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The need for designers who understand features of the interior environment that are important to persons with dementia (PwD) is increasing because of the growing number of diagnoses related to Alzheimer's disease and other forms of dementia. Research regarding the built environment and PwD often focuses on conditions that compensate for the declining cognitive abilities of occupants and users.

Many populations have demonstrated improved cognitive performance after interactions with nature, however systematic studies with PwD using natural elements in the context of the built environment and measures of cognition are few. This study explores the environment's potential to stabilize or improve cognitive function. It investigates the effects of natural elements – operationalized by live plants – on the cognitive responses of persons who have moderate to moderately severe dementia.

THE EFFECTS OF LIVING PLANTS ON COGNITIVE AND BEHAVIORAL  
RESPONSES OF PERSONS WITH DEMENTIA

by

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## CHAPTER I

### INTRODUCTION

The first priority of interior designers is to address the needs and desires of the end user -- “sound design solutions emerge from the context of human conditions; they cannot evolve without direct reference to the user” (Winkler, 2001, p. 1). This is especially true for persons with particular needs such as those diagnosed with forms of dementia that are characterized in part by a diminished ability to adapt to environmental stress. Therapeutic environments that compensate for deteriorating physical and cognitive competencies can have a positive effect on well-being and functionality (e.g., Marquardt & Schmieg, 2009). The growing body of knowledge regarding how the built environment affects persons with dementia (PwD) has resulted in increasingly effective designs that meet the needs of this vulnerable population (Brawley, 2006). However, existing research only has focused on how the environment can compensate for disabilities, rather than on the potential to stabilize or improve cognitive function. This is the challenge explored in this study.

There is some urgency to understand how to support PwD because of the increasing number of persons who have Alzheimer’s disease and other forms of dementia. The Alzheimer’s Association reports that the number of persons with Alzheimer’s disease (AD), the most prevalent form of dementia, is increasing (2014).



One in nine Americans over the age of 65 has AD, while for those over 85 the number is one in three. In 2014, 5.4 million Americans had AD and unless there are medical breakthroughs, the number is expected to grow to 13.8 million by 2050 (The Alzheimer's Association, 2014). This growth in the prevalence of AD and other forms of dementia greatly increases the number of facilities that will be needed to care for elderly persons. Elderly persons with AD are much more likely to need skilled nursing care than those without, and elderly persons without AD require 39 stays per 1000 people every year in a skilled nursing facility while those with AD require 349 (The Alzheimer's Association, 2014). Typical aging may compromise the ability to live independently due to diminishing strength, energy, reflexes, and sensory abilities but because elderly persons with dementia face these challenges in addition to memory loss, deteriorating problem solving abilities, disorientation, apraxia (the loss of the previously possessed ability to perform skilled and purposeful motor acts), and perception problems, it is not surprising that these persons will be more likely to require residential care (Winchip, 1990). The length of the illness also will affect the number of facilities needed. It is possible to live with the diagnosis for 20 years (The Alzheimer's Association, 2014).

The understanding that PwD require specialized environments did not occur until the 1970's (Calkins, 2012). Previous to that time, PwD were placed in psychiatric asylums until the community mental health system was established in the 1950's as an alternative to residential psychiatric care for all but a small percentage of persons. At this point, PwD who required residential care were transitioned to skilled nursing facilities.

Those facilities did not incorporate what we now know are the crucial guidelines for dementia care design – that the built environment should support the diminished ability to navigate, allow flexibility in managing the activities of daily living, include personalization in private spaces, encourage social interaction, and ensure safety (Calkins, 2012). These guidelines were articulated by M. Powell Lawton in the 1970's and have been validated repeatedly with empirical studies (Calkins, 2003). Nonetheless, it was many years before the majority of memory care facilities instituted these guidelines and moved away from the medical institutional model which compromised individuality and choice in favor of greater efficiency (Calkins, 2003). Lawton's guidelines and the growing body of knowledge regarding the effects of the built environment on PwD inspired a significant change in both the approach to care and the design of facilities when a cultural shift in skilled nursing care began in the 1990's. Implementing person centered care, empowering staff, and providing home-like environments were the goals of the movement (Brownie, 2011).

One of the most dramatic developments was the inclusion of safe garden spaces and allowing residents free access to them (Bossen, 2010). This was in response to studies that demonstrated multiple benefits, such as a decline in depression and agitated behavior and an improvement in social engagement for PwD, when residents spent time in natural settings (Detweiler, Murphy, & Meyers, 2008; Brooker, Woolley, & Lee, 2007). The reason that natural settings have such a positive effect on PwD may be explained by biophilia, a theory developed by Edward O. Wilson (Kellert & Wilson,

1993). He believed that humans are biologically programmed to live in natural environmental conditions and therefore enjoy physical, psychological, and cognitive benefits from interacting with nature. This theory has been reinforced by the work of Roger Ulrich with Psycho-evolutionary Theory which has demonstrated how exposure to natural elements improves physical health (Ulrich et al., 2008 and Kellert et al., 2008) and by the work of Stephen and Rachel Kaplan whose Attention Restoration Theory (ART) demonstrates how nature can improve cognitive function (Kaplan, Berman, & Jonides, 2008 and Lee & Kim, 2008). Collectively, the work of Wilson, Ulrich, Kellert, and the Kaplans indicate that human beings benefit from natural conditions, that the built environment may be manipulated to support those benefits, and that mental efficiency improves with direct connections with nature.

This study investigated the effects of natural elements – operationalized by live plants – on the cognitive and behavioral responses of persons who have moderate to moderately severe dementia. The expectation was that the presence of the plants in the day to day environment of PwD would improve their cognitive and behavioral responses.

## CHAPTER II

### REVIEW OF THE LITERATURE

A designer cannot address the needs and desires of the end users without understanding them, but Alzheimer's disease and other dementias make it difficult for persons who have the illness to communicate what they need or desire. Therefore, designers who want to create spaces for persons with dementia (PwD) need to understand the effects of the disease. They should also learn what others have discovered about appropriate environments for PwD through formal research or experience with this population.

#### **Characteristics of Persons with Alzheimer's Disease**

Dementia is a decline in cognitive ability affecting memory, language, visual-spatial skills, emotion and personality (Bolla, Filley, & Palmer, 2000). Four illnesses responsible for 90% of all dementia are Alzheimer's disease, diffuse Lewy body dementia, frontotemporal dementia, and vascular dementia. The most frequently diagnosed form of dementia is Alzheimer's Disease, which is commonly described in these seven stages (Reisberg & Franssen, 1999):

Stage one is normal functioning.

Stage two is *normal aged forgetfulness*. This is characterized by the typical subjective complaints of problems with word retrieval, concentration, and misplacing items reported by many individuals over the age of 65.

Stage three is characterized by *mild cognitive impairment* that only those close to the individual would observe. The subtle deficits may be seen when the individual is unable to learn new skills, repeats questions, and has problems with organization and executive functioning. The true length of this stage is thought to be around seven years, but by the time it is reported the next phase may occur in two to three years.

Stage four is *mild Alzheimer's disease*. Signs of cognitive deficits would include the inability to handle finances, prepare meals, or recall recent events. The individual may seem withdrawn and emotionally unresponsive. This is thought to be because one is attempting to hide cognitive deficits both from others and oneself. Independent living is still possible with community support. This stage lasts approximately two years.

Stage five is *moderate Alzheimer's disease*, and independent living is no longer possible. The inability to choose appropriate clothing is an obvious characteristic of this stage. Memory for both the present and the past are severely compromised. Home addresses, schools attended, name of the current president, or the date of the current year are examples of things that may not be recalled. Behavior problems may surface involving anger and paranoia. The mean duration of this stage is 1.5 years.

Stage six is *moderately severe Alzheimer's disease*. Individuals will require assistance with activities of daily living (ADLs) such as dressing, bathing and toileting. Incontinence becomes a problem. For a time it can be handled by frequent toileting, but

eventually other strategies become necessary. Cognitive deficits increase so that the individual may not remember a previous occupation, where he or she was born, or the current season. They still may know their own names, but confuse the names of family members. Behavior issues become problematic. They can no longer focus on productive activities and frequently fidget and pace. A fear of being left alone develops. Violent behavior and verbal tantrums may occur. Speech begins to deteriorate. They may wander and become lost. The mean duration of this stage is 2.3 years.

Stage seven is *severe Alzheimer's disease*. Individuals need constant assistance with ADLs. Speech is reduced to a few dozen words at the beginning of this stage and continues to decline until there is no language at all. The ability to ambulate independently disappears when language is gone and sitting up independently sometime after. The next loss is the ability to smile. Physical rigidity appears and worsens until there is little range of motion. This seems to be a precursor to contractures, which are deformities which prevent the range of motion of joints. The sucking reflex and infantile Babinski reflex (the toes fan out when the sole of the foot is stroked) return. It is possible for this stage to last up to eight years. Pneumonia, related to inactivity and weakened physical stamina, is the most common cause of death.

Persons with Alzheimer's disease have challenges that other residents of skilled nursing facilities do not. The decline in cognitive abilities also means a decline of coping skills which often causes residents to perceive normal stimulation as over-stimulation (Brawley, 2006). This can produce anxiety and inappropriate behavior. These persons withdraw from social interactions, communication skills disappear, and restless behavior

and the tendency to wander into unsafe situations are common. Way-finding is difficult. Even when they have the physical ability to dress and toilet independently, cognitive impairment makes assistance with these tasks necessary. In addition, PwD also suffer the normal challenges of old-age: chronic pain and declining vision, hearing, and ambulatory skills (Brawley, 2006). The institutional model of skilled nursing that dominated long-term care until the end of the 20<sup>th</sup> century was unsuccessful in meeting their needs.

### **Changes in Dementia Care**

The lack of research about dementia prior to the 1970's helps explain why the institutional model failed to meet the needs of PwD. Historically PwD were placed in psychiatric asylums and the focus was on efficiency of care (Calkins, 2012). When the community mental health system was established in the 1950's as an alternative to residential psychiatric care, many of these asylums were either closed or downsized. PwD were moved to skilled nursing facilities which replicated systems that had been used in the asylums. To illustrate, consider that the focus of skilled nursing facility floor plans was typically a central nursing station where staff would gather and passively observe residents (Calkins, 2012). From this location staff had sightlines to multiple identical corridors which provided access to residents' shared bedrooms. Large sitting and dining rooms were needed to accommodate 60 residents, the number determined to "maximize staffing efficiency" (Calkins, 2003). Inefficient measures, such as access to the outdoors or interior gardens, were rare.

Recent studies have demonstrated why this type of layout was problematic. Findings tell us that long repetitive corridors, or any repetitive spatial situations and

places, make way-finding difficult for PwD (Orsega & Smith, 2000), that persons in shared bedrooms have poorer outcomes in both physical and behavioral measures (Calkins & Cassella, 2007), and that large, noisy dining rooms provide too much stimulation, not enough privacy, and increase agitation and confusion (Hung & Chaudhury, 2011).

Dr. William Thomas pioneered reform in the design and function of nursing homes with the Eden Alternative movement (Thomas, 1994). He expressed his feelings about the inadequacies of nursing care by asking “would you (or your loved ones) rather be placed in a home that resembles an institution such as a state penitentiary or one that resembles the Garden of Eden?” (Thomas, 1994, p. 2). With the movement he planned to eliminate the institutional model. “Like the leper colony, the tuberculosis sanitarium and insane asylum, the nursing home is about to be heaved onto the ash heap of history” (p. 2). He felt that the typical long-term care facility caused most residents to feel loneliness, boredom and helplessness. He envisioned skilled nursing facilities becoming places where the residents felt at home and in control, family members were comfortable visiting and staff enjoyed working in the facilities. In his view, the existing model could not be fixed; it needed a complete transformation. Thomas first employed his new approach at Chase Memorial Nursing Home in New Berlin, New York and found significant reductions in staff turnover and residents' longevity, frequency of infections, and use of medications (Thomas, 1994).

While the Eden Alternative movement continued to grow and then expanded into Europe, Japan, and Australia, most of what had been accomplished involved changes in



caregiving, staffing, and increased sensitivity to the needs of the residents and their families – all within extant physical conditions of the built environment (Bergman-Evans, 2004). Because conditions of the interior environment affect the ways occupants and inhabitants function in the space, rethinking the built environment in order to de-institutionalize long term nursing care was necessary.

To further implement his philosophy, Thomas created the Greenhouse model, “a self-contained, purpose-built residence for 10 or fewer residents needing a nursing-home level of care” (Sharkey, Hudak, Horn, James, & Howes, 2011). The buildings resemble single family homes and are designed to blend architecturally with other buildings in their geographical locations. Sometimes they are a part of a larger medical campus, while others are placed in residential neighborhoods. In addition to looking like a home, these facilities also function much more like a home than the typical skilled nursing facility. The small size enables one of the most important aspects of the Greenhouse Model: promoting close, personal relationships between residents and staff. It is an environment more conducive for allowing residents access to what Thomas considered essential: “the company of animals, the laughter of children and the growth of green plants” (Thomas, 2003, p. 4). Windows with garden views, a contained garden which allows for independent and safe wandering, and indoor plants are included in the design. In the Greenhouse model, the normalcy of a home is promoted wherever possible.

The culture change in skilled nursing care inspired by the Eden Alternative and the Greenhouse model has had a significant impact on the quality of life for PwD. Studies tracking changes in resident outcomes when Eden Alternative directives were employed

showed improvements in various measures of quality of life (Steine, Eppelheimer, & DeVries, 2004). Reduced infection rates of residents indicate an improvement in physical health. A documented decline in the use of mood-altering medications, reports of increased levels of sociability, and decreased feelings of boredom and helplessness all indicate psychological benefits for PwD. Staff retention rates also improved which fosters Thomas' goal of close personal relationships between residents and staff (Brownie, 2011).

As a consequence of approaches such as these, memory care facilities evolved from an institutional model whose primary function was to keep residents physically safe into present designs that strive to create home-like, person-centered environments that focus on maintaining a high quality of life (Brawley, 2006). One means of doing this has been to provide access to nature through physical access to outdoor gardens, visual access through windows, and the inclusion of natural elements in interior environments (Brawley, 2006).

A condition common to new models of caregiving and physical space is the presence of our naturally occurring environment. The philosophies of both the Eden Alternative and the Greenhouse model stress the importance of natural elements (Brownie, 2011) and both have demonstrated success in improving the quality of life of PwD. This provided motivation for exploring the empirical evidence of the effects of natural effects on all humans, and specifically on PwD.

## **Biophilia, Psycho-evolutionary Theory, and Attention Restoration Theory**

Erich Fromm, a philosopher and social psychologist, first used the word “biophilia” to describe an affinity to life and growth (Fromm, 1973). The biologist Edward O. Wilson expounded on Fromm's idea and proposed that humans have an innate emotional affiliation for life and life-like processes (Kellert & Wilson, 1993). Wilson suggests that our evolutionary biology predisposes us to be attracted to biological elements that, in the past, helped us to survive. For instance, a flowering tree indicates that it will soon produce fruit. A positive reaction to flowers, which would signal a potential food source, would be an adaptive benefit. In a matter of a thousand years we humans have changed the way we live and now this innate connection to nature is not required in order to survive. But Wilson believed that our emotional connection to nature was not erased in so short a time and that humans still benefit from connections to natural elements. His belief is supported by studies that show how diverse groups of Europeans, North Americans, and Asians prefer natural landscape scenes over urban or built environments (Ulrich et al., 2008). The concept of biophilia is supported by at least two theories, Psycho-evolutionary (Ulrich et al., 2008) and Attention Restoration (Kaplan & Berman, 2008), and there is considerable empirical evidence for both.

Being in contact with nature in many forms has a restorative effect that promotes psychological well-being according to Psycho-evolutionary Theory, and also improves cognitive performance according to Attention Restoration Theory. Restoration, defined as the process of recovery from a depleted psychological, physiological or social resource

(Raanaas, Patil, & Hartig, 2011), is the key element in both theories although the depleted resource is different for each.

In Psycho-evolutionary Theory (PET) the depleted resource is physiological. This was proposed by Roger Ulrich who, like Wilson, suggests that humans are biologically programmed to live in a natural environment and living in a man-made environment devoid of natural elements creates stress. He sees stress as the process by which “an individual responds psychologically, physiologically, and often with behaviors, to a situation that challenges or threatens well-being” (Ulrich et al., 2008, p.3) . The physiological response to stress which allows us to cope with challenging events can deplete energy and cause fatigue. Many studies have supported this premise. For example, in a study comparing patients who had gall bladder surgery, patients with views of nature had shorter hospital stays and took fewer analgesics than their counterparts whose only view out a window was of a brick wall (Ulrich, 1984). In another study, 120 subjects watched a stressful movie and then viewed video tapes with colors and sounds of either natural or urban settings (Ulrich et al., 1991). Measurements of the participants' physiological responses and self-rated responses indicated that recovery from the stress of the movie was faster and more complete when subjects were exposed to natural rather than urban environments.

The ability to focus attention is the depleted resource in Attention Restoration Theory (ART). ART identifies two types of attention, involuntary and directed (Kaplan & Berman, 2010). Involuntary attention is triggered by a compelling stimulus such as a sounding alarm clock or the sudden appearance of a rainbow. The stimulus can be either

negative or positive. Voluntary, or directed, attention is managed using cognitive-control processes and is characterized by suppression of distracting stimuli. Imagine a child working on homework while siblings are playing a game in the same room. In order to complete the work, a child will use energy to direct attention to the task and also ignore the more appealing activity. The child would not be capable of redirecting attention indefinitely because this takes a sustained effort that eventually will deplete cognitive energy. But according to ART, directed attention can be improved, or restored, by interacting with nature.

Researchers at the University of Michigan did a two part study to test the effects of ART (Kaplan, Berman, & Jonides, 2008). In the first part, researchers began by testing student participants with PANAS (The Positive and Negative Affect Schedule), a psychological test to measure mood. Next, the participants took a memory test which involved repeating a sequence of numbers in reverse order and followed that with a directed forgetting test. Half of the participants were instructed to take a 50 minute walk on city sidewalks in a high-traffic area and the other half walked for 50 minutes in a secluded park. Researchers repeated the PANAS and memory tests with the participants immediately after the walks were completed. The participants repeated this process the following week, but reversed their walk locations. The results of the test showed a consistent improvement in memory test scores and elevated mood states after taking the walk in the park. The procedure of the second part of the test was identical to the first except the walking activity was replaced by 10 minutes of viewing either nature or urban scenes and rating their enjoyment of the images. Higher memory test scores were

produced after viewing nature scenes than viewing urban scenes, but no change in mood states was evident. The researchers concluded that even a modest or indirect connection to nature, such as looking at photographic images of outdoor scenes, can have a positive effect on cognitive function.

Psycho-evolutionary Theory and agitated behavior in PwD has been researched extensively. Agitated behavior takes a great toll on both the persons experiencing it as well as the persons who care for them; therefore, it is not surprising that finding treatments for agitated behavior is a priority for research. Agitated behavior is not a condition but rather a symptom of unmet needs which manifests as repetitive questioning, wandering, and verbal and physical aggression (Dewing, 2010). Many studies have demonstrated that PwD experience a decrease in agitation after increased use of outdoor spaces (Cohen-Mansfield & Werner, 1998; Connell, Sanford, March, & Lewis, 2007; Detweiler et al., 2008) which offers support for Wilson's assertions about our innate attraction to nature.

Studies also have demonstrated that PwD benefit from connecting to nature in other ways as well. Researchers at the University of Southern Indiana conducted a qualitative study regarding the effects of time spent in a garden on residents of a skilled nursing facility (Raske, 2010). Residents, family members, and staff reported many positive changes in their quality of life after a garden was installed including:

- Residents who had been withdrawn and inactive became more interactive.
- Many residents acknowledged their enjoyment of participating in meaningful activity.
- The garden promoted positive interactions between residents.
- Family members of a resident saw changes in his ability to communicate.
- Being in the garden seemed to promote functional competence in many residents.
- Staff members saw a reduction in late afternoon agitation.

Similar results were found in a study done by researchers at Virginia Tech who followed the 34 residents of a locked dementia unit when an enclosed wander garden was installed (Ford-Murphy, Miyazaki, Detweiler, & Kim, 2010). During the 12 months of the study residents displayed a reduction in agitated and aggressive behavior.

In a Korean study, residents of a memory care facility showed improvements in sleep, levels of agitation, and cognition after participating in indoor gardening (Lee & Kim, 2008). Each participant engaged in two gardening sessions a day for a five week period. The routine demanded a considerable amount of walking to plant, fetch water, trim, and harvest bean plants. The activity fostered interaction with fellow participants, staff and researchers, and provided some gratification for the participants when their plants were harvested, cooked, and eaten. The Hasegawa's Dementia Scale-Revised (HDS-R) was used to evaluate cognition, which measures orientation, memory, calculation, attention, and semantic word fluency. Each participant showed improved

scores on all measures. However, the increased exercise and social interactions or an emotional response to successfully completing an activity could have played a role in the improved cognitive performance. Because of these potential confounds, more research is necessary to confirm the connection between cognitive improvements in PwD and the natural world.

Not only is there empirical evidence to show that humans are attracted to and have positive responses to nature, but research also has demonstrated that we have a preference for specific types of natural aesthetics. Views of nature that include water, open spaces, and trees are consistently chosen by study participants from widely varied backgrounds, suggesting an innate attraction to these conditions (Kaltenborn & Bjerke, 2002). One hypothesis suggests that a preference for these types of views has an evolutionary connection. These characteristics are all present in savannahs in Africa, which is the environment where humans are believed to have evolved (Dutton, 2003). Savannahs contain elements of complexity, mystery, and coherence which Kaplan and colleagues (1989) hypothesized were appealing because of their likelihood of supporting survival. Complexity and mystery (foliage which conceals) offer potential for life sustaining elements. Coherence (organized and understandable terrain) demonstrates what is readily available such as water and edible plants.

Another view, originally proposed by the British geographer Jay Appleton, also connects the preference for savannahs to evolution, but he explains the attraction to be a combination of prospect and refuge (Appleton, 1975). Prospect (having an overview of the surrounding landscape) allows one to see what is needed for sustenance - food and



water – in addition to potential dangers. Refuge allows a hiding place from predators.

This view is similar to that of Kaplan and colleagues (1989) who also recognize the focus on information required for survival.

A third proposed explanation of the human attraction to savannahs is that human beings are attracted to a specific range of fractal dimension. Benoît Mandelbrot, a mathematician, first used the term “fractal” in his exploration of the topography of coastlines (Mandelbrot, 1983). He observed that many forms in nature continually replicate on ever decreasing scales; trees, shrubbery, coral, and clouds are examples. Euclidean geometric shapes (circles, cones, cubes, etc.) have dimensions that are integers (a circle is 2.0, a cone is 3.0), but dimensions of Fractal geometry are fractions (Hagerhall, Purcell, & Taylor, 2004). A fractal line will have a dimension, or D value, between 0 and 1.0, while a surface will be between 1.0 and 2.0. The fractional dimension is determined by its complexity. For instance, an image of a rain forest will have a higher fractional dimension than a desert. Hagerhall (2004) reported that participants in their study demonstrated a consistent preference for landscape images with a D value of 1.3, the same as savannahs (2004), and a figure that corresponded with findings from other studies (Aks & Sprott, 1996; Spehar, Clifford, Newell, & Taylor, 2003). Images in this fractal range not only are consciously favored by humans, but they also have been shown to reduce stress (Spehar et al., 2003). Some researchers have suggested that it is the geometry itself which produces these biophilic responses -- “it is not the tree that causes these emotional responses, but the fractal mathematics of the tree” (Joye, 2007, p. 3).

These three explanations of environmental preference – evolutionary preference for terrain which has sustenance producing properties, an attraction for environments which provide prospect and refuge (opportunity and protection), and an affinity for a specific fractal range in foliage – are all possibilities for the reason humans respond positively to specific natural elements. While the explanation for our positive responses to natural conditions may be unclear, the effects of these natural elements are not. Research in Psycho-evolutionary Theory has demonstrated that we heal faster and are happier when we are able to connect with natural elements. These findings support Edward O. Wilson's view of biophilia and our natural affinity for life and life-like processes. Attention Restoration Theory has shown that many populations are able to improve their cognitive performance by spending time in a natural setting or some representation of one. To date, these effects have been revealed in populations other than PwD using measures of fatigue and exposure to interventions involving natural conditions. This study investigated the effects of natural elements on the cognitive and behavioral responses of persons known to have moderate to moderately severe dementia. The participants' involvement with nature was unobtrusive involving either the presence or removal of live, potted plants in their day-to-day environment. The expectation was improvement in cognitive and behavioral responses as a consequence of the presence of the plants.

### CHAPTER III

#### METHODOLOGY

The goal of this study was to determine if exposure to natural elements affected persons with dementia. The intervention, or independent variable, was the installation of living plants in the interior of a residential memory care facility. The study used an A B A B B design. Baseline testing (A1) was followed by five days with the intervention (B1), two days without the intervention (A2), another five days with the intervention (B2), and two additional days with the intervention (B3; see Figure 1: Schedule of Days). Testing occurred at baseline and with each change in the intervention resulting in five different periods of data collection.

Figure 1. Schedule of Days

Day	Testing Days	Intervention
1 (Thursday)	A1 9:00 – 11:30 Cognitive 2:00 – 8:00 Behavioral	None until 8:00 PM Installation
2 (Friday)	None	All day
3 (Saturday)	None	All day
4 (Sunday)	None	All day
5 (Monday)	None	All day
6 (Tuesday)	B1 9:30 – 11:30 Cognitive 2:00 – 8:00 Behavioral	All day until 8:00 Removal
7 (Wednesday)	None	None
8 (Thursday)	A2 9:30 – 11:30 Cognitive 2:00 – 8:00 Behavioral	None until 8:00 PM Installation
9 (Friday)	None	All day
10 (Saturday)	None	All day
11 (Sunday)	None	All day
12 (Monday)	None	All day
13 (Tuesday)	B2 9:30 – 11:30 Cognitive 2:00 – 8:00 Behavioral	All day
14 (Wednesday)	None	All day
15 (Thursday)	B3 9:30 – 11:30 Cognitive 2:00 – 8:00 Behavioral	All day until 8:00 Removal

## **Facility and Residents**

The setting for the study was Friends Home at Guilford, a continuing care retirement community which includes independent living, assisted living, skilled nursing, and memory care. The facility has a Five Star rating from Nursing Home Compare (Medicaid.gov, 2015). It was founded by the Religious Society of Friends, the Quakers, and is located in Greensboro, North Carolina. The proximity of the facility to the investigator as well as her previous internship and volunteer experience in the memory care wing were factors in choosing this site for the study. Administration and staff were supportive during planning, recruitment, and data collection.

The skilled nursing and memory care facilities are housed in a one-story, free-standing building consisting of four wings. The wing housing the memory care facility is called the Birches.

The Birches consists of twelve bedrooms with private baths, a nursing office, kitchen, spa, small sitting room, and two sitting alcoves on the perimeter of the building (see Figure 2. Floor Plan and Figure 3. Photographs of Facility). The center of the building contains a dining room, the primary sitting room, and activity room. These spaces are encircled by an eight foot wide corridor which provides a circular walking path and access to the perimeter spaces. The unit was designed and programmed to care for up to twelve persons with dementia who have been diagnosed with stage five (moderate) to stage six (moderately severe) Alzheimer's disease. Residents live in the unit as long as they are benefitting from the type of care it provides.

Figure 2. Floor Plan

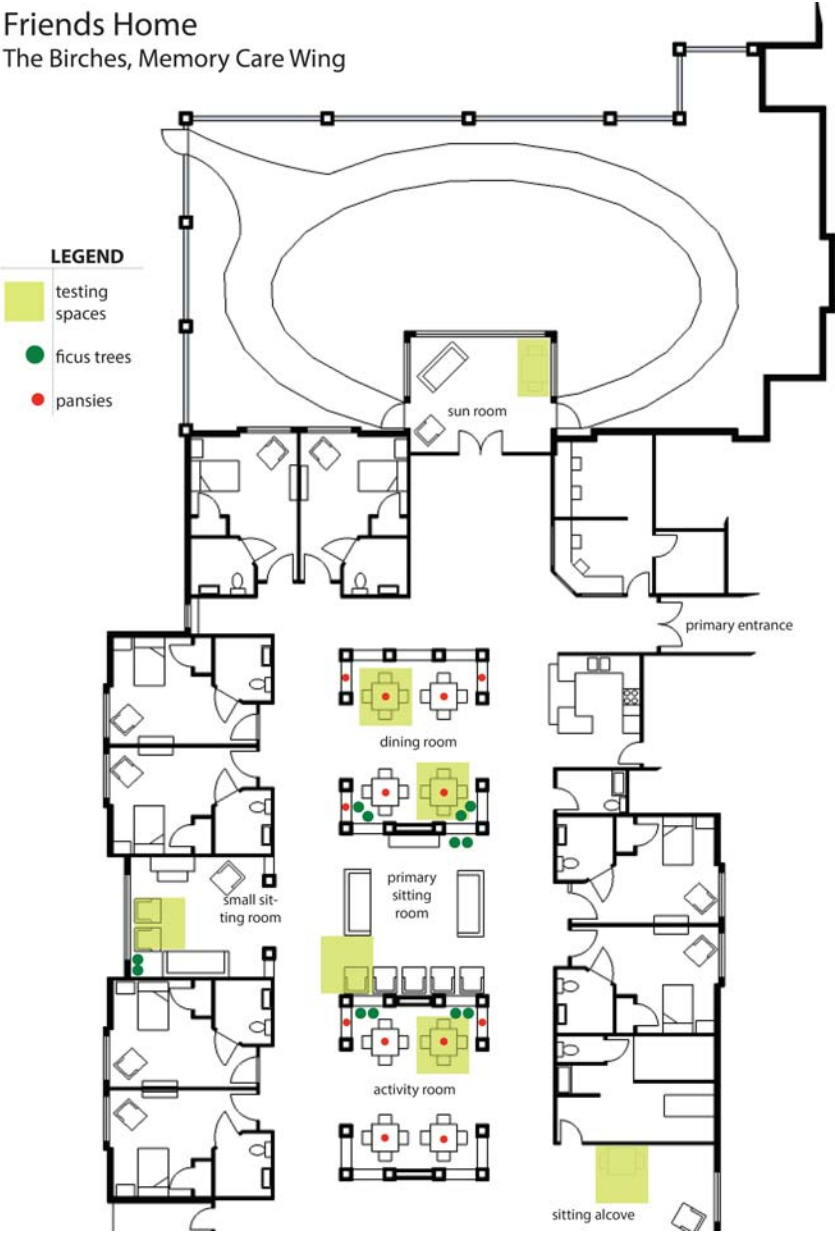


Figure 3. Photographs of Facility



sitting alcove



sun room



sun room



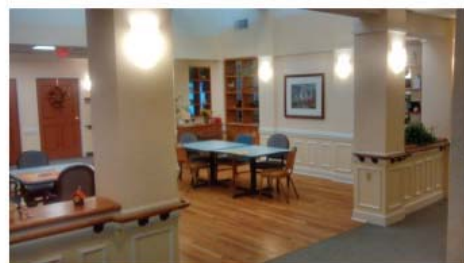
primary sitting room



primary sitting room



small sitting room



activity room



dining room



primary entrance to wing

There were twelve residents of the Birches at the time of the study, seven women and five men. This group comprised a convenient sample for this study. The researcher sent invitations to each residents' legal representative and all agreed to participate in the study. However, when data collection began one woman was not able to participate due to a fall that resulted in a broken hip.

The remaining 11 participants were American Caucasians who ranged in age from 72 to 98. They were Protestants (Quakers, Methodists, or Presbyterians) with the exception of one who claimed no religious affiliation. Education levels in the group ranged from completion of seventh grade to college graduation. None of the residents had any particular visual impairment that interfered with their ability to participate in the study. One could ambulate with assistance, two used wheelchairs, but the remaining eight were independently ambulatory (most with the aid of a walker) and capable of initiating interaction with the intervention. One of the residents had significant hearing loss and was described by staff as having failed to thrive.

### **The Intervention (Independent Variable)**

Two different types of plants representing different features of the natural environment were placed in the existing facility. Pansies were chosen due to the association of blooms and food production. Recall that the basic premise of biophilia is that our evolutionary biology causes us to have an attraction to natural elements necessary for our survival (Kellert & Wilson, 1993). Open shelving and dining tables provided placements for small potted plants. Ficus trees were chosen because their D values, the complexity of their fractal geometric form, are similar to food producing fruit



and nut trees (Hagerhall, Purcell, & Taylor, 2004). High ceilings and wide corridors allowed space for trees up to 8' tall. Collectively, 10 ficus trees (4' – 5' tall) and 16 small pots of pansies were used (see Figure 4. Photographs of Plants and Figure 2. Floor Plan for placement of plants). These plants were placed in the most frequently used areas of the public spaces in the Birches after baseline testing (A1). The plants were removed after testing on the sixth day of the study (B1), replaced after testing on the eighth day of the study (A2), and remained in place for the duration of the study (B2, B3; see Figure 1. Schedule of Days).

Figure 4. Photographs of Plants



activity room



dining room



small sitting room



primary sitting room



dining room



dining room



dining room



activity room

## **The Dependent Variables**

### **Cognitive Measures**

Time and Change Tests (Inouye, Robison, Froehlich, & Richardson, 1998) , Trail-making Test (Ashendorfa et al., 2008), and a single item from the attention section of the Montreal Cognitive Assessment (Nasreddine et al., 2005) were originally intended to assess cognitive skills. The majority of the residents of the Birches had been diagnosed with moderate dementia at the time that the cognitive assessments were being considered for the study. Yet when the data collection actually began, the overall functioning of the residents had declined. Only two participants scored points on any of the testing instruments (see Appendix A. Original Cognitive Testing Results) on the day of baseline testing. The planned data collection procedure indicated that the instruments were too advanced for the residents' cognitive abilities. As a consequence, the tasks of the standardized tests were simplified, the graphics enlarged to be easier to read and understand, and two different tests were added. The study resumed two days later.

The Time and Change Tests evaluated conceptualization, or the ability to formulate ideas. In the original Time Test, participants presented with an image of an analog faced clock at 11:10 (see Appendix B. Clock Graphic) are allowed two opportunities to correctly identify the time. Scoring is based on number of attempts to get the right answer in under 30 seconds (see Appendix C. Cognitive Scoring Rubric for scoring values). Revisions of the Time portion of the Time and Change test included a change in the scoring rubric (see Appendix D. Revised Cognitive Scoring Rubric) and

creating a clock graphic which was easier to read (see Appendix E. Revised Clock Graphic). The new rubric provided a scoring opportunity when participants could identify only the hour or minutes and did not include a time limit. Revised scoring was as follows:

4 points	correct hour and minutes on first attempt
3 points	correct hour and minutes on second attempt
2 points	correct hour on first attempt
1 point	correct hour on second attempt
0 points	no correct hour or minutes

The Change Test that evaluates calculation, conceptualization, and visual-spatial skills, asks participants to select a combination of coins that would equal one dollar. Participants doing so successfully in 15 seconds or less earn a higher numerical score. If the participant fails to identify the correct coinage during the first attempt they are asked to try again (see Appendix D. Cognitive Scoring Rubric for scoring values). The revised version of the Change section of the Time and Change Test was divided into two categories and scoring opportunities. The first required participants to identify the name of each coin (penny, nickel, dime, and quarter) with no time limit. Evaluators recorded scores on the Revised Cognitive Scoring Rubric (Appendix D) as follows:

4 points	four coins correctly identified
3 points	three coins correctly identified
2 points	two coins correctly identified

1 point	one coin correctly identified
0 points	zero coins correctly identified

During the second part of the Change section of the Time and Change Test evaluators place six identical coins on the table one at a time. Participants were asked to stop the evaluator when the value of coins reached a prescribed point. For example, when the evaluator was placing quarters she would ask the participant to stop her when she placed one dollar on the table. The value was 50 cents with dimes, 25 cents with nickels, and five cents with pennies. Evaluators recorded scores on the Revised Cognitive Scoring Rubric (Appendix D) as follows:

4 points	correct score on all coin types
3 points	correct score on three coin types
2 points	correct score on two coin types
1 point	correct score on one coin type
0 points	no correct scores

The Trail-making Test evaluates visual-spatial skills and executive functioning. Participants presented with a page of numbered dots (1-25) are asked to draw connecting lines from dot #1 to #2 to #3 up to #25 (see Appendix F. Trail-making Test Graphic). Participants have 120 seconds to complete the task. Numerical scoring of performance is based on the number of correct pairings of connecting dots and is recorded on the Original Cognitive Scoring Rubric (see Appendix A). The Trail-making test was revised by enlarging the numerals on the graphic (see Appendix G. Revised Trail-making Test

Graphic). Because of the low functional capabilities of some of the participants a second option was provided, an alternative graphic which reduced the amount of numbered circles from 25 to 10 (see Appendix H. Simplified Trail-Making Test Graphic). Participants also were given the option of pointing to the numbers in sequence instead of drawing lines. The time limit was omitted for all options. Two scoring categories were included. One was for drawing the lines, the other was for pointing. If a participant drew the lines, he or she would not only receive points from the drawing category, but automatically be given credit for the same numerical value in the pointing category. Evaluators recorded scores on the Revised Cognitive Scoring Rubric (Appendix D) as follows:

4 points	49 correct pairings
3 points	35 to 48 correct pairings
2 points	20 to 34 correct pairings
1 point	5 to 19 correct pairings
0 points	0 to 4 correct pairings

For example, if a participant drew lines to connect 25 numbered dots in numerical order he or she would receive four points for 24 pairings in the first Trail-making written column and another four points in the Trail-making point column for a total of eight points.

The Montreal Cognitive Assessment (MoCA; see Appendix I. Montreal Cognitive Assessment Graphic) is an instrument designed to determine if a person has dementia and

the degree of dementia that they have. Item #2 in the attention section tests for the capacity to sustain focused attention. MoCA is typically used for persons who are at a higher level of function than the study participants. This particular item was chosen because it was the simplest of the options in MoCA for accessing attentional capability. Participants hear a list of letters, F V A C M N A A J K L B A F A K D E A A A J A M O F A A B, and are asked to tap the table when they hear the letter A, which occurs 11 times, providing 11 opportunities for correct responses. The list is read only once. Correct responses are recorded on the Cognitive Scoring Rubric (see Appendix D) as follows:

4 points	11 appropriate taps
3 points	8 to 10 appropriate taps
2 points	4 to 7 appropriate taps
1 point	1 to 3 appropriate taps
0 points	0 appropriate taps

This assessment was altered by allowing participants to indicate that they were aware that the letter “A” had been spoken using methods other than tapping the table. This change was made because some of the participants’ hands trembled and they seemed to lack the motor skills required to tap the table. For example, participants could choose to pat their own leg, squeeze the evaluators’ hands, or tap the floor with a cane. Scoring did not change.

Even with the simplification of the standardized testing instruments there was still concern that some participants’ cognitive abilities were compromised to an extent that

would prevent them from demonstrating variations in function. Two additional tests were included to assess the range of capacities that can be measured at a lower end of cognitive functioning. Both of these new tests measured conceptualization and visual-spatial skills.

On the first test, participants were asked to identify the color of 2” paper squares (red, blue, yellow, and green). If participants identified the color which indicated that they were aware of a color family, such as responding to red as pink, they were given credit for a correct identification. Evaluators recorded scores on the Revised Cognitive Scoring Rubric (Appendix D) as follows:

4 points	four correct color identifications
3 points	three correct color identifications
2 points	two correct color identifications
1 point	one correct color identification
0 points	no correct color identifications

On the second new assessment, twelve paper squares were placed on a table – three red, three blue, three green, and three yellow. Participants were asked to find three paper squares of a specific color and place them adjacent to one another on the table. The evaluator would demonstrate how the squares should be placed. The color that the evaluator requested was sometimes determined by which color the participant could identify on the previous test. Evaluators recorded scores on the Revised Cognitive Scoring Rubric (Appendix D) as follows:

4 points	three squares of the requested color placed correctly
3 points	two squares of the requested color placed correctly
2 points	three squares of any color placed correctly
1 point	two squares of any color placed correctly
0 points	zero squares placed correctly

### **Behavioral Measures**

Behavioral effects of the intervention were assessed using Dementia Care Mapping (DCM) which involves recording observations of two participant behaviors: well-being and interactive behaviors. Well-being or ill-being documents the participants' apparent state of mind on a six point scale as perceived by an observer. The rating is based on the following parameters as described in *Dementia Care Mapping as a Research Tool* (Sloane PD, 2007, p. 1):

5	exceptional well-being with high levels of engagement, self-expression and social interaction
3	considerable interaction or initiation of social contact
1	coping adequately with present situation, no signs of ill-being observable
-1	slight ill-being visible, for example boredom, restlessness or frustration
-3	considerable ill-being, for example sadness, fear or sustained anger
-5	extremes of apathy, withdrawal, grief or despair.



Interactive behaviors are scored using a matrix which describes different types of behavior alphabetically (see Appendix J. for the complete DCM Scoring Matrix). For example, the first category is Articulation, “Interacting with others, verbally or otherwise – with no obvious accompanying activity”; the second is Borderline which represents “being socially involved, but passively (watching),” and so forth. Activity in any of these areas is recorded for each participant.

The researcher added a category to the mapping matrix to measure participants’ awareness and interaction with the plants. T (Timulation), an existing category described as “direct engagement with the senses,” was modified to TP (Timulation/Plant) to indicate when a participant was engaged with a plant. See Figure 5.

Figure 5. Dementia Care Mapping Category Documenting Participant Interaction with Plants

Code	Memory Cue	General Description of Category
TP	Timulation/Plant	Direct engagement of the senses with plants

### **Evaluator Training**

Two University of North Carolina at Greensboro Gerontology graduate students were evaluators for the cognitive testing. Each had previous experience working with persons with dementia. The evaluators and the researcher met an hour before the testing period on the first day of data collection. The researcher demonstrated the tests and scoring procedure and then the evaluators participated in practice sessions by taking turns as either the participant or the evaluator.

Two other graduate students in the UNCG Gerontology department agreed to conduct DCM for the study. A two-hour training session of DCM was provided for them and the researcher by Beth Barba, PhD, RN, in her office at UNCG. This training session was reinforced with a two-hour practice session in the public areas of the Birches. Inter-rater reliability was established by the evaluators on the last day of the study. Each mapped all participants for a one-hour and forty-minute session which indicated 74% consistency. This is below the minimum of 80% that is recommended for research but considered to be sufficient when mapping is done for purposes of behavioral activity (Brooker & Surr, 2005).

### **Data Collection**

Baseline testing using the cognitive skills tests began at 9:00 AM. Each participant was tested individually and each of the student evaluators worked with five or six participants at approximately 30 minute intervals. Evaluators would approach the participants, ask them to come and play a game, and then lead them to a quiet area in the unit where there would be a small dining table and two chairs. The evaluators and participants were seated facing each other and remained in these positions for the duration of the session.

After the first testing day with the original instruments the procedure for the location of testing was altered. If a participant was seated and resisted moving to a testing location, then the administrator would bring a rolling table to the participant. Thus, participants were tested in appropriate areas closest to where they were located. This procedure kept participants in seating of their choice thereby fostering their ability to

complete the testing which could become lengthy depending on the status of their functioning, disposition, and willingness to participate. Testing locations are indicated on Figure 2. Floor Plan.

Cognitive testing sessions were from approximately from 9:00 AM until 11:30 AM. There was variation in the time required to test eleven participants each day due to their wakeup times, willingness to participate, and ability to perform the tests on a given day. The order in which the testing instruments were administered was consistent throughout the study, but the order in which the participants were tested varied, depending upon their availability and willingness to take part. Non-ambulatory participants were tested where they were sitting. A small table on castors was moved to them to provide a surface for testing materials. Ambulatory participants were invited to move to quieter locations, such as a small dining table in the sunroom, but testing would take place where they were sitting if they displayed resistance to moving. Nine of the eleven participants completed each testing session. One participant who appeared to experience rapid decline during the course of the study was sleeping during one testing session and was unwilling to participate on another day. Another who also appeared to experience rapid decline did participate in testing but her scores were significantly lower on the last two testing days. Because of the decline observed in these two participants, data were analyzed using their scores when they were available.

Dementia Care Mapping was done by two trained observers (mappers) who observed participants between 2:00 PM and 8:00 PM in the public areas of the Birches, recording behaviors and well/ill-being appearance at five minute intervals. One mapper

was responsible for six participants, the other for five participants. In accordance with Dementia Care Mapping guidelines, they recorded both observed mood state (well/ill-being) and specific behaviors (behavioral care). See Appendix J for the complete DCM Scoring Matrix. Participant interaction with the intervention (the plants) was noted on days that the intervention was in place to enable comparisons between the cognitive and behavioral scores and interaction with the plants.

After completion of both the cognitive testing and DCM on Day A1, Baseline, the researcher installed the independent variable, the plants, throughout the public spaces of the unit (see Figure 2. Floor Plan for specific plant placement and Figure 4. Photographs of Plants). Four ficus trees were placed in the dining room, two in the primary sitting room, two in the small sitting room and four in the activity room. Staff members had indicated that these were the public spaces most frequently used by the participants. Sixteen small pots of flowering pansies were placed on tables and bookcases in the dining and activity rooms.

### **Schedule**

The plants were removed after testing on Day Six (B1), and replaced after testing on Day Eight (A2; see Figure 1. Schedule of Days and Figure 6. Study Calendar). Cognitive testing and Dementia Care Mapping were repeated in the same format on Days Six (B1), Eight (A2), Thirteen (B2), and Fifteen (B3). This enabled an initial period of baseline data (data collection on Day One prior to the installation of the plants - the intervention). The plants were removed after testing on Day Six (B1) to determine if the presence of the plants had any effect on the participants' cognitive state, emotional state,

and expressions of well/ill-being. Participants were tested on Day Eight (A2) to determine the effect of the absence of plants. At the end of testing on Day Eight (A2), the plants were reintroduced and remained in place until the end of the study with data collected on Day Thirteen (B2) to test the whether the reintroduction of plants had an effect and again on Day Fifteen (B3) to determine whether a longer exposure to the plants had a different effect.

Figure 6. Study Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				No intervention A1	Intervention	Intervention
Intervention	Intervention	Intervention B1	No Intervention	No intervention A2	Intervention	Intervention
Intervention	Intervention	Intervention B2	Intervention	InterventionB3		

## Data Analysis

The cognitive data were analyzed by comparing all participants' test scores from multiple pairs of testing days, one where there had been no intervention in place prior to testing (an A day) and one where the intervention had been in place prior to testing (a B day). Each participants' scores were tallied for each test on each testing day. Scores from one testing day were compared with scores from another testing day by subtracting scores from a specific test on one day from the same test on a comparison day. These difference scores for four comparison pairs (B1-A1, A2-B1, B2-A2, B3-A2) were generated for each of the eight scoring categories (Time, Coin Identification, etc.) for each participant. These difference scores were then coded as (improved) positive, unchanged (zero), or

(declined) negative. For example, scores on baseline testing (A1) were subtracted from scores on the first intervention day (B1) to produce difference scores. A participant scoring 2 points on the Time Test on the baseline testing day (A1) and 4 points on the Time Test on the first intervention day (B1) would be considered to have a positive (improved) score. The summary counts of the positive, no change, and negative scores of all participants were then transformed into percentages based on the total number of scores.

Table 1 presents a matrix of the comparisons.

Table 1. Percentage of Changed Cognitive Scores by Paired Test Days

Test Period Comparisons		% of Scores Improved	% of Scores Unchanged	% of Scores Declined
		(Positive)	(Zero)	(Negative)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)			
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)			
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)			
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)			

The behavioral data were analyzed by comparing all participants' scores from multiple pairs of testing days, one where there had been no intervention in place prior to testing (an A day) and one where the intervention had been in place prior to testing (a B day). The scores were calculated on two measures, well/ill-being (WIB) and behavior category (BCC), which were recorded at five minute intervals during the six hour observation period. Figure 7 shows the raw data sheet used to record these measures.

**Figure 7. Dementia Care Mapping Blank Raw Data Sheet**

## Blank raw data sheet

<b>Date:</b>		<b>Time period:</b>		<b>Place:</b>	
<b>Total number of service users:</b>		<b>Number of staff:</b>		<b>Observer:</b>	

Participant name	Time																					Total ME						
																						Total TF						
	BCC																											
	ME																											
	BCC																											
	ME																											
	BCC																											
	ME																											
	BCC																											
	ME																											
	BCC																											
	ME																											

The numerical values of well/ill being scores of each participant were averaged for each testing day. A group WIB profile was determined by averaging all of the participants' daily averages.

Behavior category scores were analyzed by sorting the 27 behavior categories into three groups: high potential, withdrawn, and agitated as directed by the DCM 8 User's Manual (2005). High potential are behaviors associated with positive well-being, withdrawn behaviors indicate a lack of engagement with the social and physical environment, and agitated behaviors signal distress or unhappiness. Behaviors C and N are categorized as withdrawn, behaviors D, S, U, W, X and Y are categorized as agitated behaviors, and the remaining are high-potential (see Appendix J; Dementia Care Mapping Scoring Matrix for names of each category). The number of times a participant displays behavior in any group of behaviors during a specific day was recorded and

summed, then the percentage of the total time the participant was recorded in each group of behaviors was calculated. All participants' percentages in each group of behavior were averaged



## CHAPTER IV

### RESULTS

The primary purpose of this study was to evaluate if natural elements (operationalized with living plants) in an interior setting would affect the cognitive performance of PwD. This was done by analyzing summary measures of eight cognitive assessments for eleven participants in this A B A B B study with multiple score comparisons of a condition A and a condition B. Observers tracked participants' interaction with the intervention, mood state (well/ill-being) and activities (behavioral categories) with Dementia Care Mapping for six hours per data point.

#### Cognitive Testing Results

Table 2 shows individual participant scores on each test from each data collection day.

Table 2. Participants' Individual Scores by Test

Participant #1											
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total	
A-1 Baseline	2	0	0	1	1	0	0	0	4	12	
B-1 1 <sup>st</sup> Exposure	1	0	0	0	0	0	2	1	4		
A-2 No Plants	0	0	0	0	0	0	4	0	4		
B-2 2 <sup>nd</sup> Exposure	sleeping										
B-3 3 <sup>rd</sup> Exposure	sleeping										

Participant #2										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	3	2	3	3	0	4	2	17	60
B-1 1 <sup>st</sup> Exposure	2	4	4	4	4	0	3	4	25	
A-2 No Plants	0	0	2	0	3	0	4	4	13	
B-2 2 <sup>nd</sup> Exposure	0	0	0	0	2	0	0	0	2	
B-3 3 <sup>rd</sup> Exposure	0	0	3	0	0	0	0	0	3	

Participant #3										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	0	0	0	0	0	0	0	0	3
B-1 1 <sup>st</sup> Exposure	0	0	0	0	1	0	0	0	1	
A-2 No Plants	0	0	0	0	0	0	0	0	0	
B-2 2 <sup>nd</sup> Exposure	0	0	0	0	0	0	1	1	2	
B-3 3 <sup>rd</sup> Exposure	0	0	0	0	0	0	0	0	0	

Participant #4										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	0	0	0	0	0	3	0	3	5
B-1 1 <sup>st</sup> Exposure	0	0	0	0	0	0	0	0	0	
A-2 No Plants	0	0	0	0	0	0	1	0	1	
B-2 2 <sup>nd</sup> Exposure	0	0	0	0	0	0	1	0	1	
B-3 3 <sup>rd</sup> Exposure	0	0	0	0	0	0	0	0	0	

Participant #5										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	2	1	0	0	0	0	1	0	4	14
B-1 1 <sup>st</sup> Exposure	0	0	0	0	0	1	0	0	1	
A-2 No Plants	0	0	0	0	0	0	3	0	3	
B-2 2 <sup>nd</sup> Exposure	2	1	1	0	0	0	1	1	6	
B-3 3 <sup>rd</sup> Exposure	sleeping									

Participant #6										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	2	0	0	0	0	4	0	6	25
B-1 1 <sup>st</sup> Exposure	0	1	0	0	1	0	3	3	8	
A-2 No Plants	0	2	0	0	0	0	0	0	2	
B-2 2 <sup>nd</sup> Exposure	0	0	0	0	0	0	4	0	4	
B-3 3 <sup>rd</sup> Exposure	0	1	1	0	2	0	1	0	5	
										25

Participant #7										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	1	0	1	1	0	2	0	5	44
B-1 1 <sup>st</sup> Exposure	2	0	0	0	0	0	3	4	9	
A-2 No Plants	2	2	0	0	0	0	3	3	10	
B-2 2 <sup>nd</sup> Exposure	0	0	2	0	1	0	4	4	11	
B-3 3 <sup>rd</sup> Exposure	0	0	0	0	2	0	4	3	9	
										44

Participant #8										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	0	3	1	3	3	4	3	4	21	132
B-1 1 <sup>st</sup> Exposure	4	3	4	4	4	4	4	4	31	
A-2 No Plants	4	4	2	0	3	3	4	4	24	
B-2 2 <sup>nd</sup> Exposure	4	3	0	4	4	2	4	4	25	
B-3 3 <sup>rd</sup> Exposure	4	3	4	4	4	4	4	4	31	

Participant #9										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	4	3	4	3	3	0	4	1	22	111
B-1 1 <sup>st</sup> Exposure	4	3	3	0	4	2	4	4	24	
A-2 No Plants	4	2	4	0	4	3	4	4	25	
B-2 2 <sup>nd</sup> Exposure	4	2	2	0	4	2	4	3	21	
B-3 3 <sup>rd</sup> Exposure	0	0	0	4	4	3	4	4	19	

Participant #10										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	3	4	1	0	3	2	3	3	19	120
B-1 1 <sup>st</sup> Exposure	4	4	3	3	3	0	4	4	25	
A-2 No Plants	3	4	4	0	3	2	4	3	23	
B-2 2 <sup>nd</sup> Exposure	4	4	3	4	4	1	4	4	28	
B-3 3 <sup>rd</sup> Exposure	4	4	4	0	2	3	4	4	25	

Participant #11										
Testing Period	Time	Identify Coins	Change	Trail Writing	Trail Pointing	MoCA	Color	Shapes	Daily Totals	Study Total
A-1 Baseline	4	4	0	1	1	0	4	4	18	81
B-1 1 <sup>st</sup> Exposure	0	2	0	0	1	0	4	4	11	
A-2 No Plants	2	2	0	0	4	0	3	3	14	
B-2 2 <sup>nd</sup> Exposure	4	1	0	2	2	0	4	4	17	
B-3 3 <sup>rd</sup> Exposure	2	4	2	3	3	0	3	4	21	

There was some variation on participant performance across the tests administered. The test that produced the highest scores was the Color Identification Test, naming the color of red, blue, yellow and green squares of paper. The next highest scoring test was the Time Test, identifying the time of 11:10 on a clock graphic. Seven of the participants identified the hour on the clock graphic correctly at least twice, but only four identified the hour and minutes with any consistency. Participants were more able to complete the pointing version as compared with the drawing version of the Trail-making Test. One participant produced scores on the drawing version of the Trail-making Test every time; four produced scores on the pointing version of the Trail-making Test every time. Most of the participants were unable to complete the item from the Montreal Cognitive Assessment which evaluates attention; only three scored a cumulative eight points or more during all five testing opportunities out of a possible 20 points.

These cognitive data were used to compare changes measured as a percentage of scores that improved (positive), did not change (zero), or declined (negative) in one condition (intervention) versus another (non-intervention). There were four comparisons scores (see Table 1):

- Scores after the first exposure to plants (B1) minus baseline scores (A1)
- Scores after plants were removed for two days (A2) minus scores after the first exposure to plants (B1)
- Scores after the second exposure to plants (B2) minus scores when no plants were in place for two days (A2)
- Scores after the third exposure (B3) to plants minus scores when no plants were in place for two days (A2)

Table 3 shows the results of the percentages of difference scores computed based on the paired test days that represented improved (positive), did not change (zero), or declined (negative) scores for the four test period comparisons for the group (see Appendix K for percentages of individual changed cognitive scores by paired test days).

Examination of the data in the tables indicates that for the first set of paired test days, B1 (first exposure to plants) – A1 (baseline), the percentage of improved scores was 6.3% greater than the declined scores. For the second set of paired test days, A2 (no exposure to plants for two days) – B1 (first exposure to plants) demonstrates an 11.2% decrease from improved scores. For the third set of paired test days, B2 (second exposure to plants) – A2 (no exposure to plants for two days), shows no change. For the fourth and last set of paired test days, B3 (third exposure to plants) – A2 (no exposure to plants for two days), the percentage of improved scores was 6.3% greater than the declined scores.

Improved scores (positive) were greater in comparisons where scores from a testing period following no exposure to the intervention were subtracted from scores from a testing period following exposure to the intervention, which may suggest a positive

response to the intervention (see Table 4). Unchanged (zero) scores are notable due to the expectation of constantly declining cognitive function in PwD -- they averaged 57 % on all four test period comparisons and were highest for the A2 (first exposure to intervention) - B1 (baseline) comparison. Declined scores (negative) were higher for the A2 – B1 test period comparisons than the other paired test days, which is suggestive of a positive intervention effect. It is also notable that for the three paired test days where positive scores would be indicative of the effectiveness of the intervention the combination of positive and unchanged scores was 77.6%, 78.5% and 81.7%, while for the A1 - B2 comparison, results for the combination of positive and unchanged scores was the lowest, 75.1%.

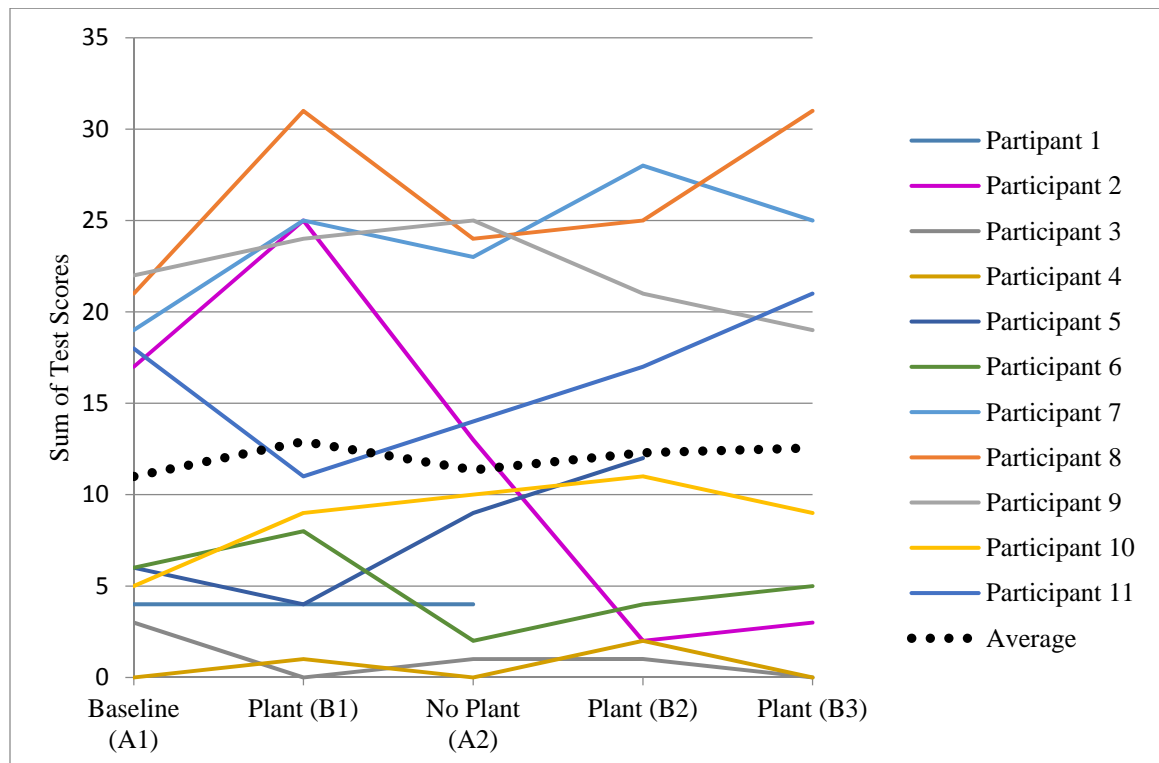
Table 3. Percentage of Group's Changed Cognitive Scores by Paired Test Days

Paired Test Day Comparisons		Percentage of Changed Scores		
		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	28.8%	48.8%	22.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	13.8%	61.3%	25.0%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	21.5%	57.0%	21.5%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	21.1%	60.6%	18.3%

The data may also be considered by comparing cumulative scores for each test day by participant. Figure 8 shows both individual and group cognitive testing results and demonstrates the large variance in function among the participants. For example,

participants 7, 8, and 9 are consistently high scoring while participants 3 and 4 scored below 6 the entire testing period. We also see that participant 2 started strong during the first testing days, but was struggling during assessment periods B2 and B3 for situational reasons beyond this study. Despite the measurement issues common to this population, the averages across the test periods (shown by the dotted line) appear to follow the hypothesis. That is, test scores were higher on testing days when the intervention had been in place prior to testing than on testing days when the intervention had not been in place prior to testing.

Figure 8. Individual Scores by Testing Period





## Data Analysis for Behavioral Measures

The category of Timulation/Plant was added to the DCM Behavior Category Scoring Matrix to record observations of participants interacting with the intervention, the plants (see Figure 5 for this category and Appendix J for the complete DCM Behavior Category Scoring Matrix). No observations of participants interacting with plants were recorded during the DCM observation periods.

Table 4 shows the mean well/ill being (WIB) scores of each individual and the group on each data collection day of the study. A score of 1 indicates that participants' average well/ill-being states was relatively neutral, i.e., neither agitated nor overly enthusiastic. There were no appreciable differences in WIB scores across the test days.

Table 4. Well/ill-being (WIB) Average Daily Scores

Participant	A1	B1	A2	B2	B3
1	1.2	0.9	1.5	-0.5	-0.2
2	2.1	1.9	2	1.3	-0.0
3	1.4	1.5	1.5	1.0	1.1
4	1.1	1.2	1.1	1.1	1.3
5	1.0	1.5	1.5	0.9	1.3
6	1.1	0.7	1.6	0.9	-1.7
7	1.2	1.2	1.7	1.0	1.0
8	1.5	1.4	1.4	2.3	1.0
9	1.3	1.5	1.6	1.4	1.1
10	2.0	1.6	2.3	1.4	1.5
11	1.7	1.6	1.6	1.2	1.7
Average	1.4	1.4	1.6	1.1	0.7

Values -5, -3, -1, 0, 1, 3 and 5

Table 5 shows the difference between well/ill-being scores on the same four test period comparisons that were used with cognitive data.

Table 5. Percentage of Changed Well/ill-being (WIB) Scores by Testing Periods

Test Period Comparisons of Well/ill-being Scores		
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	0
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	.2
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	-.5
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	-1.5

The data may also be considered by comparing cumulative scores of testing periods. Figure 9 shows both individual and group WIB results and demonstrates the large variance in apparent mood states among the participants. The chart also graphically shows how several patients were struggling during the last two test periods (B2 and B3), which may help us understand several large decreases in test scores for those days. When participants' scores are averaged the data indicate that test scores were lower on testing days when the intervention had been in place prior to testing than on testing days when the intervention had not been in place prior to testing.

Figure 9. Well/ill-being (WIB) Individual and Group Average Daily Scores

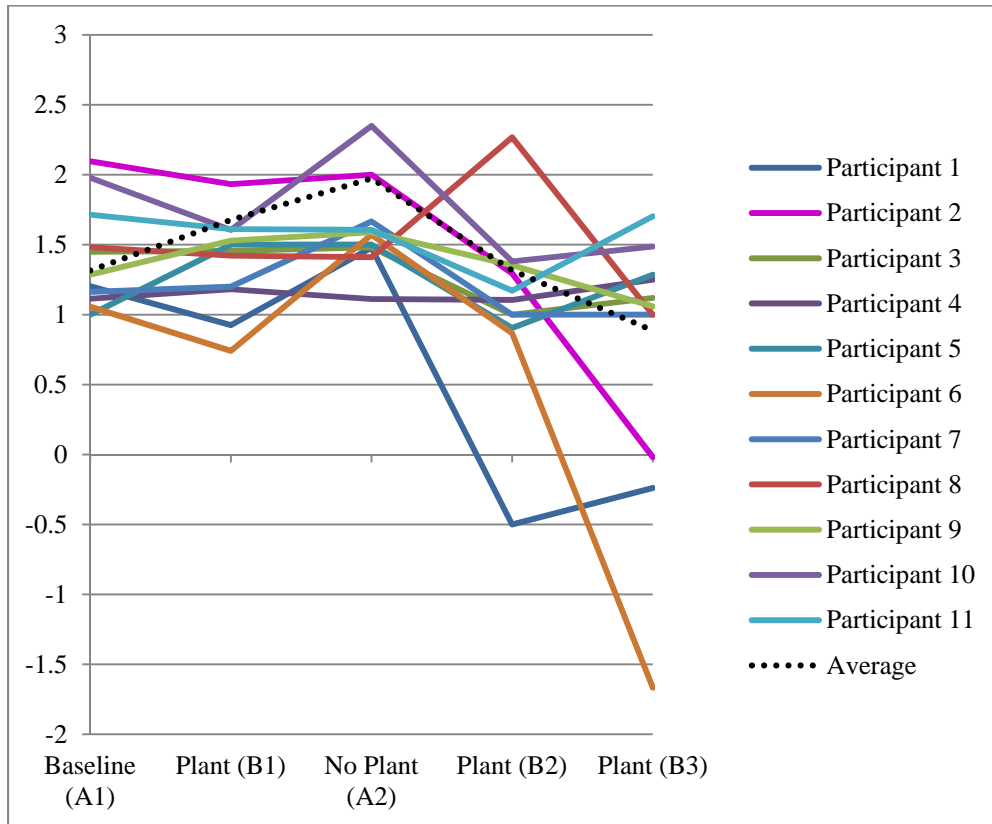


Table 6 shows the percentage of behavior category observations relative to high potential (behaviors associated with positive well-being), withdrawn (behaviors which indicate a lack of engagement with the social and physical environment), or agitated behaviors (behaviors which signal distress or unhappiness) for all participants in the study on each of the five data collection days.

Table 6. Percentage of Changed Behavior Category Scores by Paired Test Days

Comparisons	% High Potential (behaviors associated with positive well-being)	% Withdrawn (indicate a lack of engagement with the social and physical environment)	% Agitated (behaviors which signal distress or unhappiness)
A1	88	10	2
B1	78	20	2
A2	84	12	4
B2	73	17	10
B3	64	24	12

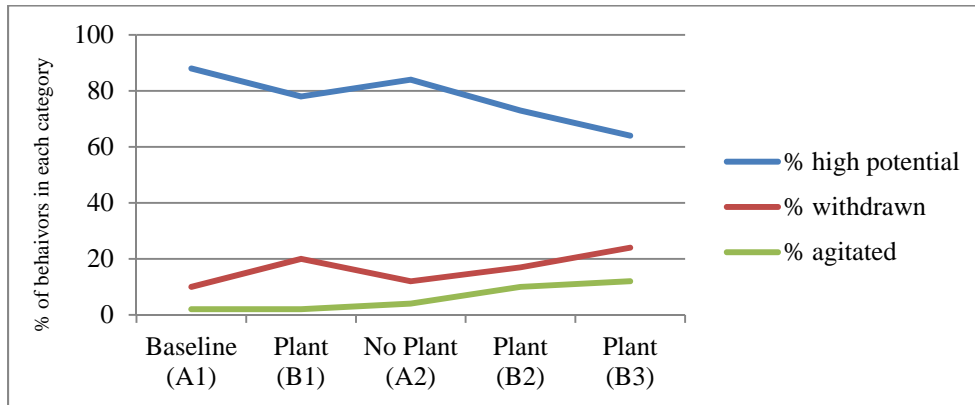
Table 7 shows the differences in percentages of high potential, withdrawn, and agitated behaviors when compared in the same ways as the cognitive data were compared, i.e., between intervention and non-intervention days. Decreases in high potential occurred on intervention days and increased on the non-intervention days. Increases in withdrawn behaviors occur on the intervention days and decrease on the non-intervention days. Agitated behavior is consistently low on each of the data collection days. This is opposite of what the cognitive data demonstrated. In three comparisons cognitive scores were higher on intervention days; one comparison showed no changes.

Table 7. Percentage of Changed Behavior Category Scores by Testing Periods

Participant 1		Percentage of Changed Scores in Behavior Categories		
Test Period Comparisons		% High Potential (behaviors associated with positive well-being)	% Withdrawn (indicate a lack of engagement with the social and physical environment)	% Agitated (behaviors which signal distress or unhappiness)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	-7	+7	0
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	+5	-5	0
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	-6	+7	-1
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	-13	+13	0

The data may also be considered by comparing high potential, withdrawn, and agitated behavior in each testing period. Figure 10 shows demonstrates the high potential averages were lower, but withdrawn and agitated percentages were higher on testing days when the intervention had been in place prior to testing than on testing days when the intervention had not been in place prior to testing.

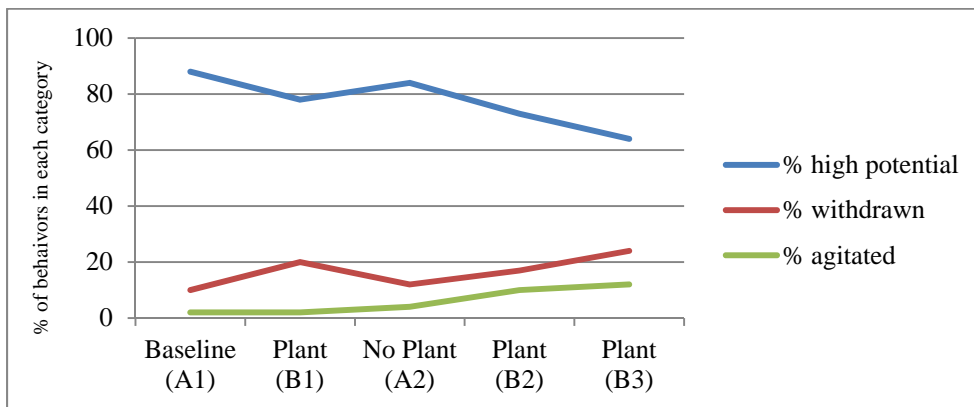
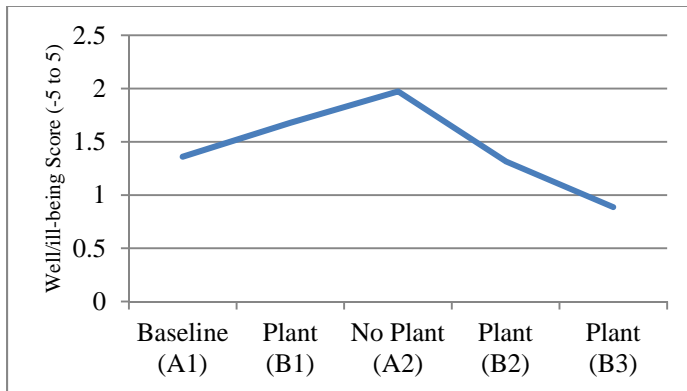
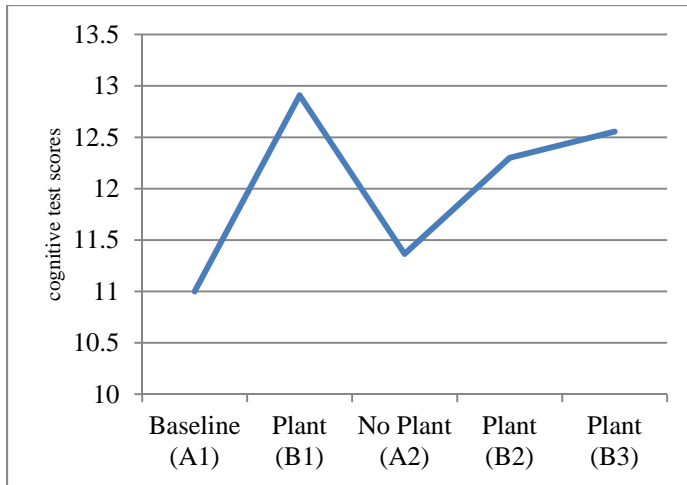
Figure 10. Behavior Category Percentages



A comparison of cognitive, well/ill being, and behavior category results could provide a way to assess for a relationship between cognitive and behavioral responses. Figure 11 provides a visual for this comparison. Categories where higher scores would indicate a positive response (cognitive, WIB, and high-potential behavior categories) are represented with blue lines. Categories where higher scores would indicate a negative response (withdrawn and agitated behavior categories) are represented with red or green lines. The expectation was that both cognitive and behavioral measures would improve when the intervention had been in place prior to testing. Cognitive measures did improve at those data points with the exception of B3, but behavioral scores showed the opposite of what was expected.

**Figure 11. Comparison of Cognitive, Well/ill-being and Behavior Category**

Scores



## CHAPTER V

### DISCUSSION

The goal of this study was to determine if exposure to natural elements affected persons with dementia. The intervention, or independent variable, was the installation of living plants in the interior of a residential memory care facility. Eleven residents of the facility, who had been diagnosed with moderate to moderately severe dementia, participated. Dependent variables were evaluated with cognitive and behavioral evaluations. The study was an A B A B B design. Baseline testing (A1) was followed by five days with the intervention (B1), two days without the intervention (A2), another five days with the intervention (B2), and two additional days with the intervention (B3; see Figure 1. Schedule of Days). Testing occurred at baseline and with each change in the intervention resulting in five different periods of data collection.

Generally, the percentage of cognitive scores increased following exposure to the plants and decreased after their removal even though the expectation of PwD is that the residents' cognitive and behavioral scores will decline over time. Yet in the brief period of this intervention, we observed that the participants' cognitive scores did not reliably decline, and in fact, showed some improvement (see Figure 8. Individual and Group Testing Period Scores). The consistency of results on the cognitive measures over the course of the study could be indicative of a positive result of the intervention.



The well/ill-being of the participants was relatively unchanged – averaging a score of 1 which indicated that the participants were coping adequately and not exhibiting any signs of ill-being whether or not the plants were in place (see Figure 9. Well/ill-being Average Daily Scores). The results of the behavior category scores are more difficult to understand. Participants' levels of agitation were relatively unchanged on all of the data collection days regardless of intervention, but percentages of high potential behaviors (those associated with positive well-being) decreased following periods of exposure to the plants while the percentages of withdrawn behaviors increased during that same period of time (see Figure 10. Behavior Category Percentages by Testing Periods). Given the improved changes in the cognitive scores, we might expect improved social and behavioral scores. Yet the scores regarding engagement with the environment are the opposite of the cognitive scores. When the cognitive scores increased (with the presence of plants), the behavioral scores decreased. When the cognitive scores decreased (absence of plants), the behavioral scores increased (see Figure 11. Comparison of Cognitive, Well/ill-being, and Behavior Category Scores).

It is difficult to surmise why the contrast in cognitive and behavioral scores occurred. The cognitive testing itself may have caused the participants some distress. Completing the tests required effort which may have caused fatigue. It is also possible that the process of testing reminded participants of their declining cognitive function, which could affect mood. However, this is unlikely to have been the reason for behavioral scores to decline after exposure to the intervention and increase when the intervention was removed. The increase in scores on A2 (no intervention had been in

place for two days at this data point) may be explained by the presence of nursing students who provided more positive stimulation than the participants experience on typical days.

There are a number of considerations related to the study that may address these findings. First, the intervention was indirect in that participants were not obliged to intervene or engage with the plants as opposed to other investigations such as those related to Attention Restoration Theory where participants engage in purposeful interventions with nature including walks outside or viewing images of natural conditions. In this study, plants were placed in the space and expected to enhance the quality of the interior environment because of human beings' innate affiliations with natural conditions. As discussed by E.O. Wilson and others, the presence of the plants was expected to enhance the quality of life of individuals in the space despite indirect interaction because human beings are in and of themselves natural beings who respond to natural conditions. Ficus trees and pansies were selected because of the association between fractals (ficus trees) or flowering plants (pansies) and food (nut or fruit) bearing plants. Perhaps other plants more directly connected to food such as vegetable plants or fruit and nut trees may have a stronger effect.

An additional consideration of the plants regarded their indoor care. Ficus trees require a considerable amount of light which was not available in the most frequented spaces of the facility and resulted in some loss of leaves. They are also more difficult to grow than other indoor tree varieties which increases their cost and ultimately limited the size and number of trees that were used. We do not know definitively that participants

would have a stronger response to ficus trees than they would to other trees that are less expensive and more tolerant of imperfect growing conditions; this may make a case for using another species in a subsequent study. There also could be an improvement in the choice of flowering plants to be used next time. Only pansies were available when the study took place (from late October through mid-November) which created less of a visual impact than plant varieties available at other times of the year. None the less, some of the residents responded positively toward the plants when they were installed, especially Participant Two. She clapped her hands, smiled broadly, and said “the plants are beautiful.” Another example was Participant Seven who was usually tested in the smaller sitting room where two ficus trees were placed close to his favorite chair. On testing Day Three (A2), when the plants were absent, he asked the administrator where the plants went. The encouraging results of this study position the researcher to consider a number of different types of plants that may be effective for a variety of reasons.

Another consideration of these results was the number of residents who became participants in the study. Twelve was a small sample with which to begin but it became smaller when a resident had a fall; two others were unable to complete in the cognitive testing. That the tests also proved too challenging and had to be modified was a further indication of the difficulties of working with PwD to improve their cognitive scores when cognition is often their most difficult challenge. This also might explain the results of the behavior care mapping which produced results opposite those of the cognitive testing. It may be that the testing activities actually tired the participants which left them with very little energy to engage in their physical environments. Brawley (2006), for example,

describes a decline of coping skills in PwD which often causes residents to perceive normal stimulation as over-stimulation. This may foster anxiety and inappropriate behavior, withdrawing from social interaction, restless behavior, or a decline in communication skills. Thus, the seemingly contrary results of the cognitive and behavioral care mapping in this study may provide some insight into the differences between cognitive energy and internal focus as opposed to environmental or external conditions that engage PwD who may have little capacity to manage both. This requires additional study.

Confounding variables include any number of conditions including the weather, the meals being served on a particular day, expected guests who did or did not come, and so on. A known confound in the study was the presence of eight nursing students who were volunteers in the facility on alternate testing days. The students actively engaged participants for six hours on each of those days in craft projects, one-on-one conversations, and physical activities. One of the physical activities, hitting balloons with fly-swatters, would usually engage even the most reserved participants. Future studies should arrange testing days to avoid unusual schedule intrusions.

Clearly, studying the effects of environmental factors on cognition with PwD is challenging because the individuals are in cognitive decline. Studying this population is further challenged by confounding variables such as health and well-being on any given day, visitors to the unit, or changes in staffing or caregiving. These and other conditions all are understood to affect the individual residents of the Birches in varying ways. Yet despite these uncontrolled and even unknown situations, the data in this study reveal

some recurring patterns which may indicate that the presence of living, potted plants in the space affected the residents in positive ways.

### **Theoretical Contributions**

The evolution of memory care facilities from an institutional model whose primary function was to keep residents physically safe to present designs that strive to create home-like, person-centered atmospheres has required changes in both how care is provided and how the built environment is designed. One area of the research that has guided these changes is exploration of the positive effect of natural elements on PwD. There is, as noted earlier, evidence that views from interiors to exterior gardens (Brawley, 2006) and access to natural areas (Detweiler et al., 2008) all improve mood, decrease agitation, result in lowered blood pressure, and increase well-being.

Findings such as those of both Detweiler et. al. (2008) and Raske (2010) have documented a soothing effect of gardens on PwD, lending support to Edward O. Wilson's theory of biophilia and Roger Ulrich's Psycho-evolutionary Theory. Most of Ulrich's research regarding Psycho-evolutionary Theory has involved natural conditions and healing effects such as faster recovery from surgery (1984). But other researchers have expounded on Ulrich's work to consider PwD particularly in regards to the challenges posed by agitated behavior which is symptomatic of dementia. A South Korean study, for example, found that indoor gardening not only significantly decreased agitated behavior in PwD, but that the participants also showed improvements in cognitive function on the Hasegawa's Dementia Scale-Revised test (Lee & Kim, 2008). The authors concluded that indoor gardening is effective to maintain and improve cognitive function of PwD.

The behavioral results in this study were surprising considering the many findings that support Psycho-evolutionary Theory in regards to the psychological benefits for PwD when they are exposed to natural elements. When the plants were in place apparent mood states and the types of behavior exhibited by the participants declined (see Figure 11. Comparison of Cognitive, Well/ill-being, and Behavior Category Scores), yet the cognitive scores indicate the opposite effect. The increased cognitive scores are consistent with expectations of Attention Restoration Theory. This may reflect differences in cognitive processing and social engagement.

However, confounds in this study may explain the results in the behavioral scores. The nursing students were present on days A1, A2 and B2. On A2, a day when the intervention had not been in place for two days, they played games with the residents which were not used on the other two days. These particular games elicited more enthusiastic and engaged responses from the residents than was typical. It is possible that the students' visit influenced the increased behavioral scores on that day and, by comparison, behavioral scores on other days appeared to decline. The students arrived during the morning cognitive testing session but did not participate in activities with the participants until later in the day, so their influence would have been limited to behavioral measures.

Interestingly, the literature does not reveal reliable comparisons of behavioral and cognitive data when assessing PwD. One of the challenges with cognitive testing with this population is inconsistencies in their willingness to cooperate. It seems likely that an

improved mood state and more engaged behavior would lead to improved cognitive performance. This would be a consideration for further study.

In addition to biophilia and Psycho-evolutionary Theory, another fruitful area of research is the connection of Attention Restoration Theory to cognitive skills in PwD, to manipulations in the built environment, and in particular, to the manipulation of interior space with elements reflecting natural conditions. The increase in scores on cognitive testing in this study is not reliable evidence that attention restoration was a factor but it is interesting to speculate that the presence of the plants may have afforded an opportunity for the participants to restore their attention and focus more clearly on the tasks at hand, i.e., cognitive testing. Methodology in future investigations should include a means to confirm that directed attention was fatigued prior to conducting cognitive evaluations. This is yet another promising area of future investigations.

This study contributed to the body of knowledge regarding the effects of an intervention on the cognitive function of PwD in two ways. The data in this study reveal some recurring patterns which may indicate that the presence of living, potted plants in the space positively affected the cognitive performance of the participants. These findings, though not statistically significant due to the small number of participants, encourage further study.

The development of methodology for evaluating cognitive function in Pwd was potentially the more significant contribution. The selection of testing instruments which could consistently demonstrate variations in function in this population was the most difficult aspect of the study. The instruments chosen were effective with most

participants, however, there were participants whose cognitive abilities were compromised to an extent that it was unclear if including their data added value to the analysis. During the course of this study we learned that there should be guidelines to determine what data should be included in the analysis. For instance, participants' data should be included only if they complete each testing opportunity and if they produce a minimum number of scores. The two participants who experienced rapid decline in this study would have been disqualified. Participant 1 did not complete testing on two of the five days. Two other participants produced five or fewer correct responses out of a possible 160. It is likely that their correct answers were random occurrences and compromised the study results.

There was no evidence in the data to support Psycho-evolutionary Theory. The modest improvements in cognitive performance after exposure to the intervention is insufficient to determine that there is a connection between PwD and Attention Restoration Theory. However, data in this study did show recurring patterns which may indicate that the presence of living, potted plants in the space affected the residents in positive ways. What this does demonstrate is the value of continuing the exploration of connections between PwD, cognition, and natural elements.



## CHAPTER VI

### CONCLUSIONS

There is empirical evidence to show that interactions with the natural world provide benefits for PwD. We are certain that positive psychological and physiological effects occur with either direct or indirect contact with nature. This study provides indications that there may be cognitive benefits as well. More research needs to be conducted to explore the cognitive connection, but what we already know about psychological and physiological effects is enough to warrant the consistent inclusion of biophilic elements in environments for PwD.

#### **Future Research**

Lessons learned during this study will assist in the design of the next iteration. Many of the challenges in this study could be overcome if the testing location were an adult day care facility. More participants would be available and their functional abilities would be more likely to demonstrate variations in cognitive performance. Higher functioning participants would also be more likely to agree to being tested twice in one day. This would allow for an A B A B design that could be completed in two testing days: one day with the intervention, plants, and one without. Participants would be tested, spend time in a space with plants (the intervention) and be tested sometime later the same day. The process would be repeated on another day but with no plants. Fewer plants

could have a more significant impact if their placement was limited to one space where participants would engage in activities and have meals.

This design is less costly and labor intensive than the current study which could make it possible to duplicate the procedure at other facilities and increase the number of participants. Plants would be required for only one day with each participant group, thus reducing the cost of rentals. In the previous study the plants had to be maintained for a 15 day period and placed three times. In this plan maintenance would not be required and the plants would be placed only once.

Lessons learned through this study will guide other methodology decisions, also. Guidelines should be in place to determine what data should be included in the analysis. Participants' data should be included only if they complete each testing opportunity and if they produce a minimum number of scores. Another instrument for accessing attention needs to replace the attention question from the Montreal Cognitive Assessment due to the inability of most participants to complete that evaluation. Dementia Care Mapping may not be included in the next iteration. Many other studies have made determinations about the connections with PwD and Psycho-evolutionary Theory. Observing participants for six hours at each data point is labor intensive. Applying those resources to explore new directions may be more prudent.

### **Going Forward with Design for Persons with Dementia**

Studies with PET show us that PwD benefit from physiological and psychological connections to nature and there is a possibility that there also could be cognitive benefits. But providing actual contact with the natural world is only one strategy for satisfying our

need to connect with nature. Biophilic design is “the deliberate attempt to translate an understanding of the inherent human affinity to affiliate with natural systems and processes” (Kellert and Heerwagen, 2008, p. 3).

When applying biophilic elements to interior design one may consider the three theories of environmental preference – evolutionary preference for terrain which has sustenance producing properties, an attraction for environments which provide prospect and refuge (opportunity and protection), and an affinity for a specific fractal range in foliage. Stephen Kellert’s six categories of elements and attributes of biophilic design include factors which relate to all three of these theories:

- environmental features
- natural shapes and forms
- natural patterns and processes
- light and space
- place-based relationships
- evolved human-nature relationships

This study explored the benefits of including the environmental features represented in living plants, but there are other methods for including this category and others in the built environment. For example, color, water, sunlight, and habitats and ecosystems are some of the environmental features Kellert suggests. Designers could select finishes and materials to mimic colors in nature. Fountains, pools or images of water scenes would introduce water into the interior environment, which would appease

our innate desire for life sustaining elements. Natural lighting through windows, clerestories, and skylights would benefit humans and plants.

The inclusion of aquariums or bird cages provide habitats and ecosystems. Empirical support for the benefits of aquariums is found in a study which explored how the installation of an aquarium in the dining rooms of memory care facilities could affect appetite. This is an important consideration because a loss of interest in food is common with PwD and can affect physical health. During the 10 week study with 70 participants, food intake increased resulting in an average weight gain of 2.2 pounds (Edwards & Beck, 2013). The researchers felt that these results support their conviction that a connection to the natural environment is so innate that it can survive advanced dementia.

Many design solutions can satisfy multiple biophilic attributes. Incorporating curving corridors to replace the long straight corridors common to many skilled nursing facilities would satisfy the element of curved lines in the natural shapes and forms category, and also the curiosity and enticement attribute in the evolved human-nature relationships category. Curving paths of carpet could substitute if curving corridors aren't possible. Providing both spacious rooms and smaller, intimate spaces satisfies spatial variability in the light and space category, complementary contrasts in the natural patterns and processes category, and prospect and refuge in the evolved human-nature relationships category. All of these approaches attempt to bridge the gap of the natural world our ancestors inhabited and the built environment that we live in now.

Studio classes in the Masters of Fine Arts program in Interior Architecture have provided opportunities for me to design spaces for PwD which incorporate living plants

and other biophilic elements. Figure 12 is an example of this work. The space was designed for an adult day care facility and intended to be used for many functions, including meditation, meetings, concerts, and social events. Visuals of natural elements are provided by a window wall open to a wooded setting and a skylight with a view of passing clouds. Natural light pours through the skylight which reflects from glass leaves suspended from the ceiling, providing a focal point for meditation. Biophilic elements are included with materials used in the floor, ceiling, and furnishings. Living plants - nourished by the irrigation systems in the four green wall panels - provide tactile, visual, and aromatic stimulation. Biomimicry is used in the glass panels flanking the green walls. Images of trees in the glass mimic the living trees seen through the window. Recessed lighting behind the panels creates the illusion of sunlight filtering through the branches. Our attraction to the fractal geometry range inherent in trees allows us to find pleasure in both the real and artificial trees.

Figure 12. Adult Day Care Center Meeting Room



Considering the generous amount of research that demonstrates the positive psychological and physiological effects of natural elements on PwD and the cognitive benefits suggested by this study and the horticultural therapy study (Lee & Kim, 2008), there are strong implications for how designers should approach creating spaces for memory care facilities. This study showed modest improvements in cognitive function with a relatively small number of plants, imagine what designers could do to improve the quality of life going beyond such a simple intervention.

Facilities could provide multiple ways for their users to access natural elements.

- Safe and accessible outdoor gardens
- Designs that provide infrastructure to support living plants in interiors: sunlight, easy maintenance, placement to support interaction, and enough

space to accommodate plants without interfering with other functions

- Indoor and outdoor spaces for horticultural therapy so that persons will have access to this resource in all seasons and weather conditions.
- Views of gardens from interior spaces.

Figure 13 demonstrates how plants can be included in indoor spaces to provide passive and interactive enjoyment of living plants. Interior window boxes are placed at a height which allows convenient visual access, but also allows persons who are not physically capable of gardening tasks which require reaching the ground to participate in horticultural activities. The orientation to the sun must be considered for light requirements for the plants, but also to avoid glare which can be painful for elderly eyes. In this dining setting edible plants are used and are intended to contribute to meals which are prepared and served in the space.

Figure 13. Adult Day Care Center Dining Room



Considering the many benefits of horticultural therapy for persons with dementia (Lee & Kim, 2008), the inclusion of in and outdoor gardening spaces should be a priority for memory care facilities. Figure 14 is an example of how an indoor space can accommodate gardening for this population. It allows space for supplies, accommodation for persons with physical disabilities, and sunlight. Furnishing and finish selections tolerate water and soil. Figure 15 demonstrates a functional design for outdoor gardening. Multiple levels of planters are available for gardeners who come in a variety of sizes and physical ability. Prospect and refuge is considered by providing open spaces with unencumbered views and protected alcoves which create privacy.



Figure 14. Residential Memory Care Facility Horticultural Therapy Space



Figure 15. Adult Day Care Facility Garden



The challenges provided by plant placement in this study gives some insight on specific directives for how facilities should be designed in order to accommodate living plants. Options for plant placement were limited by access to sunlight. Friends Home has clerestory windows over two of the primary public areas located in the center of the building. This was helpful, but probably not a long-term solution for many plant species, such as ficus. During the course of the study, the ficus trees were rotated to ensure that they were not without sunlight for lengthy periods of time. Adequate space was another issue. Many skilled nursing facilities already do not have enough room to accommodate ambulatory aids comfortably. Walkers and canes often obstruct pathways in sitting and dining rooms because their owners want to have them close by. The floor plan in Friends Home is better than many other facilities in this respect, but even there quarters were cramped in spots when plants were in place. Flooring materials are also a concern. Carpet might be vulnerable to damage by water or soil, especially if elderly residents with balance or strength problems were engaged to care for plants.

Careful decisions regarding plant selection and placement could promote resident interaction with the plants. Easy access and attracting attention are two considerations. Plants should be sized and placed so that elderly persons who are restricted in their ability to bend or reach would be able to touch the plants easily. For example, a potted plant only 12” high which sits on the floor may be visually appealing, but it is unlikely that it would be touched by a passersby. A six foot tall ficus tree would be a better choice, but it should not be placed with an obstacle between it and a resident. Interaction with the tree would not occur if it were placed in an alcove and blocked by furniture. Blooming plants

often require considerable maintenance, but residents would be stimulated by the flowers and receive benefits from nurturing them.

Both the physical environment and the level of care at Friends Home is excellent, as demonstrated by the five-star rating from Nursing Home Compare (Medicaid.gov, 2015), but this facility can still benefit from the addition of natural elements in the interior space. The primary sitting, dining, and activity rooms do not have windows or views of the outdoors. Murals of natural scenes could be placed on the walls in the corridor which surrounds these spaces (see Figure 2. Floor Plan). The current placement of dining tables on the perimeter of the dining room could be changed in order to accommodate large trees in each corner. The same could be done in the activity room. Furniture would also need to be adjusted in the smaller sitting area to allow room for more plants. Currently, the lack of natural lighting in the primary sitting room restricts the use of living plants in the space, but there are types of artificial light which can support some species of plants. The rarely used sunroom could easily be transformed into an indoor gardening space with new furnishings. The small, enclosed outdoor garden is oriented to accommodate a vegetable garden. Seating and a circular walkway are already in place; a few planter tables and storage for supplies would allow residents to benefit from horticultural therapy. These suggestions show that even in existing facilities with a modest budget it is possible to create environments which accommodate our need for natural connections.

Designing for the needs and desires of the end user is always the priority of good designers, and especially true for those who design for PwD. It is the designer's

responsibility to provide therapeutic environments that are designed for deteriorating physical and cognitive competencies and assist in increasing occupants' quality of life.

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## APPENDIX A

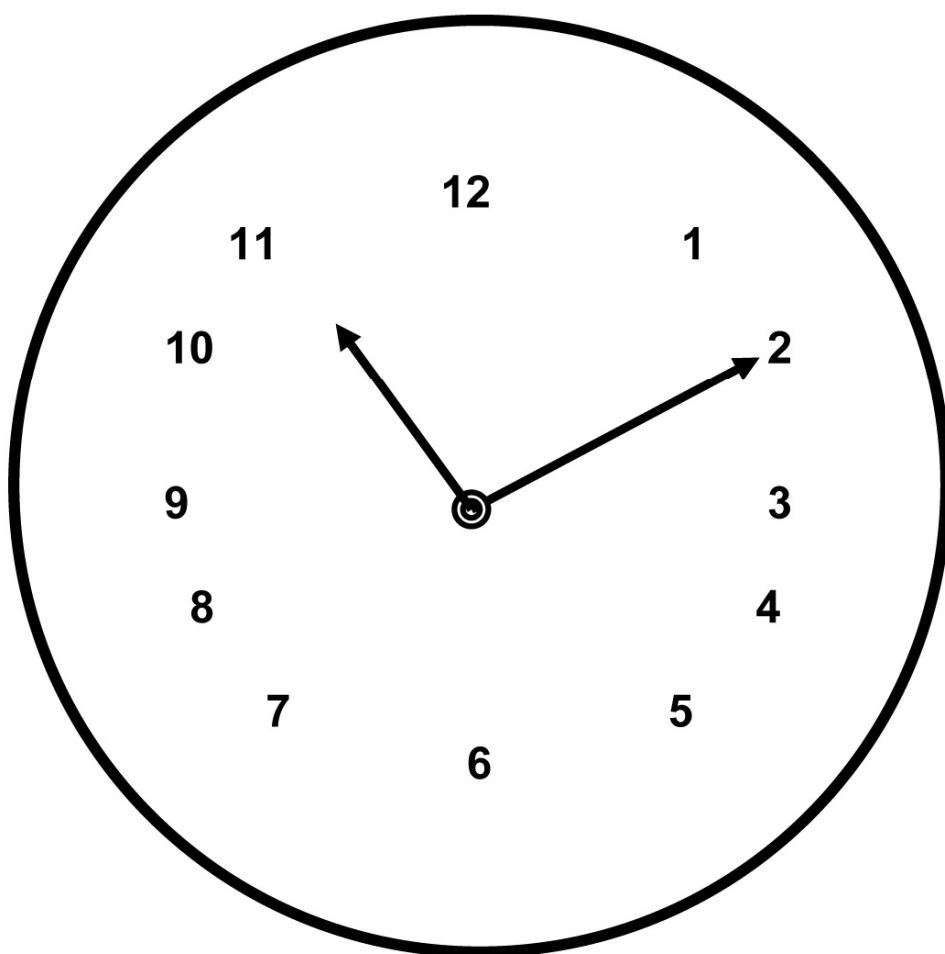
### ORIGINAL COGNITIVE TESTING PROCEDURE RESULTS

Participant	Time	Change	Trail-making	MoCA	Total
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	1	1	1	0	3
9	0	1	0	4	5
10	0	0	0	0	0
11	0	0	0	0	0

APPENDIX B

CLOCK GRAPHIC

**Time and Change Test:  
Tell the Time**



## APPENDIX C

### COGNITIVE SCORING RUBRIC

Cognitive Evaluation Scoring Rubric				
Score	Time & Change, time section	Time & Change, change section	Trail-making	MoCA, item 2 in attention section
4	correct score on first attempt in less than 15 seconds	correct score on first attempt in less than 30 seconds	24 correct parings in less than 120 seconds	11 appropriate taps
3	correct score on first attempt in less than 30 seconds	correct score on first attempt in less than 60 seconds	16 to 20 correct parings in less than 120 seconds	8 to 10 appropriate taps
2	correct score on second attempt in less than 15 seconds	correct score on second attempt in less than 30 seconds	11 to 15 correct parings in less than 120 seconds	4 to 7 appropriate taps
1	correct score on second attempt in less than 30 seconds	correct score on second attempt in less than 60 seconds	5 to 10 correct parings in less than 120 seconds	1 to 3 appropriate taps
0	no correct scores	no correct scores	0 to 4 correct pairings in less than 120 seconds	0 appropriate taps

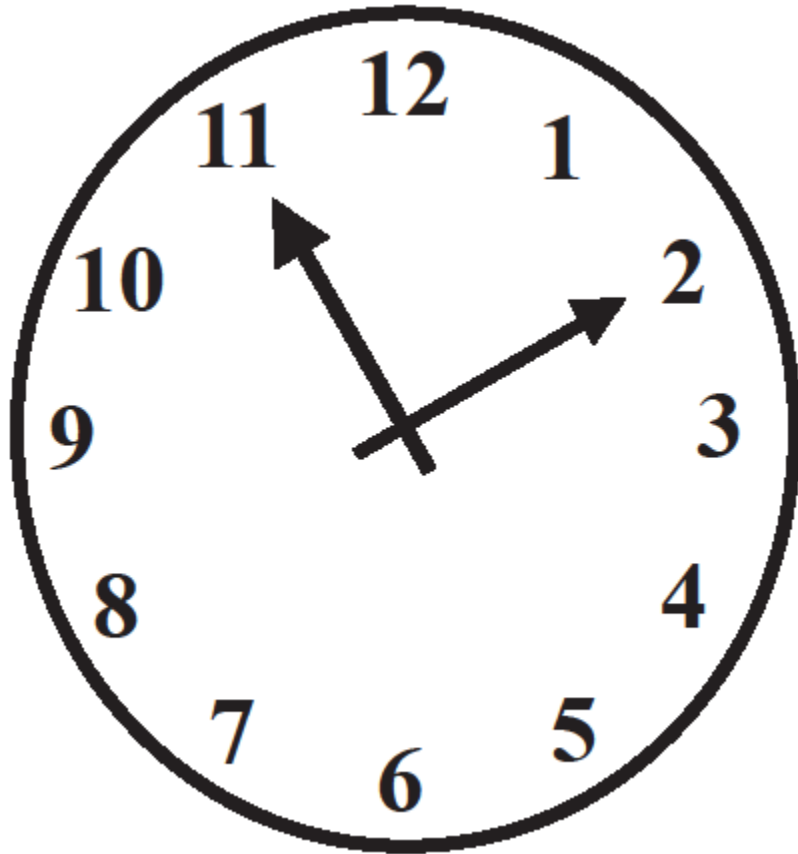
## APPENDIX D

### REVISED COGNITIVE SCORING RUBRIC

COGNITIVE EVALUATION SCORING RUBRIC								
Participant						Evaluator		Date
#	Time & Change TIME section	Time & Change IDENTIFY COINS	Time & Change CHANGE section	TRAIL-MAKING written	TRAIL-MAKING point	MoCA, ITEM 2 in attention section	COLOR	COLOR & SHAPES
4	Correct hour and minutes on first attempt	4 coin types identified	Correct score on all coin types	15 to 24 correct parings	15 to 24 correct parings	11 appropriate taps	4 colors identified	3 same color squares placed correctly
3	Correct hour and minutes on second attempt	3 coin types identified	Correct score on 3 coin types	8 to 15 Correct parings	8 to 15 correct parings	8 to 10 appropriate taps	3 colors identified	3 same color squares placed touching
2	Correct hour on first attempt	2 coin types identified	Correct score on 2 coin types	3 to 7 Correct parings	3 to 7 Correct parings	4 to 7 appropriate taps	2 colors identified	3 same color squares placed
1	Correct hour on second attempt	1 coin type identified	Correct score on 1 coin type	1 to 2 correct parings	1 to 2 Correct parings	1 to 3 Appropriate taps	1 color identified	3 same color squares identified
0	0 correct time	0 coin types identified	0 correct scores	0 correct pairings	0 correct pairings	0 appropriate taps	0 colors identified	0 identifications .

APPENDIX E

REVISED CLOCK GRAPHIC





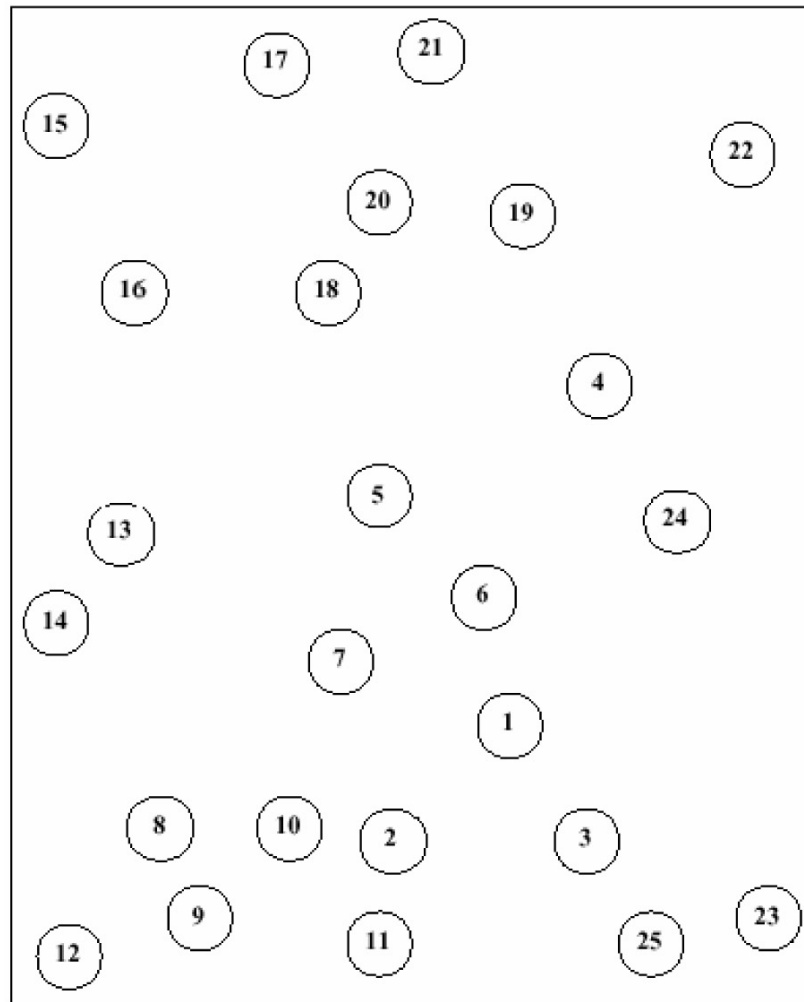
## APPENDIX F

### TRAIL-MAKING TEST GRAPHIC

#### Trail Making Test Part A

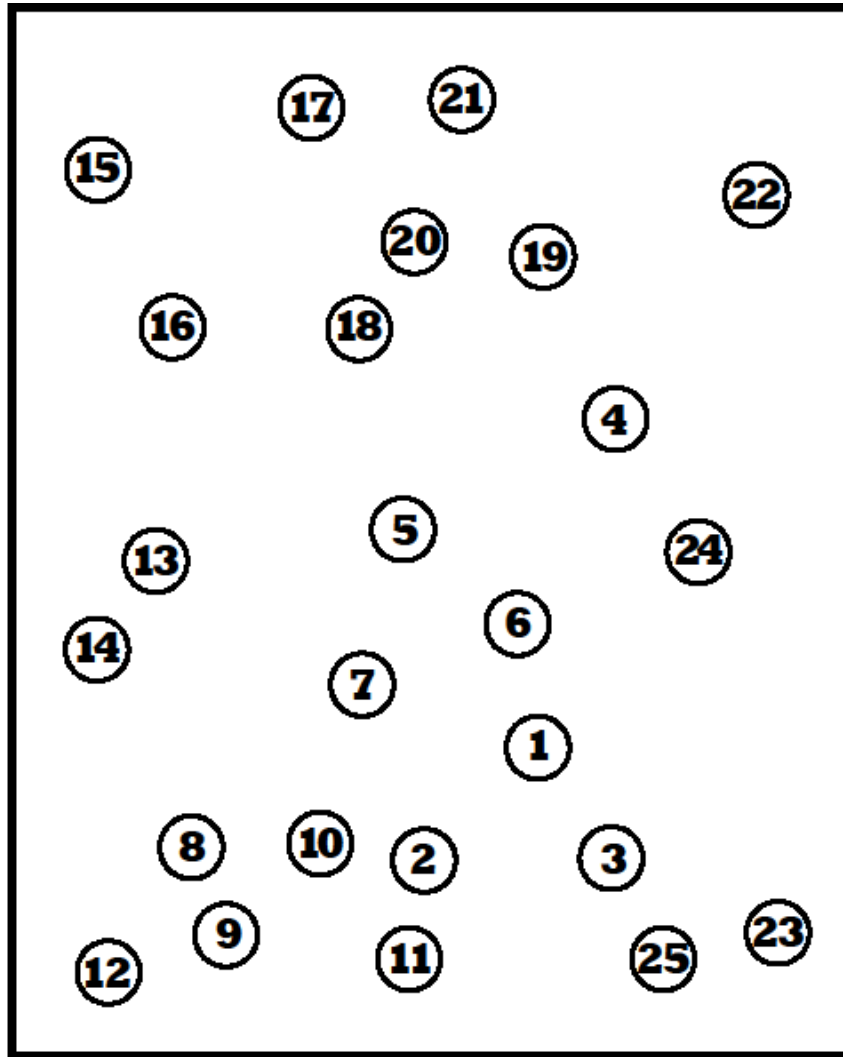
Patient's Name: \_\_\_\_\_

Date: \_\_\_\_\_



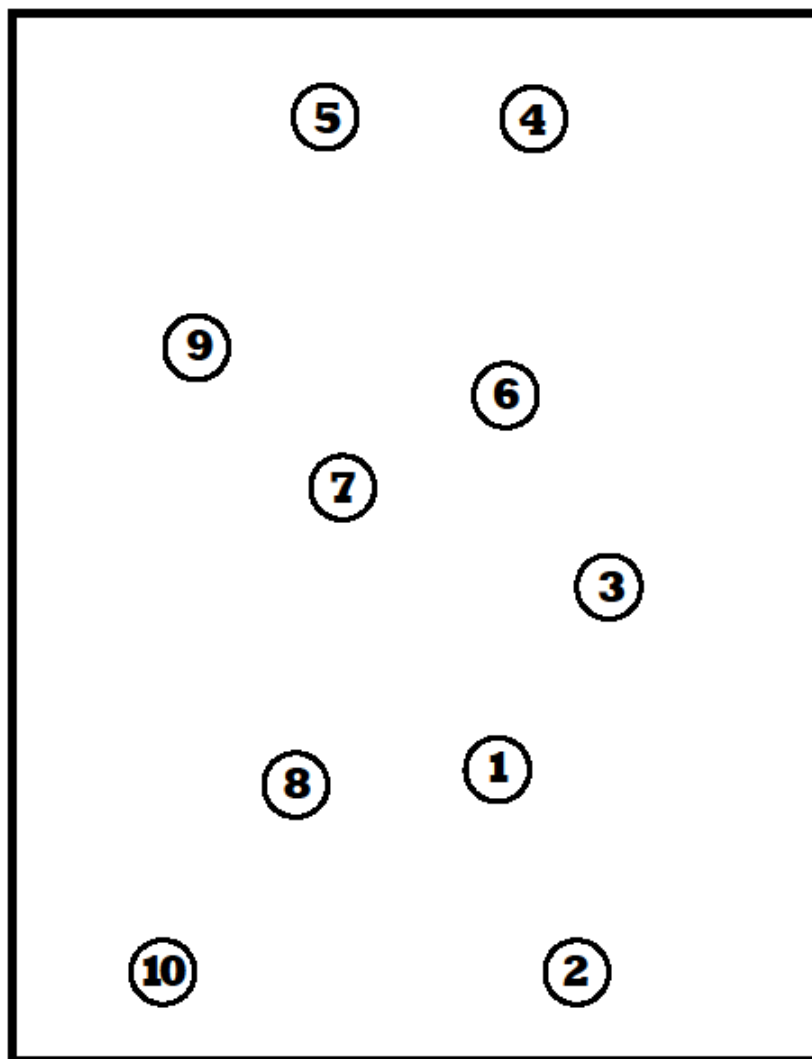
APPENDIX G

REVISED TRAIL-MAKING TEST GRAPHIC



## APPENDIX H

### SIMPLIFIED TRAIL-MAKING TEST GRAPHIC



# APPENDIX I

## MONTREAL COGNITIVE ASSESSMENT

MONTREAL COGNITIVE ASSESSMENT (MOCA)				NAME : _____		Date of birth : _____	
				Education : _____		Sex : _____	
				DATE : _____			
<b>VISUOSPATIAL / EXECUTIVE</b>				Copy cube		Draw CLOCK (Ten past eleven) (3 points)	
						<div style="display: flex; justify-content: space-around;"> <div><input type="checkbox"/> Contour</div> <div><input type="checkbox"/> Numbers</div> <div><input type="checkbox"/> Hands</div> </div>	
						___/5	
<b>NAMING</b>							
[ ]				[ ]		[ ]	
						___/3	
<b>MEMORY</b>							
Read list of words, subject must repeat them. Do 2 trials. Do a recall after 5 minutes.				FACE	VELVET	CHURCH	DAISY
1st trial							
2nd trial							
				No points			
<b>ATTENTION</b>							
Read list of digits (1 digit/ sec.). Subject has to repeat them in the forward order				[ ] 2 1 8 5 4			
Subject has to repeat them in the backward order				[ ] 7 4 2			
Read list of letters. The subject must tap with his hand at each letter A. No points if 2 or more errors				[ ] FBACMNAAIKLBFAKDEAAAJAMOFAB			
Serial 7 subtraction starting at 100				[ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65			
4 or 5 correct subtractions: 3 pts, 3 or 2 correct: 2 pts, 1 correct: 1 pt, 0 correct: 0 pt				___/3			
<b>LANGUAGE</b>							
Repeat : I only know that John is the one to help today. [ ]				___/2			
The cat always hid under the couch when dogs were in the room. [ ]				___/1			
Fluency / Name maximum number of words in one minute that begin with the letter F				[ ] _____ (N ≥ 11 words)			
<b>ABSTRACTION</b>							
Similarity between e.g. banana - orange = fruit				[ ] train - bicycle [ ] watch - ruler			
<b>DELAYED RECALL</b>							
Has to recall words WITH NO CUE				FACE	VELVET	CHURCH	DAISY
Category cue							
Multiple choice cue							
				Points for UNCUE recall only			
				___/5			
<b>ORIENTATION</b>							
[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City				___/6			
© Z. Nasreddine MD Version November 7, 2004				Normal ≥ 26 / 30			
www.mocotest.org				TOTAL			
				___/30			
				Add 1 point if ≤ 12 yr edu			

## APPENDIX J

### DEMENTIA CARE MAPPING SCORING MATRIX

Code	Memory Cue	General Description of Category
A	Articulation	Interacting with others, verbally or otherwise – with no obvious accompanying activity
B	Borderline	Being socially involved, but passively
C	Cool	Being socially uninvolved, withdrawn
D	Distress	Unattended distress
E	Expressive	Engaging in an expressive or creative activity
F	Food	Eating, drinking
G	Games	Participating in a game
H	Handicraft	Participating in a craft activity
I	Intellectual	Actively prioritizing the use of intellectual abilities
J	Joints	Participating in exercise or physical sports
K	Kum and Go	Independent walking, standing, or wheelchair moving
L	Labour	Performing work or work-like activity
M	Media	Engaging with media
N	Nod, land of	Sleeping, dozing
O	Own care	Independently engaging in self-care
P	Physical care	Receiving practical, physical or personal care
R	Religion	Participating in a religious activity
S	Sex	Activity related to explicit sexual expression
T	Timulation	Direct engagement of the senses
TP	Timulation/Plant	Direct engagement of the senses with plants
U	Unresponded to	Communicating without receiving a response
V	Vacant	Person has left the space
W	Withstanding	Repetitive self-stimulation

X	X-cretion	Episodes related to excretion
Y	Yourself	Talking to oneself, or an imagined person, hallucination
Z	Zero option	Behaviors that fit no existing category

## APPENDIX K

### PERCENTAGE OF INDIVIDUAL CHANGED COGNITIVE SCORES BY PAIRED TEST DAYS

Participant 1		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	25.0%	37.5%	37.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	62.5%	25.0%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	0.0%	85.7%	14.3%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	0.0%	85.7%	14.3%

Participant 2		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	75.0%	12.5%	12.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	25.0%	62.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	0.0%	50.0%	50.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	12.5%	50.0%	37.5%

Participant 3		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	12.5%	87.5%	0.0%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	0.0%	87.5%	12.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	25.0%	75.0%	0.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	0.0%	100.0%	0.0%

Participant 4		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	0.0%	87.5%	12.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	87.5%	0.0%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	0.0%	100.0%	0.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	0.0%	87.5%	12.5%



Participant 5		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	12.5%	50.0%	37.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	75.0%	12.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	50.0%	37.5%	12.5%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	0.0%	100.0%	0.0%

Participant 6		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	25.0%	50.0%	25.0%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	50.0%	37.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	50.0%	25.0%	25.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	12.5%	75.0%	12.5%

Participant 7		Percentage of Changed Scores		
Paired Test Day Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	37.5%	25.0%	37.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	75.0%	12.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	50.0%	25.0%	25.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	25.0%	50.0%	25.0%

Participant 8		Percentage of Changed Scores		
Test Period Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	62.5%	37.5%	0.0%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	12.5%	37.5%	50.0%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	25.0%	37.5%	37.5%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	50.0%	37.5%	12.5%

Participant 9		Percentage of Changed Scores		
Test Period Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	37.5%	37.5%	25.0%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	25.0%	62.5%	12.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	0.0%	62.5%	37.5%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	12.5%	50.0%	37.5%

Participant 10		Percentage of Changed Scores		
Test Period Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	62.5%	25.0%	12.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	25.0%	37.5%	37.5%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	50.0%	25.0%	25.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	37.5%	50.0%	12.5%

Participant 11		Percentage of Changed Scores		
Test Period Comparisons		Positive (Improved)	Zero (Unchanged)	Negative (Declined)
B1 – A1	1st exposure to plants, in place 5 days (B1) minus Baseline (A1)	0.0%	62.5%	37.5%
A2 – B1	No plants in place for 2 days (A2) minus 1st exposure to plants, in place 5 days (B1)	25.0%	50.0%	25.0%
B2 – A2	2nd exposure to plants, in place for 5 days (B2) minus No plants in place for 2 days (A2)	50.0%	25.0%	25.0%
B3 – A2	3 <sup>rd</sup> exposure to plants, in place for 7 days (B3) minus No plants in place for 2 days (A2)	50.0%	37.5%	12.5%

## APPENDIX L

### PARTICIPANT DESCRIPTIONS AND TESTING OBSERVATIONS

#### **Participant One**

##### Description

Participant One was an 82 year old Caucasian, Methodist, male college graduate who had resided in the Birches for four years. He had severe dementia, was non-ambulatory, and had adequate vision with eye glasses. Staff reported that he would exhibit restlessness and maneuver the wheelchair with his feet. They also warned the researchers that Participant One would occasionally attempt to strike others with his hands or feet.

##### Testing Observations

Participant One had difficulty maintaining engagement and comprehending instructions during cognitive testing. The lack of focus would sometimes be a result of his worrying about a problem at his work. It was difficult for the researchers to re-direct him back to the tests because he would insist that they listen to him describe the problem. Participant One's inability to stay attentive made it impossible to administer the Trail-making test and the attention section of MoCA. He was able to use a pencil and drew on the Trail-making form, but did not follow directions. Participant One only produced scores on three other testing instruments. He identified the hour on the clock graphic twice, identified colors on two testing days, and placed same color blocks beside one another once. On Day A2 (no intervention for two days) Participant One did not get out of bed until 11:00 a.m. and appeared to be groggy during testing. He slept through the

testing period on Day B2 (intervention had been in place for two days). On Day B3 he was agitated and uncooperative, refusing to participate in testing (intervention had been in place for seven days). He did not calm down until much later in the afternoon when his wife arrived and sat with him.

## **Participant Two**

### **Description**

Participant Two was a 72-year-old Caucasian, Presbyterian, female college graduate who had resided in the Birches for 20 months. She had early onset dementia which began in her 50's and was progressing rapidly at the time of the study. There were no other impairments; she had adequate vision with eye glasses and was independently ambulatory. The staff reported her to have a "sunny disposition, friendly, and pleasant most of the time." After talking with her, one of the researchers reported that he was surprised to learn that she was a resident of the Birches. Her illness was not apparent during their conversation.

### **Testing Observations**

Participant Two was cooperative during testing, but often appeared to be embarrassed when she was unable to find the answer to a question. She could use a pencil and seemed to comprehend instructions for the Trail-making test, but gave the impression that she had difficulty focusing. After drawing a few lines she would look at the researcher, smile, and begin conversing. The apparent inability to concentrate may have also contributed to her scores on the attention section of MoCA. She was successful with both the Color and Shapes test, which all but the lowest functioning participant could do,

which was not surprising. What was surprising is how well she did on the Change test, in which the evaluator places coins on the table and the participant is asked to identify when the value of the coins totals a specific amount. Only three other participants produced positive scores on this test on more than one day. One of the research assistants suggested that her career as a math teacher could have been a factor.

### **Participant Three**

#### Description

Participant Three was an 89-year-old Caucasian female with no known religious affiliation. She had been a resident of the Birches for 10 months. Staff described her as having “moderate dementia, primarily memory loss.” She had adequate vision with eye glasses. Ambulation was accomplished independently, but she has continued to use a walker after recovering from a hip fracture.

#### Testing Observations

The only testing directions Participant Three appeared to understand were those for the color identification exercise. Her mood seemed to vary considerably from session to session. For instance, on Day A1 she was interactive and did not seem to mind being asked the testing questions, but on Day A2 she was agitated and talked to herself during the session.

### **Participant Four**

#### Description

Participant Four was an 80-year-old Caucasian, protestant female who had resided in the Birches for 20 months. Staff reported her as having moderate dementia. There were

no other impairments; her vision was satisfactory with glasses and she ambulated independently.

#### Testing Observations,

The moderate dementia diagnosis surprised the researchers due to her apparent disinterest in conversing with others or participating in testing. It was difficult for them to coax Participant Four into answering questions. She refused to attempt to use a pencil for the Trail-making test. She was more responsive to a researcher's attempt to engage her on Day B1 while she was intently focused on a coloring activity. She produced the lowest scores in the participant group.

### **Participant Five**

#### Description

Participant Five was a 92-year-old Caucasian, Methodist, male, college graduate who had resided in the Birches for three years and two months. He had moderate to severe dementia and was described by staff as having “[failed] to thrive.” He had substantial hearing loss which inhibited his ability to communicate with others even with the assistance of hearing aids. His non-ambulatory status resulted in his spending much of his time in a wheelchair. The staff reported that he did not seem interested in engagement with others and dozed frequently.

#### Testing Observations

Participant Five had difficulty maintaining engagement and comprehending instructions during cognitive testing. His inability to stay engaged made it impossible to administer the Trail-making test and the attention section of MoCA. He was cooperative



and obviously attempted to answer the researcher's questions, but his problems with comprehension interfered. For instance, at one point when the researcher was asking him to identify the colors of the paper squares he seemed to be trying to identify shapes, answering "it is a sphere."

Participant Five only appeared to demonstrate any consistent ability to perform parts of three of the tests. He was able to identify the hour on the clock graphic - but not minutes - twice, identified one coin type at two sessions, and identified at least one color during three testing sessions. There were three more tests where he scored one point on one testing day, which may have been accidental occurrences. For example, during the Change section of the Time and Change test he was asked to tell the evaluator when she had placed coins on the table whose value equaled a specified amount. He was able to do this once with sixteen opportunities. On Days B1 and A2 Participant Five was very sleepy and this seemed to affect his performance. He did not get out of bed on Day B3.

### **Participant Six**

#### **Description**

Participant Six was a 95-year-old Caucasian, protestant, male college graduate who had resided in the Birches for two months. He had severe dementia, was ambulatory with maximum assistance, and had adequate vision with eye glasses. The staff reported that he did not initiate interactions with others but seemed pleased to converse when offered the opportunity. He often articulated confusion regarding his present situation.

### Testing Observations

Participant Six was oppositional during the session with the original cognitive testing method. He seemed suspicious of the researcher's motives. A staff member suggested that his testing time should be delayed until his morning medications had taken effect. This directive was followed for each of the subsequent five testing sessions. There was an improvement in his willingness to cooperate. He had difficulty maintaining engagement and comprehending instructions during cognitive testing. His inability to stay engaged made it impossible to administer the Trail-making test and the attention section of MoCA. He scored consistently on only two tests, coin identification on the Time and Change test and Color Identification.

### **Participant Seven**

#### Description

Participant Seven was an 82-year-old Caucasian, Quaker, male, grade school graduate who had resided in the Birches for two weeks. He had moderate to severe dementia with significant loss of function. His condition was deteriorating quickly during the time of the study. He had adequate vision with eye glasses but required extensive assistance ambulating. The staff reported him to be reserved but open to talking with others.

### Testing Observations

Participant Seven was cooperative during testing and produced the second highest scores in the participant group. He appeared to understand directions and replied appropriately, but periodically it was necessary for the researcher to bring Participant Seven's attention back to the task. He had difficulty with a pencil, but was able to perform quite well on the writing version of the Trail-finding test on two days. It was unclear if either he did not understand or was unable to perform the MoCA test. Typically he did not volunteer conversation, but on Day A2 pointed out to the researcher that the plants were missing.

### **Participant Eight**

#### Description

Participant Eight was a 98-year-old Caucasian, Presbyterian, female college graduate who had resided in the Birches for four months. She had moderate dementia, adequate vision with eye glasses, and ambulated independently with a walker. The walker became necessary following a hip fracture.

#### Testing Observations

Participant Eight was cooperative with testing during Days A1 and B1, but for the remainder of the study demonstrated considerable resistance. She appeared to be suspicious of the researchers' motives or insulted by the simplicity of the tasks. However, once engaged she seemed to understand directions and was capable of doing all of the tests; she produced the highest scores in the participant group.

## **Participant Nine**

### **Description**

Participant Nine was an 86-year-old Caucasian, Methodist female who had resided in the Birches for 16 months. She had moderate dementia but appeared to have no other impairments. She spoke softly and was often quiet, but was eager to engage in conversation with the researchers.

### **Testing Observations**

Participant Nine was cooperative with testing, appeared to comprehend directions, and was capable of doing each of the tests; she produced the third highest scores in the participant group. Even when she was unable to provide a correct answer she would often demonstrate the ability to reason. For instance, when asked to identify a penny she commented that it looked like a dime but was the wrong color.

## **Participant Ten**

### **Description**

Participant Ten was an 80- year-old Caucasian Quaker male college graduate who had resided in the Birches for 22 months. He had moderate dementia. He had adequate vision with eye glasses and ambulated independently. The staff reported that he seemed to enjoy walking much of the day and engaged staff and visitors in conversation frequently. Participant Ten's social behavior suggested that he would be capable of performing as well as or better than all other residents, but that was not the case.

### Testing Observations

Participant Ten was cooperative during the testing process and seemed eager to please the researchers. However, he appeared to be more interested in conversing than staying on task; the researchers had to redirect him frequently. It was unclear if this behavior indicated only enjoyment with conversation, or if he was wanting to hide an inability to perform the task. Many times when he was asked questions he would smile, but look a bit anxious until the researcher moved to the next test. Another difficulty was his apparent uncertainty with how to hold a pencil. This interfered with his performance on the written version of the Trail-making test. He had only moderate success with the pointing version of the test. During three testing sessions he was able to point to just a few numbers in proper sequence. It was unclear if he did not understand or was unable to perform the item from MoCA which tested attention. On the Time test he identified the hour on two days, but seemed to struggle and be uncomfortable. He only identified the name of one coin one day and two coins another. He told the evaluator when she had placed the proper number of coins to equate to a particular value once, but only doing this once out of sixteen attempts could indicate that he arrived at the proper score accidentally. The only tests that he seemed confident doing were the Color Identification and Shape exercise. He identified at least two colors, but usually all four, every day. On all but the first day he placed like color squares into a rectangular shape.

## **Participant Eleven**

### **Description**

Participant Eleven was an 86-year-old Caucasian, Methodist female who had resided in the Birches for three years. Staff designated her as having “high-functioning dementia with memory loss.” She seemed unaware of her husband’s recent death. Ambulation was accomplished independently with the aid of a walker. She had adequate vision with eye glasses. A staff member described her as being “good-natured and enjoys being with people.”

### **Testing Observations**

Participant Eleven was generally cooperative during the testing process and seemed eager to please the researchers, smiling when she was able to provide answers. The one exception was Day B3 when she resisted leaving an art project. A staff member assisted with the transition from art activity to testing and commented that Participant Eleven “can be kind of OCD (Obsessive Compulsive Disorder) sometimes.” Participant Eleven typically remained engaged with testing, but appeared to lose track of the task when doing the Trail-making test independently. Instead of drawing lines from the numbers in numerical order she would draw circles around the numbers. The attention section of MoCA was also problematic for her. She continued to stay engaged, but seemed to be unable to discriminate between the “A” and other letters. She tapped the table almost every time a letter was spoken. Her ability to tell time varied. Twice she was able to tell hour and minutes, twice she could only tell minutes, and once she did not communicate either. She typically had success with identifying coins, colors, and shapes.