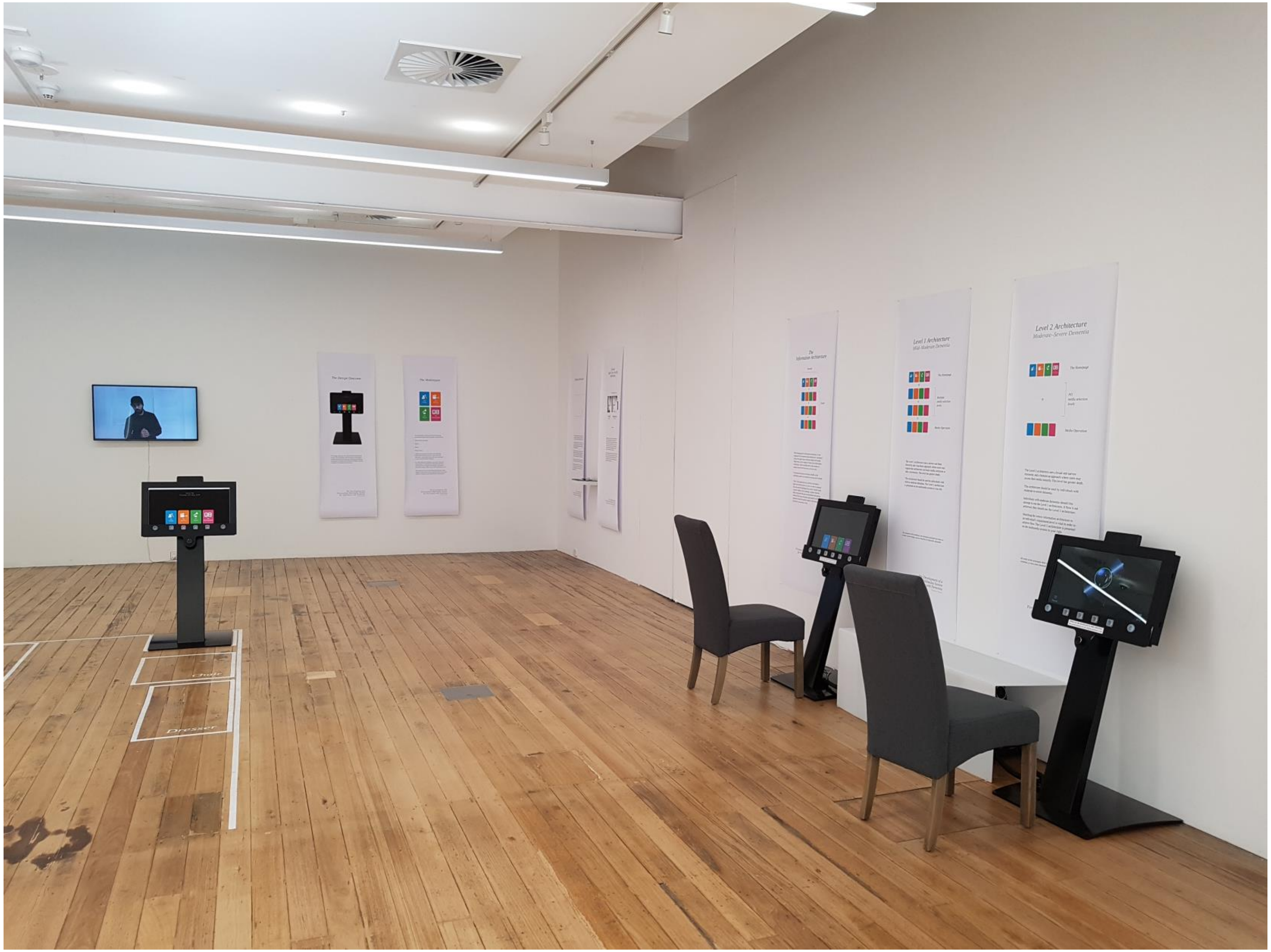
The Exhibition [22–26 May 2018, D1.20, Caulfield Campus, Monash University]



CURRENT SHOW
PHD CANDIDATE
MADA GALLERY G1.20
MONASH UNIVERSITY ART DESIGN & ARCHITECTURE
EXHIBITION: 22-26 MAY 2018
FREE ENTRY
KANVAR NAYER
THE DEVELOPMENT OF A PERSONALISED MULTIMEDIA SYSTEM FOR INDIVIDUALS WITH DEMENTIA
OPENING HOURS
Tuesday-Friday, 10am-5pm
Saturday, 12-5pm
CLOSING DRINKS: THURSDAY 24 MAY, 5-7PM
MADA GALLERY G1.20
900 Dandenong Road
Caulfield East
VIC 3145 Australia
monash.edu/mada/galleries/mada-gallery
gallery@monash.edu
Residents at aged-care facilities face challenges posed by the common symptoms of dementia, in particular loss of self-reliance (which may lead to depression), boredom, isolation and loneliness.
Kanvar Nayer's research aimed to propose and develop a response to these challenges within the context of an industrial design study. The outcome was a multimedia system consisting of a dedicated physical dimension offering personalised multimedia to individuals with dementia through specially considered information architecture.
The exhibition summarises the research and presents the multimedia system that has shown potential in: providing a high degree of autonomous use to residents at any stage of dementia; reducing depression and anxiety in mild dementia; alleviating agitation in moderate or severe dementia; adapting to the deterioration in impairment levels; and providing high levels of enjoyment to affected individuals, their family members and caregivers.

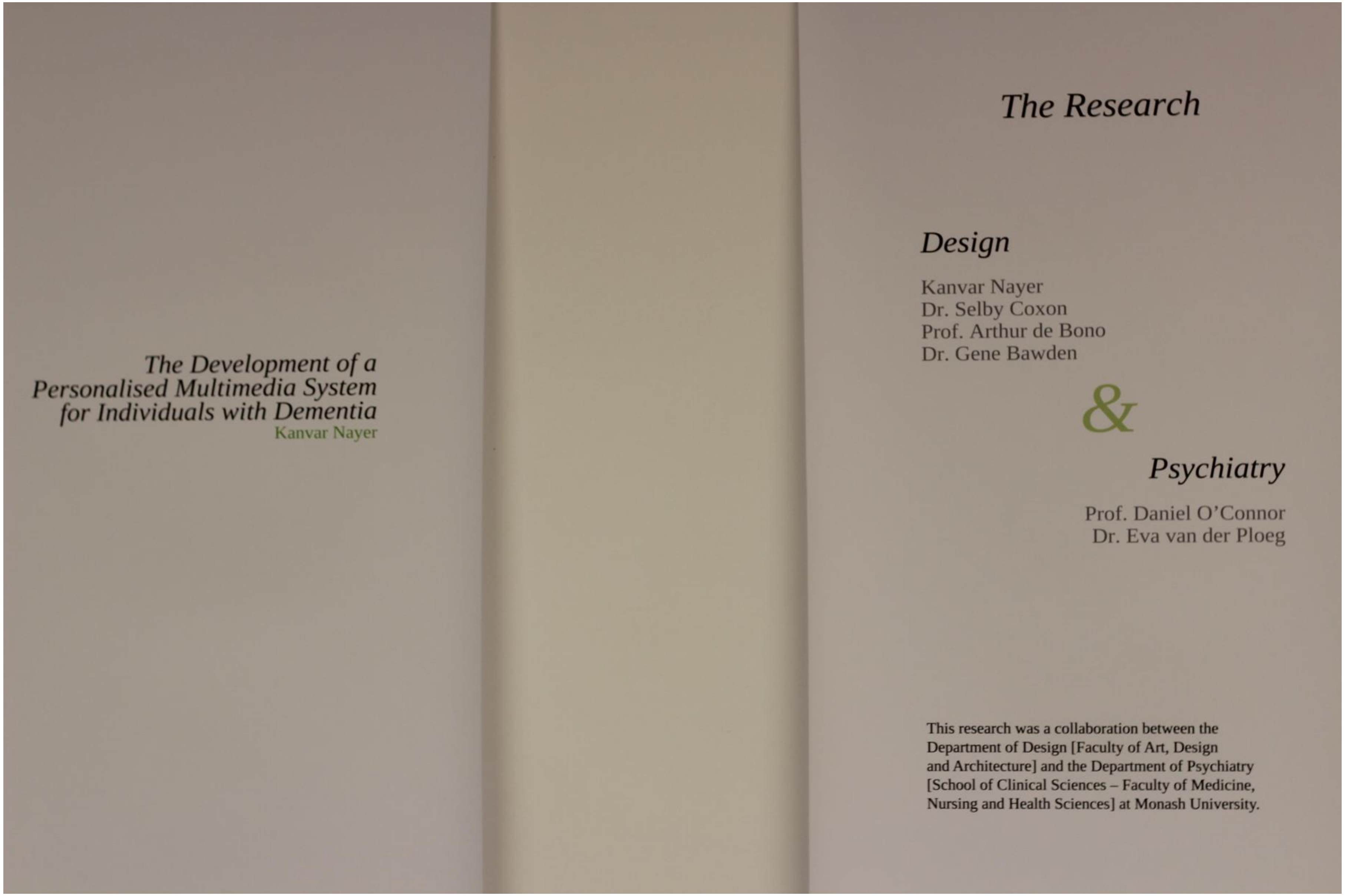

THE DEVELOPMENT OF A
PERSONALISED MULTIMEDIA
SYSTEM FOR INDIVIDUALS WITH
DEMENTIA
MADA GALLERY
EXHIBITION: 22-26 MAY 2018
FREE ENTRY
KANVAR NAYER
PHD CANDIDATE


Global Ageing
Dementia
Bed
Chair
Dresser
Wardrobe
An example of a Small Aged-Care Facility Bedroom



Level 1 Architecture
Level 2 Architecture
Moderate–Severe Dementia
Dresser


The Development of a
Personalised Multimedia System
for Individuals with Dementia
Kanvar Nayer
In memory of my grandparents
Dedicated to
the worldwide community
of people affected by dementia
The Research
Design
Kanvar Nayer
Dr. Selby Coxon
Prof. Arthur de Bono
Dr. Gene Bawden
&
Psychiatry
Prof. Daniel O'Connor
Dr. Eva van der Ploeg
Global Aging


The Development of a
Personalised Multimedia System
for Individuals with Dementia
Kanvar Nayer
The Research
Design
Kanvar Nayer
Dr. Selby Coxon
Prof. Arthur de Bono
Dr. Gene Bawden
&
Psychiatry
Prof. Daniel O'Connor
Dr. Eva van der Ploeg
This research was a collaboration between the
Department of Design [Faculty of Art, Design
and Architecture] and the Department of Psychiatry
[School of Clinical Sciences – Faculty of Medicine,
Nursing and Health Sciences] at Monash University.


Bed
Dresser
Wardrobe
An example of a Small Aged-Care Facility Bedroom


The Development of
a Personalised Multimedia System
for Individuals with Dementia
Kanvar Singh Nayer
Industrial Design PhD Candidate 2018
Faculty of Art, Design and Architecture Monash University


A Personalised Multimedia System
for Individuals with Dementia

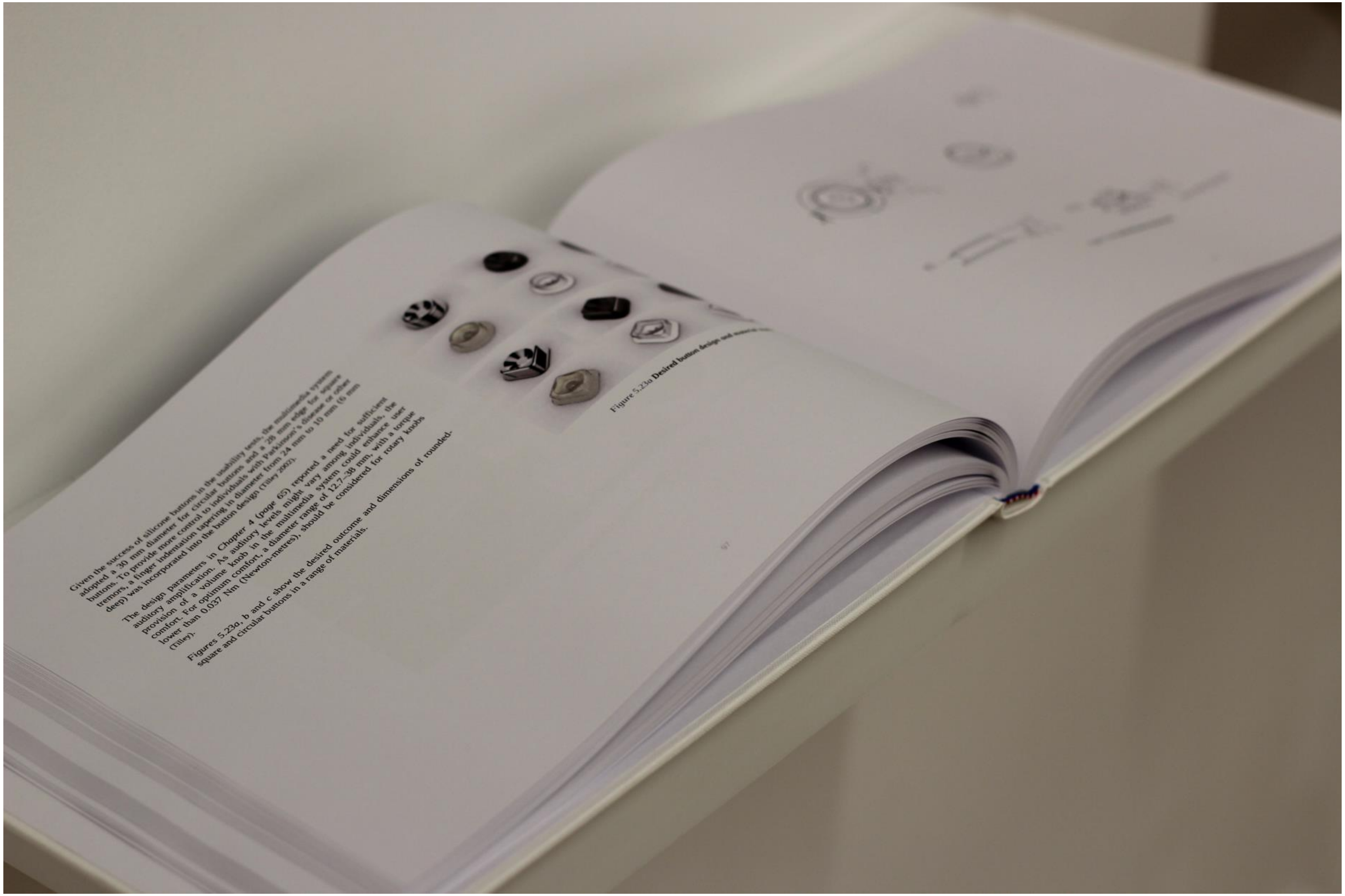
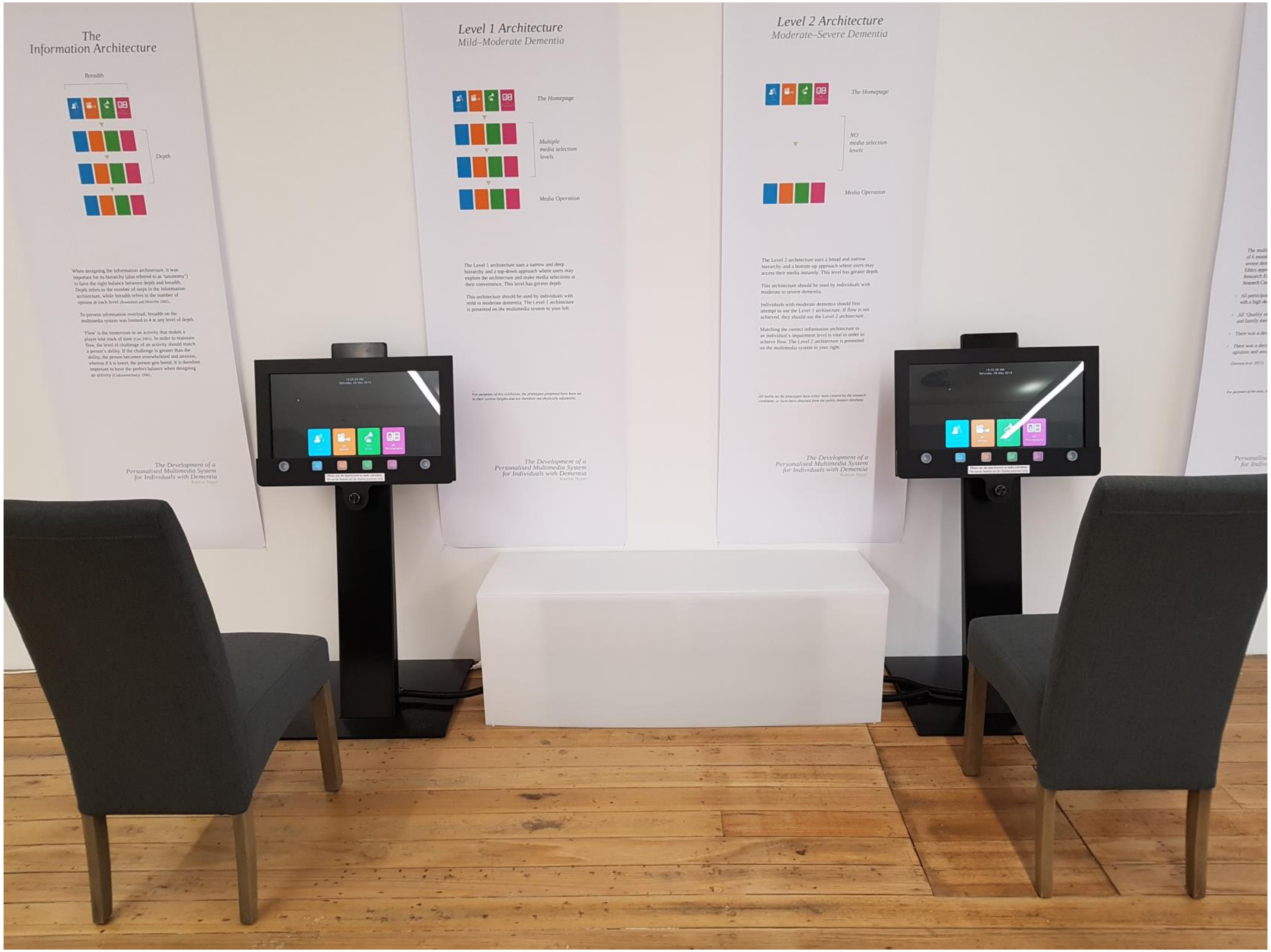
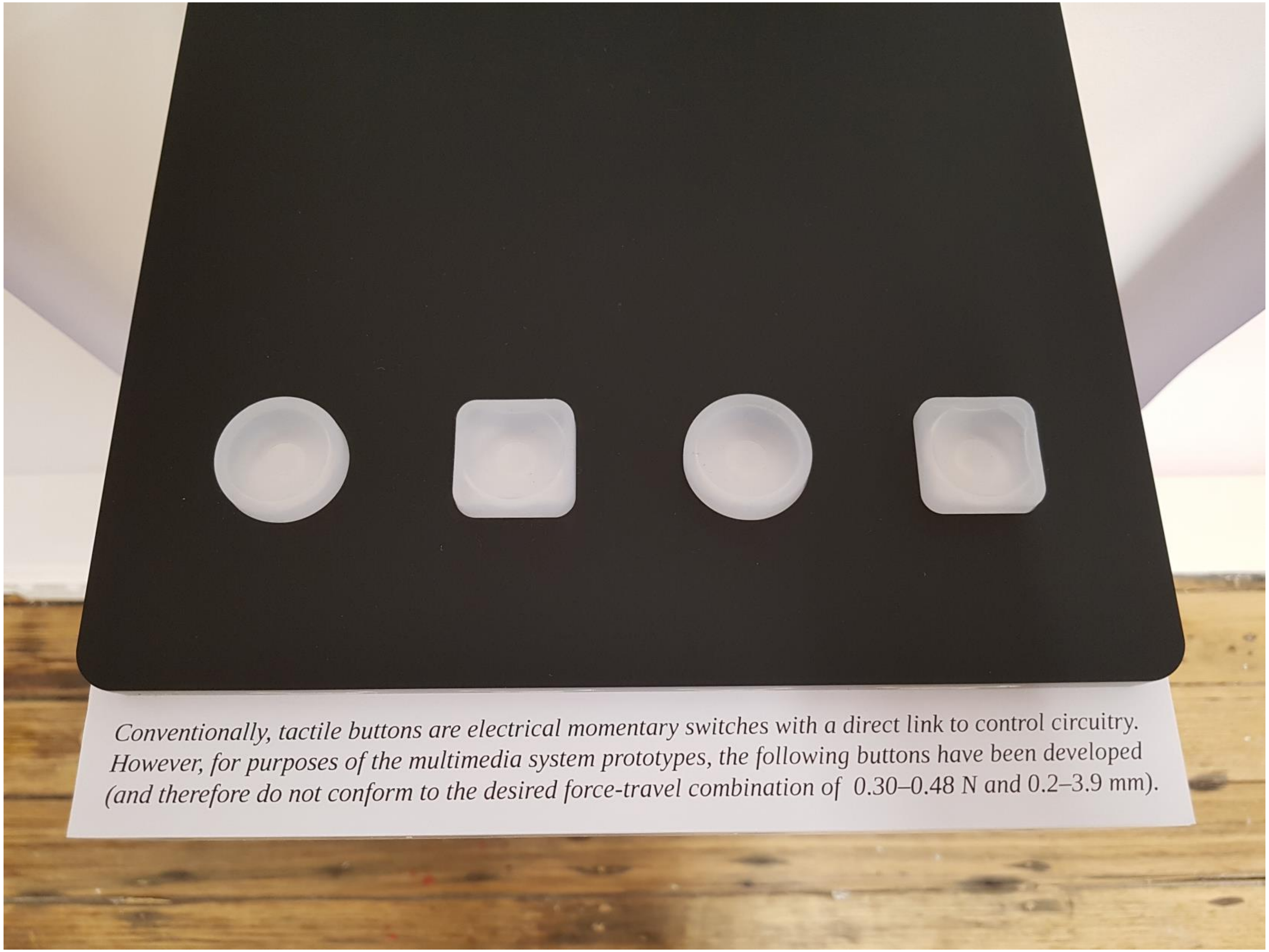


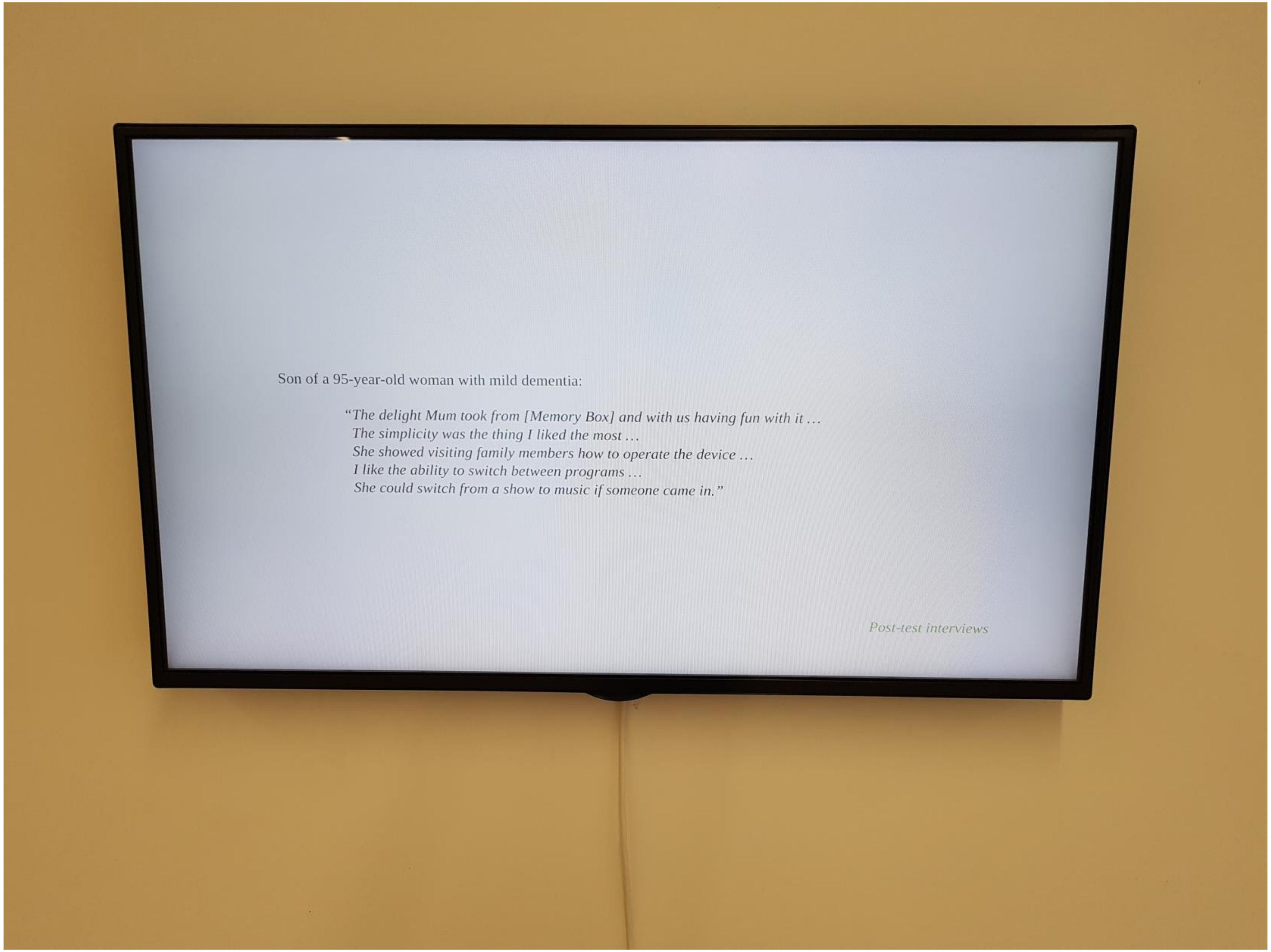
Figure 5.23a Desired button design and
Given the success of silicone buttons in the usability tests, the multimedia system adopted a 30 mm diameter for circular buttons and a 28 mm edge for square buttons. To provide more control to individuals with Parkinson's disease or other tremors, a finger indentation tapering in diameter from 24 mm to 10 mm (6 mm deep) was incorporated into the button design (Tilley 2002).
The design parameters in Chapter 4 (page 65) reported a need for sufficient auditory amplification. As auditory levels might vary among individuals, the provision of a volume knob in the multimedia system could enhance user comfort. For optimum comfort, a diameter range of 12.7–38 mm, with a torque lower than 0.037 Nm (Newton-metres), should be considered for rotary knobs (Tilley).
Figures 5.23a, b and c show the desired outcome and dimensions of rounded-square and circular buttons in a range of materials.


My
Family
My
Movies
My
Music
My
Photographs


5:00:03 PM
Thursday, 24 May 2018
My
Family
My
Movies
My
Music
My
Photographs
Please use the touchscreen to make selections.
The tactile buttons are for display purposes


The Information Architecture
Breadth
Depth
Level 1 Architecture
Mild–Moderate Dementia
The Homepage
Multiple media selection levels
Media Operation
Level 2 Architecture
Moderate–Severe Dementia
The Homepage
NO media selection levels
Media Operation
The Development of a Personalised Multimedia System for Individuals with Dementia


Conventionally, tactile buttons are electrical momentary switches with a direct link to control circuitry.
However, for purposes of the multimedia system prototypes, the following buttons have been developed
(and therefore do not conform to the desired force-travel combination of 0.30–0.48 N and 0.2–3.9 mm).


Son of a 95-year-old woman with mild dementia:
"The delight Mum took from [Memory Box] and with us having fun with it …
The simplicity was the thing I liked the most …
She showed visiting family members how to operate the device …
I like the ability to switch between programs …
She could switch from a show to music if someone came in."
Post-test interviews

Fin