2016

The effects of biophilic design in interior environments on noise perception: Designing a person-centered biophilic space for older adults

Jingfen Guo
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/etd

Part of the Architecture Commons, Art and Design Commons, Family, Life Course, and Society Commons, and the Gerontology Commons

Recommended Citation
Guo, Jingfen, "The effects of biophilic design in interior environments on noise perception: Designing a person-centered biophilic space for older adults" (2016). Graduate Theses and Dissertations. 15709.
https://lib.dr.iastate.edu/etd/15709

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Graduate Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
The effects of biophilic design in interior environments on noise perception: Designing a person-centered biophilic space for older adults

by

Jingfen Guo

A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

MASTER OF FINE ARTS

Major: Interior Design

Program of Study Committee:
Jihyun Song, Major Professor
Frederic Malven
Jennifer Margrett

Iowa State University
Ames, Iowa

2016

Copyright © Jingfen Guo, 2016. All rights reserved.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>viii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>ix</td>
</tr>
<tr>
<td>CHAPTER I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1. Problem Statement</td>
<td>1</td>
</tr>
<tr>
<td>2. My Study</td>
<td>6</td>
</tr>
<tr>
<td>3. Thesis Questions</td>
<td>8</td>
</tr>
<tr>
<td>4. Scope</td>
<td>9</td>
</tr>
<tr>
<td>CHAPTER II LITERATURE REVIEW</td>
<td>11</td>
</tr>
<tr>
<td>1. Past and Current Development of Biophilic design</td>
<td>11</td>
</tr>
<tr>
<td>2. Biophilic Design Attributes and their Benefits</td>
<td>12</td>
</tr>
<tr>
<td>3. Influences of Audiovisual Interaction on Noise Perception</td>
<td>19</td>
</tr>
<tr>
<td>4. Methods for Audiovisual Experiments</td>
<td>25</td>
</tr>
<tr>
<td>5. Sensory and Person-centered Design</td>
<td>27</td>
</tr>
<tr>
<td>6. Significance</td>
<td>32</td>
</tr>
<tr>
<td>CHAPTER III METHODOLOGY</td>
<td>34</td>
</tr>
<tr>
<td>1. Design</td>
<td>34</td>
</tr>
<tr>
<td>2. Preliminaries to actual study</td>
<td>36</td>
</tr>
<tr>
<td>2.1 Recruitment</td>
<td>36</td>
</tr>
<tr>
<td>2.2 Pilot Study</td>
<td>37</td>
</tr>
<tr>
<td>2.3 Actual Study- Visual Experiment</td>
<td>38</td>
</tr>
<tr>
<td>2.4 Actual Study- Audiovisual Experiment</td>
<td>44</td>
</tr>
<tr>
<td>3. Content Analysis</td>
<td>48</td>
</tr>
<tr>
<td>4. Quantitative data analysis</td>
<td>49</td>
</tr>
</tbody>
</table>
CHAPTER IV  RESULTS ............................................................................................................. 50

Demographic Information................................................................................................. 50
Visual Experiment Results............................................................................................... 50
Graphic Representations of visual experiment results ..................................................... 55
Audiovisual Experiment Results...................................................................................... 60
Audiovisual Experiment Subjective Results .................................................................... 65
Summary ........................................................................................................................... 66

CHAPTER V  DISCUSSION AND DESIGN SOLUTIONS .................................................... 67

Discussion of Results Relating to First Research Question............................................ 67
Discussion of Results Relating to Second Research Question ........................................ 68
Limitations and Future Research .................................................................................... 69
Conclusion with Design Solutions .................................................................................. 70

REFERENCES ................................................................................................................ 83

APPENDIX A INSTITUTIONAL REVIEW BOARD APPROVAL......................................... 91
APPENDIX B VISUAL QUALITY EVALUATION .............................................................. 92
APPENDIX C RATING FOR (SUBJECTIVE) LOUDNESS

AND ANNOYANCE (MODIFIED) .................................................................................... 94
APPENDIX D EMAIL SENT TO POSSIBLE PARTICIPATORY NURSING FACILITIES .................................................................................................................. 98
APPENDIX E INTRODUCTORY SCRIPT ...................................................................... 99
APPENDIX F INFORMED CONSENT DOCUMENT .................................................... 100
APPENDIX G RECRUITMENT SCRIPT .......................................................................... 103
APPENDIX H FLYER ....................................................................................................... 104
APPENDIX I A QUESTIONNAIRE ................................................................................. 105
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Restorative Environment Design and Biophilic Design</td>
<td>4</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Three Types of Encounters with Biophilic Attributes</td>
<td>6</td>
</tr>
<tr>
<td>Figure 3</td>
<td>A Conceptual Model of Factors that Influence Noise Perception in Interior Spaces</td>
<td>7</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Biophilic Design Attributes Organized According to Three “Experiences”</td>
<td>13</td>
</tr>
<tr>
<td>Figure 5</td>
<td>A Conceptual Map of Factors that Influence Noise Annoyance (Li, 2011)</td>
<td>24</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Three Basic Concepts for Developing Comprehensive Guideline for Designing a Person-centered Biophilic Space for Older Adults</td>
<td>33</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Word “Stressful” Replaced by “Annoying”</td>
<td>38</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Process, Instruments and Analytical Method Used in Visual Experiment</td>
<td>39</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Sketch of Room and Identification of Visual Surfaces</td>
<td>39</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Visual Stimuli and Color Palette</td>
<td>41</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Six Sequences when “A” was Placed in the First Position</td>
<td>42</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Twenty-Four Sequences for Visual Stimuli</td>
<td>42</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Visual Experiment Procedures</td>
<td>43</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Visual Stimuli for Training Participants</td>
<td>44</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Process, Instruments and The Analytical Method Used in Audiovisual Experiment</td>
<td>45</td>
</tr>
</tbody>
</table>
Figure 16  Testing Equipment Settings ........................................................................ 47
Figure 17  Experiment Rooms .................................................................................... 47
Figure 18  Audiovisual Experiment Procedures ......................................................... 48
Figure 19  Word Count of Positive Features, Comparing “General Comments” with “Biophilic Design Attributes” When Viewing Image A, B, C And D ................................................................. 54
Figure 20  Word Count of Negative Features on Attractiveness Viewing all Images ......................................................................................................................... 55
Figure 21  Comments and Subjective Attractiveness Ratings on Image A .................. 56
Figure 22  Comments and Subjective Attractiveness Ratings on Image B .................. 57
Figure 23  Comments and Subjective Attractiveness Ratings on Image C ................. 58
Figure 24  Comments and Subjective Attractiveness Ratings on Image D ................. 59
Figure 25  Noise Annoyance Rating Scores When Viewing Images A, B, C and D ........ 65
Figure 26  Subjective Loudness Rating Scores When Viewing Image A, B, C and D .......................................................... 65
Figure 27  Comprehensive Guideline for Designing A Person-centered Biophilic Space for Older Adults ................................................................. 72
Figure 28  “Before” Image of the Redesigned Dining Room ....................................... 73
Figure 29  Illustrations Of the Settings of Redesigned Dining Space .......................... 74
Figure 30  Illustrations of Noise Problems Existing in Redesigned Dining Space .......... 75
Figure 31  Illustrations of Strategies for Redesigning Dining Space ............................ 76
Figure 32  The Entry of the “Back Dining Room” .................................................. 77
Figure 33  The “Family Corner” at the “Back Dining Room” .......................... 78
Figure 34  Overall Design of the “Back Dining Room” .................................. 79
Figure 35  “Back Dining Room” Floor Plan and Reflect Ceiling Plan .......... 80
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Overview of Reviewed Studies with Regard to Variables, Research Methods, and Results.</td>
<td>20</td>
</tr>
<tr>
<td>Table 2</td>
<td>Finishes for Visual Stimuli A, B, C and D</td>
<td>40</td>
</tr>
<tr>
<td>Table 3</td>
<td>Subjective Attractiveness Rating Scores for Images</td>
<td>51</td>
</tr>
<tr>
<td>Table 4</td>
<td>Ranking on the most attractive to the least attractive image</td>
<td>52</td>
</tr>
<tr>
<td>Table 5</td>
<td>Content Analysis on Interior Spaces A, B, C, and D</td>
<td>53</td>
</tr>
<tr>
<td>Table 6</td>
<td>Subjective Sound Rating Scores for Image Groups</td>
<td>60</td>
</tr>
<tr>
<td>Table 7</td>
<td>Pearson’s Product Moment Correlations for Sound Rating with Visual Evaluations</td>
<td>61</td>
</tr>
<tr>
<td>Table 8</td>
<td>Pearson’s Product Moment Correlations for Overall Sound Rating with Overall Visual Evaluations</td>
<td>63</td>
</tr>
<tr>
<td>Table 9</td>
<td>Pearson’s Product Moment Correlations between Subjective Loudness and Annoyance</td>
<td>64</td>
</tr>
<tr>
<td>Table 10</td>
<td>Pearson’s Product Moment Correlations for Sound Ratings (S1) with Hearing Loss Level</td>
<td>64</td>
</tr>
<tr>
<td>Table 11</td>
<td>Pearson’s Product Moment Correlations for Sound Ratings (S2) with Hearing Loss Level</td>
<td>64</td>
</tr>
</tbody>
</table>
ACKNOWLEDGMENTS

I would like to thank my major professor Jihyun Song as well as my other committee members, Fred Malven and Jennifer Margrett, for their guidance and support throughout the course of this research. I would like to give my special thank to my major professor for her invaluable assistance, as well as her patience. I would also like to thank my writing consultant, Anna Prisacari for her professional guidance on academic writing.

In addition, I would also like to thank my family including my husband James and my son Gabriel who give me support throughout my study. I would also like to thank my friends, colleagues, the department faculty and staff for making my time at Iowa State University a wonderful experience. I want to also offer my appreciation to those who were willing to participate in my surveys and observations at Sunny View Care Center in Ankeny, Iowa and Green Hills in Ames, without whom this thesis would not have been possible.
ABSTRACT

Research suggests that the contemporary built environment has increasingly isolated people from the beneficial experience of natural systems and processes due to societal trends such as urbanization, building design and lifestyle. Biophilia and biophilic design promise to foster a positive relationship to nature. Studies of psychological effects of biophilic design on noise perception have primarily focused on the attributes of natural elements in outdoor area. The aim of this study is to analyze how the visual characteristics of an interior space can influence the subjective loudness and annoyance of noise in older adults. Data were collected by conducting visual and audiovisual experiments and by analyzing content analysis, ANOVA and correlation techniques.

This study investigates the effects of major interior-related factors on the assessment of perceived loudness and noise annoyance. The study created virtual scenarios and presented these to participants by means of computer and audio speakers to provide an environment with auditory and biophilic design features of a dining place.

The study produced a null result but data did suggest that positively rated interior spaces led to lower perceived loudness and annoyance. In addition, the limitations of small sample size, audiovisual testing device and setting needed to be addressed. Finally, this study develops design guidelines to aid design decisions of designers and administrators for older adults in long-term care environment. Based on the proposed design guidelines, redesigning an existing dining space was suggested with design visualizations. Further research is needed to explore the effects of biophilic design in interior design on noise perception.
CHAPTER I
INTRODUCTION

The relationship between nature and society has been a long-time concern for Stephen Kellert, as seen by his early works such as The Value of Life: Biological Diversity and Human Society (1996) and Kinship to Mastery: Biophilia in Human Evolution and Development (1997). This interest has expanded to his consideration of nature and built environments, as in the collection Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life, edited by Kellert, Heerwagen, and Mador in 2008. Kellert’s interest is reflected in a growing body of research regarding nature and the built environment and entails study of both exterior environments and, more recently, interior spaces.

My focus in this study draws upon this research as it investigates the influence of biophilic interior design on noise perception of older adults.

Problem Statement

According to research promoting biophilic design, people spend most of their time in indoor settings. The contemporary built environment has increasingly isolated people from the beneficial experience of nature (Nyrud, Bringslimark & Bysheim, 2013). In addition, Gillis and Gatersleben (2015) claim that this isolation is due to societal trends such as urbanization, building design and life style. In terms of urbanization and building design, Joye (2011) pointed out that increasing urbanization and typical geometrical modern buildings are replacing nature. The resultant proliferation of geometrical forms and volumes seems to be of an entirely different category than nature’s forms (Gillis & Gatersleben,
2015). Kellert and Calabrese (2015) add that the dominant approach to modern building and landscape design generally treats nature as either an obstacle to be overcome or a trivial and irrelevant consideration. This approach has increased the disconnect between people and nature in the built environment and is reflected in inadequate contact with natural light, ventilation, materials, vegetation, views, natural shapes and forms, and, in general, beneficial contact with the natural world (Kellert & Calabrese, 2015). They continue by pointing out that the habitat of contemporary people has largely become the indoor built environment where people now spend 90% of their time.

Furthermore, according to Kellert and Calabrese (2015), a growing body of scientific study increasingly reveals that “most of our inherent tendencies to affiliate with nature continue to exercise significant effects on people’s physical and mental health, performance, and wellbeing” (p. 4). The efforts to foster the connection between nature and people become ever more important as the world population continues to urbanize (Browning, Ryan and Clancy, 2014).

In response to such isolation from nature and its purported benefits on health and well-being, Kellert and Calabrese (2015) propose that biophilia and biophilic design “promise” the fostering of a positive relationship to nature (p. 22). “Biophilic design seeks to create good habitat for people as a biological organism in the modern built environment that advances people’s health, fitness and wellbeing” (p. 6). The benefits of biophilic design have been pointed out by other researchers as well. Browning, Ryan, and Clancy (2014) claim that biophilic design can reduce stress, improve cognitive function and creativity, improve well-being and expedite healing. Ulrich (2008) similarly concludes that biophilic design can have
a positive impact by reducing stress, improving emotional well-being, alleviating pain and fostering improvements in other outcomes in a highly stressful healthcare environment.

“Biophilic design” has been defined by Kellert (2005) as “the deliberate attempt to translate an understanding of the inherent human affinity into the design of built environment,” and the strategy of biophilic design is to “incorporate natural features and systems into the built environment” (p.5). According to Kellert (2008), biophilic design is based on the biophilia hypothesis, which Beery, Ingemar and Elmberg (2015) acknowledged as a significant theory of human connectedness with nature. Biophilia has been defined as the inherent human inclination to affiliate with nature (Blomberg, 2015). Biophilic design incorporates natural materials, natural light, vegetation, nature views and other experiences of the natural world into the modern built environment (Blomberg, 2015).

To understand biophilic design, it is important to distinguish it from restorative environment design (R.E.D.), sustainable design and “green” building. As defined by Burnard (2014), R.E.D. is a building design paradigm combining sustainable building practices with building practices that benefit occupant health. Gifford and McGunn (2012) suggest that biophilic design can be viewed as belonging under a larger restorative design umbrella. Joye (2011) suggests that existing research in the field of restorative environments lends support to the ideas of biophilic design. Kellert (2008) claims that biophilic design is one of the two dimensions of restorative environmental design. Figure 1 illustrates a hierarchical relationship between biophilic design and R.E.D.
Figure 1. Restorative environment design and biophilic design

Figure 1 also illustrates the relationship between sustainable/green design and biophilic design. Biophilic design incorporates elements derived from nature in order to maximize human functioning and health (Molthrop, 2011). "Sustainable" or "green" design is the other dimension of restorative environment design; it seeks to minimize or mitigate the impact of the built environment on natural systems (Kellert, 2012). According to Kellert and Calabrese (2015), sustainability will remain an elusive goal until a fundamental shift occurs in our values and ethical relations to the natural world. Biophilic design promises to foster a positive relationship to nature and it ultimately motivates us to become good stewards and sustain these places over time.

Not withstanding the importance of biophilic design, Kellert and Calabrese (2015) claim that scientific study data on its effects has been limited and depend on questionable methodology. It is true that biophilic design has received increasing interest from the building industry around the world in recent years (Gillis & Gatersleben, 2015), and biophilic design publications have been increasing. For example, “The Practice of Biophilic Design” (2015) details three “experiences” and twenty-four attributes of biophilic design, which will be explained in Chapter II: Literature. In addition, a publication "Fourteen Patterns of Biophilic Design” has proposed biophilic design applications in aiding designers in creating
biophilic spaces. The recent publication by Gillis and Gatersleben (2015) points out that the study on psychological effects of biophilic design are limited; plants have been the most researched attributes in the built environment, in natural landscapes and in ecosystems. They concluded that more research regarding natural material and various combinations is needed.

Studies on psychological effects of biophilic design on noise perception are also limited to the attributes of natural elements such as water (Leung, Chau, Tang, & Pun, 2014; Li, 2011) and greenery in urban outdoor environments, including residential open spaces (Gidlöf-Gunnarsson & Öhrström, 2007; Langdon, 1976; Liu, Kang, Luo, & Behm, 2013; Li, Chau, & Tang, 2010; Pedersen & Larsman, 2008; Yang & Kang, 2005). Additional locations in studies of noise perception involve urban street, roadside and sidewalks (Ge & Hokao, 2004; Ge & Hokao 2005; Kastka & Noack, 1987; Yang, Bao, & Zhu, 2011), and urban open spaces (Tamura, 1997; Viollon, Lavandier, & Drake, 2002; Yang & Kang, 2005). These studies point out two key findings. First, positively evaluated visual factors often involve nature being present or being seen, which is one type of encounter with biophilic attributes. Figure 2 illustrates three types of such encounters that explain “passive visual experience.” Second, higher evaluation of biophilic visual factors leads to lower perceived loudness and less annoyance. Higher evaluation of visual factors is also interpreted by Pedersen & Larsman (2008) as “positively evaluated visual appearance of visual factors” and the evaluation is “an overall attitude towards the noise source” (p. 380).
My Study

This thesis explores sound perception in combination with visual senses in interior environments. It assumes the following, using the Figure 3 as a conceptual model. In an indoor environment: (1) When there is passive visual experience involving natural material, the image of nature and indoor plants may influence the visual evaluation of visual settings, and (2) Positively evaluated visual appearance of interior spaces may impact noise perception. In other words, a visually appealing interior space may impact the way people perceive noise and mollify the feeling of the annoyance.
This thesis explores biophilic design attributes, including natural materials, images of nature and the presence of indoor plants and their influence on perception of sound. My focus on noise is supported by the current interests in noise pollution (Citation & Expanded, 2014). Guski, Felscher-Suhr, and Scheuemer (1999) point out that noise annoyance can be seen as the major effect of such noise. My focus on noise also fills a gap in that, according to Gillis & Gatersleben (2015), most of the literature on biophilic design focuses on visual aspects and the study of other senses has been limited. In addition, recent research in the field of restorative environments has yielded a shift from the visual sense to the auditory and olfactory (Gillis & Gatersleben, 2015).
Thesis Questions

This thesis explores several research questions:

“To what extent, do biophilic design attributes influence the evaluation of visual appearance of interior spaces?”

“What are the relationships between subjective evaluation of subjective attractiveness of interior spaces and the subjective perception of noise including loudness and annoyance?

To explore these thesis questions, this thesis focuses on the older adults because according to Gascon et al., (2015), older population have been studied less than other populations, both on the topic of psychological benefits of biophilic design on health and well-being as well as the topic of noise perception. In addition, although sound strongly influences the quality of everyone’s life, sound and noise can play an even stronger role in the well-being of older adults (Brawley, 1997). Negative effects of noise on the elderly include increased anxiety, sleep loss, pain perception and prolonged convalescence (Cabrece & Lee, 2000). Noise also interferes with speech communication and social participation in older adults (Brammer, Laroche, 2014). As Joosse (2011) suggests, more attention needs to be given to sound and its impact on the older adult population.

I used visual and audiovisual experiments to explore the research questions. The method was approved by Institutional Review Board (See APPENDIX A). The visual experiment focused on how biophilic design attributes influence the subjective attractiveness of given interior spaces (four computer-generated images). The audiovisual experiment investigated how the subjective loudness and annoyance rating scores differed with the influence of the given interior spaces.
Scope

There are some methodological limitations that arose from this study with regard to sample size, testing room environments and visual and sound stimuli. These are discussed in Chapter IV, below.

This thesis will focus only on criteria related to the psychological noise reduction of visual sensations from natural environments and simulated natural environments. This study will not cover the design criteria on noise control in physical ways. However, my study develops comprehensive guidelines for designing a person-centered biophilic space for older adults. The design guidelines were applied to the redesign one of the sites where the participants resided.

Further chapters include:

Chapter II: A literature review that shows the research on four aspects: (1) biophilic design attributes and their psychological benefits, (2) influence of audiovisual interactions on noise perception, (3) methods on audiovisual experiment, and (4) noise as a problem for the older population and design considerations.

Chapter III: A discussion of methodology, includes an overview, pilot study, actual study and data analysis.

Chapter IV: A discussion of results, including an overview, visual experiment results and audiovisual experiment results.

Chapter V: A discussion and conclusions, regarding both research questions, limitations and suggestions for future study and design demonstrations.
CHAPTER II
LITERATURE REVIEW

In examining how the subjective perception of noise is influenced by biophilic design attributes, this study focuses on the perceptions of the older adult population in long-term care facilities. In doing so, it draws from research about:

- Past and present developments in biophilic design
- Biophilic design attributes and their benefits
- Influence of audiovisual interactions on noise perception
- Methods for audiovisual experimentation
- Sensory and person-centered design

The first and second sections provide information necessary to understanding biophilic design including a brief review of past and current biophilic design development, a discussion on biophilic design attributes related to my study and an overview of design principles suggested by nature. Information found here helps in the application of attributes to construct visual stimuli for the audiovisual experiment, and furthermore suggests criteria for interior design. The third and fourth sections include information that will aid in understanding both which visual features influence noise perception and which methodologies have been used for audiovisual experiments. The last section provides information important to understanding the noise issues in the environments, the sensory limitations of the older adults, as well as the person-centered care concept in long-term care environments. The section also suggested designing considerations. All in all, the
information found in this chapter will aid in developing comprehensive guidelines for
designing a person-centered biophilic space for the older adults.

Past and Present Developments in Biophilic Design

As established in the Introduction, biophilic design is one dimension of restorative
environmental design with an objective to elicit a positive, valued experience of nature in the
human built environment (Kellert, 2005).

The current efforts on incorporating biophilic design can be seen in the two building
ing rating systems that originated in the United States and are being promoted globally. Each of
these systems embraces elements of biophilic design. The Living Building Challenge
incorporates it through the Biophilia Imperative, and the new WELL Building Standard
incorporates it through the Biophilia Precondition and Biophilia Optimization. In addition,
consulting firms are also incorporating biophilic design. Terrapin Bright Green has published
various white papers on biophilic design. Interface flooring has created a Human Spaces
website to encourage discussion around biophilic design with a current focus on green
building design.

Recent publications on biophilic design provide current and useful information.
Browning, Ryan, and Clancy (2014) synthesize the concepts put forth by Kellert (2008),
Cramer and Browning (2008) propose the patterns of biophilic design in order to help aid
designers in creating biophilic space. Browning, Ryan, and Clancy (2014) provide an
opportunity for designers who are looking for design advice to go when searching for
biophilic design strategies (Gillis & Gatersleben, 2015).
Biophilic Design Attributes and their Benefits

Research has developed two dimensions of biophilic design, including “naturalist” and place-based. Naturalist is an organic or nature dimension, defined as shapes and forms in the built environment that directly, indirectly or symbolically reflect the inherent human affinity for nature (Kellert 2005). The place-based or vernacular dimension is defined as buildings and landscapes that connect to the culture and ecology of a locality or geographic area (Kellert 2005).

Under the two dimensions, biophilic design was categorized into three “experiences” and about seventy design attributes organized under the three categories shown in Figure 4 on the next page (Kellert 2005; Kellert & Calabrese, 2015).

My study focused only on the “naturalist” dimension. With respect to “experiences”, my study focused only on “direct experience with nature” and “indirect experience with nature.”

Attributes of biophilic design are very broad. However, most of the findings on the benefits of biophilic design on health and well-being are based on the visual sense. One review article written by Gillis and Gatersleben (2015) reviews findings that support benefits of biophilic design. This article finds that much of the literature depends on the visual sense although nature is multisensory. In addition, most of its findings are about the attributes of natural lighting, vegetation, as well as representational and symbolic depictions of nature such as pictures (Kellert, 2008).
Figure 4. Biophilic design attributes organized according to three “experiences”

Source: Kellert 2005; Kellert & Calabrese, 2015
Gillis and Gatersleben (2015) point out that not all the attributes have received the same amount of attention in academic research. More specifically:

1. Much of the existing evidence supports certain attributes of biophilic design such as the presence of natural elements, while the empirical evidence for other attributes such as the use of natural materials or process is lacking.

2. While individual attributes of biophilic design have been studied on their own, there has been little research on the various combinations of proposed attributes. Do plants and natural materials have a larger impact than plants and water? Does natural light have a larger impact on attention than plants?

The above information suggests that biophilic design attributes other than natural light and greenery need more attention and empirical study. Researchers have discussed the attributes of plants/greenery, natural material, images of nature and indoor plants. The following section discusses these attributes in terms of benefits.

**Plants / greenery**

In terms of window view of greenery, Joye, Willems, and Brengman (2010) review the aesthetic and restorative effects of greenery. They point out that a large body of empirical evidence has accumulated a primary finding: natural (i.e. green) environments are consistently preferred over non-green urban settings or environments dominated by artifacts.

According to Kaplan (1992), a significant part of the satisfaction derived from nature does not require being in the natural setting, but rather having a view of it. Health benefits related to experiencing nature have been based on opportunities for noticing and observing it, rather than on performing activities in nature (Kaplan, 1992).
Another important observation is that nature can have “healing” effects on human in scenes promote positive emotion, physiology, cognition, and health. These studies have identified particular health effects of the landscape, (1) short-term recovery from stress or mental fatigue (psychological); (2) physical recovery from an illness or reduced incidence of physical illness; (3) a long-term behavioral change and an overall improvement in well-being (increased social interaction and reduction of aggressive behavior).

Because of the holistic benefits of access to greenery such as reducing stress, enhancing creativity and clarity of thought, improving our well-being and expediting healing, using greenery can be important to built environments such as offices, hospitals, and senior living communities.

Plants are capable of bringing living nature into the indoor environment. Han (2009) points out that plants are used not only to bring a number of aesthetic as well as psychological benefits, better air quality and higher work productivity to the indoor environment, but also to improve the climate and decoration outside the buildings. The placement of indoor plants has psychological benefits such as stress reduction, positive distraction and pain tolerance (Bringslimark, Hartig, & Patil, 2009; Dijkstra, Pieterse, & Pruyn, 2008; Qin, Sun, Zhou, Leng, & Lian, 2013). Other research further explain the effects of placing indoor plants on increasing attractiveness and comfort of interior environments. For example, Dijkstra, Pieterse, and Pruyn (2008)’s study is relevant to my study by indicating that indoor plants in a hospital room reduce feelings of stress through the perceived attractiveness of the room. In addition, an environment with plants can effectively improve human comfort (Qin, Sun, Zhou, Leng, & Lian, 2013)
Less research has been done on the qualities of plants that humans prefer. Qin et al. (2013) conducted a study that tested various plant types to identify the most beneficial type of plant based on psychological and physiological assessment. Qin et al. (2013) indicate that small, green, lightly scented plants are the most optimal for health and well-being. This research assisted me by suggesting that the indoor plants may reduce the perceived loudness and noise-induced annoyance.

Images of nature

This section introduces the biophilic design attribute of symbolic nature and one of its forms: images of nature. The following discussion includes outlining the benefits of symbolic nature including images of nature.

Kellert (2005) points out that the experience of nature in the built environment often occurs symbolically or vicariously, particularly within building interiors and facades. Kellert (2008) states that symbolic or vicarious experience involves no actual contact with real nature, but the representation of the natural world through images, pictures, video, metaphor, and more. In a built environment, building design may use symbolic nature through various forms such as decoration, ornamentation, pictorial expression, and shapes and forms that simulate and mimic nature (Kellert, 2008). These are also seen in a wide diversity of building features: such as walls, doors, entryways, columns, trim, casements, fireplaces, furnishings, carpet, fabrics, art, and sometimes even an entire façade.

Kjellgren and Buhrkall (2010) published an article that is very useful to my study in understanding how real natural and simulated natural environments reduce stress. Their study compares the restorative effects of relaxation in a natural environment with those of
relaxation in a simulated natural environment, in terms of some psychological and physiological measures. The results show that both environments are equally efficient in reducing stress (Kjellgren & Buhrkall, 2010). Ulrich (1990) argues that the images of nature have an even larger role in an environment where exterior views are not available. Meanwhile, many buildings are located in urban areas where views of urban or built settings tend to impede recuperation.

Some studies go into detail to examine different types of representations. For example, Ulrich (1990) notes that representations of natural landscapes within the context of built environments have been found to result in measurable restorative effect. He points out that patients felt less stressed on days when a large mural depicting a natural scene was hung on a wall. Felsten (2009) finds that students perceived mural views of nature with water as the most restorative. This is also true when heart patients were exposed to a picture of water in a natural setting; they experienced less post-operative anxiety than did the control groups and the groups exposed to the other types of pictures (Ulrich, 1990). According to Bringslimark, Hartig, and Patil (2011), office workers have been found to compensate for a lack of nature exposure by adding images of nature to the office environment.

In summary, central to biophilic design is attempting to tap the positive or “biophilic” effects of nature in architecture, either by including actual nature (e.g., real plants) in architectural environments or by symbolically referring to nature in architectural design (e.g., natural ornaments) (Joye, 2007; Kellert, 2008).
Natural material

Natural material as one of the attributes of biophilic design has received very limited attention in academic research from a psychological perspective (Gillis & Gatersleben, 2015). Research by Nyrud, Bringslimark, and Bysheim (2014) focused on the effects of natural elements, particularly wood in a hospital environment. Their study indicates that use of a natural material, such as wood, influences user preference, and the preference for different rooms is due to room design and the amount of wood used in the interiors. Their study also points out that patients preferred an intermediate amount of wood, with the floor, one wall and furniture being made of wood. They suggest using wood material within indoor environments where there are limitations to the use of indoor plants or limitations to a view through a window.

A relevant study by Joynt and Kang (2010) shows that aesthetic preference and preconceptions held about various materials can influence the perception of how a barrier will perform at attenuating noise. Joynt and Kang (2010) introduce the idea that the visual characteristics of the element providing attenuation can influence noise annoyance perception.

In summary, the information in this section provided theoretical foundations for my exploration of the psychological effects of biophilic design attributes on noise annoyance attenuation.

Influence of Audiovisual Interactions on Noise Perception

Biophilic design attributes and benefits manifested visually and auditorily. Researchers have provided criteria for evaluating the assumption that visual contact with
interior elements would influence sound perception. Researchers have also identified how biophilic design attributes, emotion and colors influence sound perception. Definitions are given at the end of this section.

Audiovisual interactions

Data coming from neuroscience and cognitive psychology show that vision and audition are not independent modalities but interact in complex ways (Iachini et al., 2012). Urban sounds are rarely perceived in isolation but rather within a context that includes information from other sensory modalities such as vision and touch (Iachini et al., 2012; Viollon, Lavandier, & Drake, 2002). Auditory and visual information closely interact along all stages of stimuli processing (Ernst & Bülthoff, 2004; Stein & Meredith, 1993). The sound environment evaluation of a space depends strongly on the specific characteristics of the space, as well as various physical environmental conditions (Meng, Kang, & Jin, 2013).

Biophilic design attributes and sound perception

This section provides theoretical information that connects biophilic design with sound/noise perception study. Table 1 on the next page illustrates some commonalities of these studies such as the stimuli, settings, methods and outcomes. These studies involve biophilic design attributes (mostly greenery) as visual factors and noise that is widely defined as “unwanted noise” (Keizer, 2012). These studies commonly point out two key findings. First, positively evaluated visual factors often involve nature being present or being seen, which is one type of encounter with biophilic attributes. Second, higher evaluation of biophilic visual factors leads to lower perceived loudness and less annoyance.
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langdon (1976)</td>
<td>Visual</td>
<td>Parks &amp; green spaces</td>
<td>• High neighborhood quality in terms of attractive appearance, presence of parks and green spaces lowered dissatisfaction with traffic noise to a significant degree.</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>Traffic noise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>Survey</td>
<td></td>
</tr>
<tr>
<td>Kastka &amp; Noack (1987)</td>
<td>Visual</td>
<td>Urban street</td>
<td>• Visual aesthetic context of an environment influences the effect of acoustic stressors. The same noise level produces more annoyance in less attractive streets than those with higher arousal quality.</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>Road traffic, highway, railroad &amp; industrial noise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>Field study</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Questionnaires</td>
<td></td>
</tr>
<tr>
<td>Tamura (1997)</td>
<td>Visual</td>
<td>City view &amp; landscape</td>
<td>• Effects of landscape on the relief of annoyance correspond to about 5 dBA or one rank on the 7-level scale of “quiet-annoying”</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>Traffic noise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>Experiment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Field survey</td>
<td></td>
</tr>
<tr>
<td>Viollon, Lavandier &amp; Drake, (2002)</td>
<td>Visual</td>
<td>Urban open spaces</td>
<td>• Listeners’ judgments were influenced by what they saw; the more urbanized, the more negative the sound rating; visual influence depends on the types of sounds involved.</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>Urban sound</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>Experiments</td>
<td></td>
</tr>
<tr>
<td>Ge &amp; Hokao (2005)</td>
<td>Visual</td>
<td>Residential landscape and nature</td>
<td>• The sound senses in streets are influenced considerably by landscape in the natural and silent places; Visual information can change the image of soundscape when the street has green and is not too noisy</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>Sound environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>On-site investigation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interview</td>
<td></td>
</tr>
<tr>
<td>Gidlöf-Gunnarsson &amp; Öhrström (2007)</td>
<td>Visual</td>
<td>Greenery and its accessibility</td>
<td>• Neighborhood quality due to elements of nature lowered dissatisfaction with traffic noise. If green areas are perceived as visually attractive, they may also help to reduce stress</td>
</tr>
<tr>
<td></td>
<td>Sound</td>
<td>High road traffic noise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Setting</td>
<td>Survey</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Visual</td>
<td>Sound</td>
<td>Setting</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Pedersen &amp; Larsman (2008)</td>
<td>Landscape, appearance of the noise source</td>
<td>Field study, Questionnaire</td>
<td>Field study, Questionnaire</td>
</tr>
<tr>
<td>Li, Chau, &amp; Tang (2010)</td>
<td>Residential characteristics such as greenery</td>
<td>Interview, Survey</td>
<td>Interview, Survey</td>
</tr>
<tr>
<td>Joynt &amp; Kang (2010)</td>
<td>Noise barriers varying in material</td>
<td>Lab, experiment</td>
<td>Lab, experiment</td>
</tr>
<tr>
<td>Yang, Bao &amp; Zhu (2011)</td>
<td>Landscape plants &amp; water &amp; roadside green spaces &amp; sidewalks</td>
<td>Lab, experiment, Emotional tests</td>
<td>Lab, experiment, Emotional tests</td>
</tr>
</tbody>
</table>
Table 1. Continued 2

| Li (2011) | Visual | Greenery & sea view | • Laboratory experiments  
| Sound | traffic noise and human noise | • Field surveys | • Both greenery and sea views are determined to be able to reduce noise annoyance.  
<table>
<thead>
<tr>
<th>Setting</th>
<th>Residential</th>
<th></th>
<th>• Noise annoyance related to personal characteristics, such as sensitivity to the sound.</th>
</tr>
</thead>
</table>
| Iachini et al. (2012) | Visual | A metro and platform (3D graphic virtual reality)  
| Sound | Noise on train | • Laboratory | • Participants’ cognitive performances were worse when soundtracks were associated to their natural visual contexts than when they were not.  
| Setting | Metro system | | • Participants reported to be less annoyed by metro noise when they were immersed in the virtual visual metros. |
| Liu et al. (2013) | Visual | Landscape  
| Sound | Urban sounds  
| Setting | City parks | • Field survey | • Visual landscape shows significant effects on experienced occurrence of individual sounds. |
| Maffei et al. (2013) | Visual | Noise barriers  
| Sound | A train passing at constant speed  
| Setting | A train passing | • Immersive Virtual Reality (IVR) laboratory test  
| | | Barriers with different visual characteristics | • The barriers type concerning: the visibility of the noise source, some aesthetic issues, and the noise level  
| | | | • Transparent barriers--perceived loudness and noise annoyance were judged lower than for opaque barriers; this difference increased as noise level increased. |
| Sound | Noise in the neighborhood | • Survey | • Views with higher restorative rating would lead to lower annoyance rating.  
| Setting | Residential | | • Views with sea or both sea and river could provide noise moderation effects. |
Emotion, color and sound perception

Loudness perception is often described as a modular system where information is processed by dedicated auditory systems that do not communicate with other brain systems (Fodor 1983). However, recent neuroscience research has shown that acoustic perception is affected by input from other modalities (e.g., visual processing), and that visual perception is affected by emotion processing. Recently Asutay & Västfjäll (2012) proved that auditory perception is influenced by emotion, and the effect of negative emotion can influence a basic sensory dimension: loudness perception.

Some studies have shown that visual factors, such as colors, may modulate loudness judgments. For example, vehicle color influences the judgment of loudness. This is investigated by Menzel et al. (2008), who conclude that colors such as red or pink seem to increase perceived loudness, whereas grey or pale green seem to decrease loudness. Parizet & Koehl (2011) find that pictures of red trains caused an increase in perceived loudness as compared with trains having pale colors.

Loudness and annoyance

This thesis focuses in particular on the modification effects of biophilic design attributes on subjective noise perception in two aspects: subjective perception of loudness and subjective feelings of annoyance.

Loudness: a psychological term used to describe the magnitude of an auditory sensation (Fletcher & Munson, 1933). A study by Kuwano, Namba, Kato, and Hellbrück (2003). This is relevant to my study because this study conducted a subjective-loudness evaluation test with a 30-second duration (short-term noise). Their study used a 20-minute
noise (long-term noise) and their results show that long-term noise is perceived to be louder than the average of the subjective loudness of short-term noise.

Annoyance: Guski et al. (1999) conclude that noise annoyance is seen as the major effect of noise. The term “annoyance” is generally referred to by Lindvall and Radford (1973) and Koelega (1987) as a feeling of displeasure associated with any agent or condition known or believed by an individual or group to adversely affect them. Perceived annoyance assesses only subjective reactions to noise (Iachini et al., 2012). Guski et al. (1999) conclude that noise annoyance is a multifaceted psychological concept dealing with immediate behavioral (disturbance and interfering with intended activities) and evaluative aspects (nuisance, unpleasantness, and “getting on one's nerves”).

Research has found that different noise sources affect in different ways the perception of loudness and annoyance for individuals (Maffei et al., 2013). Figure 5 is a conceptual map of factors that influence noise annoyance (Li 2011)

![Figure 5. A conceptual map of factors that influence noise annoyance (Li 2011)](image-url)
map of factors on annoyance developed by Li (2011) in his dissertation. As can be seen, noise sensitivity is one of the individual personal characteristics that has effects on noise annoyance. Other influential factors include the neighborhood environment with greenery and noise properties including the number of noise events and noise level. This information is important for my study because the influences from individual personal characteristics are excluded, which included gender, age, marriage status, education, health and time.

Methods for Audiovisual Experiments

There are different approaches to examining audiovisual interactions, especially the influence of vision on auditory perception (Raimbault et al., 2003). Two major approaches examine involve laboratory experiments (Carles, 1992; Kastka et al., 1987; Viollon et al., 2002, Yang & Kang, 2005; Yang, Bao, & Zhu, 2011) and field study (Southworth, 1969; Langdon, 1976; Tamura, 1997; Gidlöf-Gunnarsson & Öhrström 2007; Liu et al., 2013; Leung, Chau, & Pun, 2014). For details, see Table 1 on pages 20-22, above.

Both of the methods using laboratory experiments focused on audiovisual interactions within an environmental approach; these use commonly occurring realistic audiovisual situations (Viollon et al., 2002). A study by Yang et al. (2011) on landscape and its effect on noise perception study serves as an example. They pointed out that landscape stimuli could be the views from the window, views of a video clip or still images on a screen. The stimuli could also be participants walking through different types of landscape. According to Velarde, Fry, & Tveit (2007), approximately half of the studies reported were conducted using images of landscapes (from a window, video, photograph, etc.) but featured no exposure to real landscapes.
Field study approaches according to Yang et al. (2011) are mainly qualitative and subjective, including observations, self-reports, questionnaires and structured interviews. Yang et al.’s study of audiovisual interactions used qualitative methods to obtain quantitative emotional responses in addition to the qualitative evaluation of questionnaires. My study attempted the laboratory approach because experiments in a laboratory have a better chance to ensure that the results are precise (Yang et al., 2011). In addition, the studied populations are older and have a limited ability to go in the field.

In general, audiovisual experiments include common parameters (Viollon et al., 2002):

- The use of simulated environments such as photographs, slide shows or video.
- A global approach to audiovisual interactions, specifically focusing on the influence of vision on audition (or vice versa)
- The examination of the effects of audiovisual interaction through the combination of one specific visual environment and one specific auditory environment or the crossing of controlled auditory and visual environments.

In my study, I adopted the following three guidelines taken from Viollon et al., (2002):

1. Creation of a unified artificial environment from the juxtaposition of visual scenes (slides) and background sounds.
2. Use of audition as the main modality (which may be influenced) and vision as the accessory modality (which may influence the auditory judgment). (‘Main’ and ‘accessory’ are defined by Gribenski (1978).

3. Creation of controlled audiovisual combinations, by crossing all the visual scenes with all the auditory environments. The visual scenes vary along the controlled visual contents of biophilic design attributes; auditory environments vary along two sound volumes of one sound sample.

Sensory and Person-centered Design

It is important to understand how noise affects the older population, many of whom are experiencing a decline in hearing and vision. Therefore this section includes the general hearing and vision problems and noise issues for older people, noise in nursing home dining rooms, as well as design considerations for interiors.

Sensory limitations and design considerations

According to the National Institute of Hearing Statistics, 45% of adults 75-84 years old have trouble hearing, and 62% of adults older than 85 have trouble hearing (Pratt, 2004). In assisted living facilities, the average age is 82. In addition, the majority of old people in nursing homes have some vision impairment in addition to being hearing impaired. Both of these problems cause discomfort and affect attention span, often making conversation difficult. This loss of easy, intimate communication with others often results in self-doubt and lowered self-esteem (Brawley, 1997).
Research has established that sound levels contribute to physiological and psychological problems both in older adults who live in a continued care retirement community (CCRC) and in infants (Joosse, 2011). According to Bakker (2003), older adults in a nursing facility environment may experience overwhelming amounts of auditory and visual stimulation. Noise pollution causes increased amounts of anxiety, sleep loss, pain perception, and prolonged convalescence (Cabrece & Lee, 2000) and stress (Glass, 1997). Leibrock (2000) mentions that older people have difficulty understanding a conversation when ambient noise levels exceed 30 decibels. Higher noise levels hinder social interaction and therefore quality of life for older adults (Nussbaumer, 2014).

According to Brawley (1997), the acoustical comfort for older adults includes freedom from distracting and intrusive noise, which makes concentration difficult. For speech to be understood, volume must be increased, and reflected sound or background noise must be decreased to facilitate speech comprehension (Brawley 1997).

To avoid distraction and to lower background noise, there are physical solutions such as space planning and architectural design. Brawley (1997) suggests that space planning can strategically move spaces away from noisy zones and architectural design can create spaces with enclosed soundproof walls. Sound absorption and other techniques can substantially reduce stress caused by noise from activities and routine operations.

To optimize hearing and minimize ambient noise, Leibrock (2000) points out that there should be no acoustical leaks between ceiling and wall, and between door and wall assemblies. Mechanical ductwork such as heating and ventilation ducts should be properly insulated. Transmission noise may adversely affect the hearing aids.

To prevent transmission noise Leibrock (2000) suggests:
1. Using double or triple glazing
2. Placing doors and windows away from the noise
3. Staggering the doors
4. Avoiding back-to-back wall outlets
5. Properly insulating ductwork

To minimize background noise Leibrock (2000) suggests:
1. Using highly reflective material on the enclosure
2. Avoiding long, rectangular rooms
3. Using suspended or wall-mounted fixtures

In addition, in order to facilitate communication, Leibrock (2000) suggests enhancing visual acuity because older adults often rely on reading lips and facial expressions. Good natural lighting increases visual comfort (Elyezadi, 2012; Kim & Kim, 2007) in addition to its positive impact on circadian system functioning (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009). In addition, good lighting design also prevents glare that causes discomfort. The lighting should minimize eye fatigue and avoid shadows. Many older people are sensitive to glare, susceptible to veiling glare, have difficulty seeing certain colors and have lower awareness of orientation and mobility (Leibrock, 2000). Interior designers should consider using front light and soft diffusion light.

To avoid glare Leibrock (2000) advocates:
1. Maintaining an adequate and consistent lighting level
2. Shielding lighting sources to prevent contrast glare
3. Providing several low intensity lights instead of one bright source
4. Using indirect pendant light and cover light
5. Eliminating veiling reflection by specifying low-glare surfaces on floors, furnishings and walls.
6. Avoiding fluorescent lighting, which may interfere with hearing aids

**Person-centered concept and design considerations**

This section reviews current philosophies found in research about long-term care (LTC) communities including “culture change” and person-centered care.

“Culture change” is a movement to foster a philosophical shift in the care and services for older adults particularly in LTCs (Li & Porock, 2014). The foundation of culture change is a person-centered philosophy that advocates for choice, dignity, respect, self-determination and purposeful (Network, 2013).

Person-centered care is considered the gold standard for the care of older adults in LTCs settings and is commonly referred to as a core concept that guides changes in care philosophy from a traditional biomedical model to a more humanistic approach (Li & Porock, 2014). Research by Kansas State University (2016) PEAK 2.0 (Promoting Excellent Alternatives in Kansas, an education program to encourage providers in Kansas to adopt person centered care) has established five domains essential to person-centered care: the foundation, resident choice, staff empowerment, home environment, and meaningful life. Resident choice is the core value, and it is essential to provide a supportive home environment to support other domains. Of these five domains, home environment is most relevant to interior design.
In terms of home environment, Lustbader (2000) sees nature as an essential part of the living habitat for older people, and suggests a connection between person-centered care and biophilic design. Lustbader (2000) writes:

“A nursing home is a human habitat. As such, it must be inspired by the natural habitats that surround and nurture us all. Dogs, cats, birds, plants children, and gardens accessible to everyone can transform a sterile monoculture into a human habitat worthy of a home.”

Another researcher, Lois Cutler (2004), discusses the meaning of person-centered care and suggests design considerations for an LTC in dining area:

1. Multiple uses of the dining place such as devoting a corner to recreate a formal dining room with parlor seating. Redesign of an environment to accommodate receptions, showers, and social hour for the residents.
2. Waiting area outside of the dining room with grouping of chairs, and possibly a salad bar and/or appetizers.
4. Addition of intentionally designed window views.
5. Division of the room into different zones., such as lattice screens.
6. Upgrading amenities. For example, table coverings can inexpensively transform a room into a gingham checked picnic area, or battery-powered lighted lanterns or battery candles can transform the room into an elegant dining spot for a special evening out or for the increasingly popular social hour that features alcoholic and nonalcoholic beverages and snacks.
Noise in nursing home dining area

One of the major problems residents and staff experience in assisted living or nursing home settings occurring is noise (Joosse, 2011; Rylan, 1995). According to Nussbaumer (2014), in a crowded dining room, noise levels can reach 60-70 decibels, and for the older adults conversation can be difficult to understand. Such noises are disturbing and confusing, causing irritation and loss of appetite among resident diners (Rylan, 1995). In terms of the causes of the noise, two scholars reach different conclusions. Joosse (2011) points out that staff talking created more noise (26%) while only 3% is directed at or included the residents. Rylan (1995) mentioned that both residents and employees often generate noise.

Basic design principles

According to Ching (1996), when it comes to the design or redesign of a building or space, “there exists a natural diversity and complexity in the program requirements for buildings” (p. 320). In recognition of this natural diversity, complexity, and hierarchy in the programing, designing, and making of buildings, it is important to include ordering principles. “Order without diversity can result in monotony or boredom; diversity without order can produce chaos. A sense of unity with variety is the ideal” (Ching, 1996, p. 320). Ching also suggests ordering principles which include axis, symmetry, hierarchy, rhythm, datum and transformation.

Significance

Based on this literature review, I have developed three basic general concepts and a range of aspects and discussion points that could be used as criteria for comprehensive
guidelines for designing a person-centered biophilic space for older adults, illustrated in Figure 6.

<table>
<thead>
<tr>
<th>Biophilic design attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views through the window (being seen)</td>
</tr>
<tr>
<td>Outdoor nearby greenery (being available)</td>
</tr>
<tr>
<td>Indoor plants</td>
</tr>
<tr>
<td>Image of nature</td>
</tr>
<tr>
<td>Natural material</td>
</tr>
<tr>
<td>Natural light</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Person-centered design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design reflects person centered care domains</td>
</tr>
<tr>
<td>Home environment</td>
</tr>
<tr>
<td>Design facilitates hearing</td>
</tr>
<tr>
<td>Design facilitates vision</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Following the basic design principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organized complexity</td>
</tr>
<tr>
<td>Integration of parts to the wholes</td>
</tr>
</tbody>
</table>

*Figure 6. Three basic concepts for developing comprehensive guidelines for designing a person-centered biophilic space for older adults.*
CHAPTER III
METHODOLOGY

This study builds upon the concept of audiovisual interactions (Tamura 1997, Viollon, Lavandier, & Drake, 2002). The study explores the associations between biophilic design features and noise perception within a context of a specific interior environment, namely a computer-generated dining environment for the older population. In so doing, it addresses the research questions:

1. To what extent do biophilic design attributes influence the subjective evaluations of the attractiveness of the interior spaces?

2. What are the relationships between evaluations of subjective attractiveness and of loudness and noise annoyance for the older population?

Design

To answer these research questions, I designed one visual and one audiovisual experiment. Then I recruited the participants. Then I conducted a pilot study with three participants to see if adjustment were necessary.

The visual experiment identified how biophilic design attributes influence subjective attractiveness of given interior spaces as represented in four computer-generated color-slide images. During the visual experiment, I provided the images and asked participants to rate them according to their subjective attractiveness. Following the rating, participants responded to open-ended questions about their answers. The visual experiment used a 10-point subjective attractiveness scale from “ugly” to “beautiful” (see APPENDIX B). The
subjective attractiveness scale was developed based on Dijkstra, Pieterse and Pruyn’s study (2008). In their study, they measured the perceived attractiveness of hospital rooms, with assessment ratings on “pleasant to unpleasant”, “beautiful to ugly” and “friendly to unfriendly”. My study used only “ugly to beautiful” to reduce the demands on the older participants.

The audiovisual experiment determined differences among subjective loudness and noise annoyance rating scores given the influence of attributes in specific interior spaces. During the audiovisual experiment, I coupled sound stimuli with viewing stimuli. I asked participants to rate the sound stimuli using the dimension of subjective loudness and annoyance. The sound stimulus was a recording of a dining situation. The subjective loudness scale (see APPENDIX C) used a “not noisy” to “extremely noisy” scale, and the noise annoyance scale used “not annoying” to “extremely annoying”. The subjective loudness rating scale is suggested by William, Beach and Gilliver (2013). In addition, before the audiovisual experiment, a very short training session was given to participants to familiarize them with the procedures.

Both of the experiments used a 10-point scale for subjective attractiveness, subjective loudness and annoyance. According to Wittink & Bayer (2003), the 10-point Likert scale may offer more variance than a smaller Likert scale.

My study used a “within-subject” design in which the participants were compared with each other. My study measured the subjective perception of visual factors and sounds. I used within-subject design as opposed to “between-group” design because this method avoids the possibilities of individual differences such as cultural and social background.
I also used a “repeated-measures” design. Each image was presented once with *Sound Stimulus* (S1) and once with *Sound Stimulus* (S2). Repeated-measures design allowed testing whether the influence on sound perception with exposure to the visual stimuli would occur when the volume of the sounds changed.

Preliminaries to Actual Study

**Recruitment**

I first contacted Lifelong Links (2013) who provided lists of nursing homes, assisted living and independent living facilities in Polk County, Iowa, area. A professor on my committee suggested sites in Story County.

Then I emailed the facility administrators, asking if they would agree to be part of the study. The email (see APPENDIX D) contained an “Introduction of Study” that stated the needs of the research including the availability of a room for testing, the length of the testing and the number of participants needed. After an administrator agreed to participate, the administrator established the recruitment method preferred by her or his facility.

My study used two major methods for recruitment of individual participant: emails and meetings. The recruitment email included the Introductory Script (APPENDIX E) and an Informed Consent Document (APPENDIX F) for forwarding to residents. The Recruitment Script (APPENDIX G) administered by the facility was used in the recruitment meeting at a Residents Council meeting.
Only two facilities agreed to participate. One was a CCRC often referred to as a skilled nursing facility. This facility used the recruitment meeting method. The other facility, an RCD in Story County, is an independent living community. RCD used the email method, as well as the flyer (see APPENDIX H) distribution for recruitment.

In general, residents in these two types of facilities are different. According to Pratt (2004), CCRCs are often referred to as nursing homes, which provide one type of long-term care that is often extended care. In a nursing facility, residents are admitted because of functional disabilities resulting from various medical or physical conditions. According to Lucas (2004), RCD facilities, on the other hand, are often called “independent living communities” and provide the older population with an additional housing option. The residents in RCD are typically healthy, physically active, busy individuals enjoying various social and recreational pursuits with substantial financial resources at their disposal (Lucas, 2004).

I recruited a total of thirty-two residents, twenty-nine from the CCRC located in Polk County and three from the RCD located in Story County. The participants ranged from 65 to 90 years old. Both genders were represented. I collected self-reported hearing loss level information because the experiment involved judgments based on sound. I analyzed the correlation between hearing loss and subjective loudness scores and noise annoyance scores with the purpose of identifying the influences of hearing loss on the subjective loudness and annoyance perception.
Pilot study

Before the actual study, an informal pilot study was conducted with three of the participants. The purpose of the pilot study was to test out the methods before the main data collection started. The pilot study focused on my observation of how the participants reacted to the instruments and the scales. The pilot study used the actual visual and audiovisual experiments and suggested two changes. The first change involved the auditory scale and second the method for recording the participants’ responses.

The adjustment to the scale involved a change in vocabulary. Instead of the term “stress,” the term “annoyance” was used because some participants were not sure how to interpret the word “stress”. In addition, according to Guski et al. (2009), annoyance is seen as the major effect of noise. Figure 9 shows the adjustment of the wording.

<table>
<thead>
<tr>
<th>Not Stressful</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely stressful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Annoying</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>Extremely Annoying</td>
</tr>
</tbody>
</table>

**Figure 7.** Word “Stressful” was replaced by “Annoying”

The second change involved the researcher becoming responsible for filling out all the rating scales after the participants orally reported their responses. It was apparent that some participants had difficulties marking on the form due to vision or manual dexterity limitations. This approach eased participants’ fatigue and increased efficiency.
Actual study – visual experiment

I designed the visual experiment and I used content analysis to analyze the relationship between evaluations of the visual appearance of each given interior space and biophilic design features. The process and instruments as well as the analytical method are illustrated in Figure 8.

**Figure 8.** Process, instruments and analytic method used in visual experiment

Visual stimuli

For the experiment, I designed four computer-generated images of the same dining room with different interiors. A corner of a room was selected in order to provide different interiors. Figure 9

**Figure 9.** Sketch of room and identification of visual surfaces; floor (I), walls (II, III) ceiling (IV)
provides a schematic overview of the room and the surfaces that were simulated: (I) floor, (II) back wall, (III) wall on the right, (IV) ceiling. The interiors differ with respect to biophilic design features including passive visual experience with biophilic attributes (see Table 2), natural color and natural light. For each room, biophilic attributes dominated and featured interior finishes or real greenery. The finishes and greenery were selected with an intention to create an overall expression of materiality and scenery. For example, wild cherry wood was arbitrarily assigned to create an image of an interior with wood material.

**Table 2.**
*Finishes for visual stimuli A, B, C and D*

<table>
<thead>
<tr>
<th>Room Number</th>
<th>Surface I (Floor)</th>
<th>Surface II (Wall left)</th>
<th>Surface III (Wall right)</th>
<th>Surface IV (ceiling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>End grain wood</td>
<td>Floor-to-ceiling windows</td>
<td>Floor-to-ceiling windows</td>
<td>Skylight and Douglas fir wood beams</td>
</tr>
<tr>
<td>B</td>
<td>Wild cherry wood floor</td>
<td>Natural stone wall</td>
<td>Warmer brown color paint</td>
<td>Wild cherry wood panel and cherry rose beams</td>
</tr>
<tr>
<td>C</td>
<td>Floral patterned carpet</td>
<td>Realistic landscape painting</td>
<td>Floor-to-ceiling tree graphics</td>
<td>Natural motif incorporated on ceiling tiles and applied to the beams</td>
</tr>
<tr>
<td>D</td>
<td>Linoleum with earthy tone</td>
<td>Neutral color paint</td>
<td>Texturized surface with shaded green paint</td>
<td>White ceiling tiles and neutral color paint</td>
</tr>
</tbody>
</table>

Table 2, above, provides more detail regarding the biophilic attributes of each room design. Room A featured natural windows views. Room B featured natural material such as cherry wood, which is commonly used for flooring and ceiling beams. Room C featured symbolic nature such as realistic landscape painting, floral patterns and tree graphics. Room D featured neutrally colored paint as well as indoor potted plants.
For each room (see Figure 10, next page), the color and natural light were controlled. Natural color palettes were selected for each room from the Japanese leading color psychologist Shigenobu Kobayashi’s (1992) book, *Color Image Scale*. Although the renderings of all rooms used natural lighting conditions, the brightness of each room appears different because their materials absorb, reflect or diffuse light differently. For example, Image B appears darker than other images. Each room has the same furniture because the study intended to exclude their impact on visual evaluation.

*Figure 10. Visual stimuli and color palettes*
Counterbalanced design was used to come up with different sequences for four images in order to avoid possible correlation between participants’ ratings of the images.

When A was placed in the first position for example, there were six sequences (Figure 11).

![Image of sequences](image.png)

**Figure 11. Six sequences when “A” was placed in first position.**

In the first box, Image A was followed by Image B in the second position twice, once with C in the third position and once with D in the third position. In the second box Image A was followed by Image C in the second position twice, once with Image B in the third position and once with Image D in the third position. In the third box, Image A was followed by Image D in the second position twice, once with Image B in the third position and once with Image D in the third order. Similarly, Image B, C and D were placed in the first position six times. In total, there were 24 (6x4=24) image sequences (see Figure 12). Twenty-four image sequences were randomized using Excel.

<table>
<thead>
<tr>
<th>Sequence 1</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence 2</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 3</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 4</td>
<td>A</td>
<td>C</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 5</td>
<td>A</td>
<td>D</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Sequence 6</td>
<td>A</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 7</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 8</td>
<td>B</td>
<td>A</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Sequence 9</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 10</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>Sequence 11</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Sequence 12</td>
<td>B</td>
<td>D</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Sequence 13</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 14</td>
<td>C</td>
<td>A</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 15</td>
<td>C</td>
<td>B</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Sequence 16</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>A</td>
</tr>
<tr>
<td>Sequence 17</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 18</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Sequence 19</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Sequence 20</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 21</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Sequence 22</td>
<td>D</td>
<td>B</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Sequence 23</td>
<td>D</td>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Sequence 24</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

**Figure 12. Twenty-four sequences for visual stimuli**
A 13-inch MacBook displayed the visual images and the participant was able to adjust his/her distance from the screen. The visual images were also printed out on a matte paper that was mounted on foam board, which facilitated their use by the participants.

Procedure

The visual experiment was designed to identify the relationships between evaluations of the visual appearance of interior spaces and the nature of the biophilic design attributes. At the start of the session, participants were briefed about the experiment’s aim, content and safety through reading the Informed Consent Document. Demographic information was also collected using a questionnaire (See APPENDIX I).

The experiment procedure is shown in Figure 13. The researcher displayed the slides on a computer. Participants were asked to rate each image on a subjective attractiveness scale and orally report their rating scores. Using the printed images, participants were asked to rank each image and orally report their ranking sequence.

The oral instruction was:

“Please look at this picture: this is a corner of a public dining place. Please tell me how beautiful it is to you. Pick a number from 0-10. 0 indicates this room is very ugly and 10 indicates this room is very beautiful. The four images are all together, please rank them.”
After the evaluation, participants were asked to orally give reasons for the rating and their audio responses were recorded. Additional questions included: “Please tell me the features that you like about this place,” and “Please tell me the features that you do not like about this place.”

**Actual study- audiovisual experiment**

**Training participants**

Before the actual audiovisual experiment, I conducted a training session using the same procedures to be used in the actual experiment but using different visual and sound stimuli. The purpose of the training session was to familiarize participants with the audiovisual procedure. Visual stimuli used two interior images of a *SUBWAY* restaurant (see Figure 14), obtained from Google images. The reason for using *SUBWAY* interior images is that participants were likely to be familiar with it. The intent was to make it easier for them to imagine being in the depicted environments. The sound stimulus used a different sound sample representing dining situations.

*Figure 14. Visual stimuli for training participants*

Source: Picture (left) from https://www.123rf.com/stock-photo/subway_food.html; Picture (right) from http://bradenconstruction.com/project-gallery/commercial/hospitality-retail/subway
Audiovisual experiment process

I used the audiovisual experiment to collect data and I used the correlation to quantify the degree of association between subjective attractiveness and subjective loudness/annoyance. ANOVA was used for comparing the subjective attractiveness scores, subjective loudness scores and annoyance scores when viewing four different visual stimuli. The procedure and instruments as well as analytical methods are illustrated in Figure 15.

Figure 15. Process, instruments and the analytical method used in audiovisual experiment

Auditory stimuli

Several restaurant sound effects can be found at YouTube and one video that was titled “Chattering in a restaurant, sound effect” (Youtube Broadcast Yourself, 2014) was chosen as the initial sound sample. This sound sample included most common sounds such as
those made by the presence of people, equipment and activities. This complied with Jossee’s (2011) description of common sounds at dining time in nursing homes.

A 30-second clip was cut from the initial sound sample as sound stimuli. This 30-second clip represented dining sound conditions. It was played at two different volumes, S1 and S2. S1 was played at roughly 61.93 dB and S2 was played at an increased decibel level of roughly 70.25. S1 and S2 were switched by clicking the volume button three times to increase or decrease the volume.

S1 was set up in the test room. I played the sound sample in the test room and used a sound pressure meter (BAFX Products E 11549621) to register the sound sample until the average sound level got to a level close to 60.43 dB. The benchmark of 60.43 dB comes from Jossee’s (2011) study. He concluded that the mean of average sound level during mealtime at several nursing homes in the Midwest area is 60.43 dBA. Because my study was also conducted in a midwestern state, the findings from Jossee’s study for decibel level was considered suitable.

The sound simule were played on an iPad Mini through a portable speaker (JBL FLIP 2). As suggested by Yang et al. (2011), sound samples for each participant produced from the speaker should maintain the same loudness for the purposes of testing perceived noise level. Every effort was made to ensure that the sounds appeared the same to each participant. For example, a suitcase method was used to keep all the devices in a fixed location and the same for each participant (see Figure 16).
Testing Equipment Setting
1. Speaker
2. Mini IPad (Sound stimuli Player)
3. Iphone (Sound level monitor)
4. Computer (Visual Stimuli Display)
5. Participants seating location
6. Table (4’ by 4’)
7. Suitcase

**Figure 16. Testing equipment settings**

Experiment rooms

As shown in Figure 17, two rooms were used for the experiments: one was a family dining room at the CCRC, the other a meeting room at the LCD. The rooms were chosen where the participants live, sparing them the challenge and inconvenience of travel.

- Non soundproof
- Windows
- Viewing blind
- Dining sounds from outside
- Decibel levels of sound samples:
  - S 1: 62.69
  - S 2: 68.41

- Soundproof
- No windows
- Viewing white wall
- No sounds from outside
- Decibel levels of sound samples:
  - S 1: 61.17
  - S 2: 72.09

**Figure 17. Experiment rooms**
Audiovisual experiment procedure

The audiovisual experiment was designed to determine correlative relationships and significances between subjective attractiveness and subjective perception of noise. Figure 18 shows the audiovisual experiment procedure. The participants were exposed to images first and asked to imagine dining in the room presented on the slide. The visual stimuli (Image A, B, C, and D) were previously used in the visual experiment. The participants were asked to listen to the sound samples and focus on the sounds. When the sound stopped, the participants were asked to judge exclusively the sounds using the auditory rating scales (subjective loudness and annoyance) and respond orally.

![Audiovisual experiment procedure](image)

**Figure 18. Audiovisual experiment procedures**

The oral instruction was:

*Please look at this picture: this is a dining place. Imagine you are dining in this room. (Play the sound samples). Please tell me how loud the sound was to you; pick a number from 0 to 10. 0 indicates it was really quiet, 10 indicates it was extremely loud. Also please tell me how annoying the sound is to you. 0 indicates the sound did not bother you and 10 indicates the sound is very annoying.*

Content analysis

I used content analysis to analyze participants’ responses of the questionnaires and to identify the relationship between subjective attractiveness rating scores and biophilic design features. The content analysis process included four steps. First, transcribe the recorded
answers. Second, identify the keywords associated with subjective attractiveness and conduct word count. Third, count the existence and frequency of the keywords. Fourth, visualize the distributions of the key words and the subjective attractiveness scores.

**Quantitative data analysis**

I used one-way analysis of variance (ANOVA) and bivariate correlative statistics to analyze quantitative data that are ratings scores for the scales. The significance level used in this study is $p = .05$ (Hinkle, Wiersma, & Jurs, 2003). The ANOVA was used for analyzing the differences between subjective attractiveness evaluations and subjective loudness evaluations and annoyance evaluations when viewing four different visual stimuli.

A correlation (two-tailed) analysis was used to quantify the degree of association between subjective attractiveness and subjective loudness/annoyance. For this study, using Cohen’s (1988) guidelines, the Pearson’s correlation coefficient $r$ is computed as a qualitative measure to determine the strength and direction of the relationship between the two variables (Pallant, 2005, p. 126).

ANOVA and correlation analysis were conducted using software of Data analysis SPSS 15.0 (Pallant, 2005).
CHAPTER IV
RESULTS

This section presents the results of the visual and audiovisual research addressing each research question. This section includes demographic information, visual experiment results and audiovisual experiment results.

Demographic Information

The study was conducted using twenty-four participants (n = 24) for all testing phases. Demographic data were collected from all participants. Twenty-one participants were from a continuing-care retirement community (independent to skilled nursing levels) and three from an independent living community. Seventy-five percent were female and 25% male. Ages ranged from 65 to 90 years old, with 68% ranging from 81 to 90. Nine percent of the participants did not have hearing loss, 45% had mild hearing loss and 17% had moderate hearing loss.

In analyzing the audiovisual experiments results, it was necessary to discard the data from two participants because it was discovered that the sound stimuli were measured about 10 decibels higher than they were supposed to be. So the audiovisual results are limited to 22 participants.

Visual Experiment Results

This section presents the results on the relationship between evaluations of attractiveness of each given interior space and biophilic design features. ANOVA and content analysis were used to analyze the data.
Subjective attractiveness comparison

ANOVA with post-hoc Tukey HSD test was conducted to identify which visual stimuli pairs significantly differed from each other on the subjective attractiveness ratings.

ANOVA in Table 3 showed that there was a statistically significant decrease in subjective attractiveness rating from Image A ($M = 8.31, SD = 2.037$) to Image B ($M = 5.79, SD = 2.037, F (3, 92) = 6.985, p < 0.01$). Similarly, there was a statistically significant decrease in subjective attractiveness rating from Image A ($M = 8.31, SD = 2.037$) to Image C ($M = 6.79, SD = 2.126, F (3, 92) = 6.985, p = 0.036$).

<table>
<thead>
<tr>
<th>Experimental group</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective attractiveness</td>
<td>8.31ab</td>
<td>5.79a</td>
<td>6.79b</td>
<td>6.98</td>
</tr>
<tr>
<td>(1.41)</td>
<td>(2.04)</td>
<td>(2.12)</td>
<td>(2.02)</td>
<td>6.985***</td>
</tr>
<tr>
<td>$F$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta^2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *** = $p$ * = $p$

This table shows the overall significant main effect of group. Post hocs demonstrate group difference. The pair that has statistical significance is denoted by the same letter a or b in a row.

Ranking on subjective attractiveness

Participants were asked to rank Image A, B, C, and D in terms of visual appearance from the most attractive to the least attractive. The result is presented in Table 4 below.
Table 4.

*Ranking on the most attractive to the least attractive image*

<table>
<thead>
<tr>
<th>Image</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>A</td>
<td>62.5</td>
</tr>
<tr>
<td>B</td>
<td>12.5</td>
</tr>
<tr>
<td>C</td>
<td>8.3</td>
</tr>
<tr>
<td>D</td>
<td>16.7</td>
</tr>
</tbody>
</table>

**Note.** The highlighted numbers indicate highest ranking for each image.

Image A was ranked first most often. Image D was ranked third most often and B and C were most often ranked last.

**Biophilic design and subjective attractiveness**

The analysis begins with the existence and word count of keywords associated with subjective attractiveness. The analysis secondly shows the frequency of biophilic design attributes recognized as positive features and the frequency of negative “general comments”. This section finally shows the visualization of the distributions of the keywords and the subjective attractiveness scores.

Table 5, below, shows the existence and frequency of the keywords categorized as “General Comments” and “Biophilic Design Attributes”. Both categories included positive and negative aspects.
Biophilic design attributes were identified as positive features in more than two-thirds of the instances, as illustrated in Figure 19, below. For example, biophilic design attributes

### Table 5

**Content analysis on interior spaces A, B, C, and D**

<table>
<thead>
<tr>
<th></th>
<th>General Comments</th>
<th>Biophilic Design Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>A</strong> (Attr) score is 8.31</td>
<td>Beautiful (2), Pretty (2), peaceful, Nice, restful, Harmony, Like it, Refreshing Eye-catching.</td>
<td>None.</td>
</tr>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>B</strong> (Attr) score is 5.79</td>
<td>Nice (2), Neat, restful, Pleasing, Quiet, pretty, Balance, Well lit.</td>
<td>Mismatching, Plain (5), Enclosed (2), Tried, Noisy.</td>
</tr>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>C</strong> (Attr) score is 6.79</td>
<td>Colorful, Peaceful, Clean, Balance, Brightness (2), Nice (2).</td>
<td>Enclosed (4), Mismatching (3), Not appealing, Dark.</td>
</tr>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td><strong>D</strong> (Attr) score is 6.98</td>
<td>Comfortable (2), Clean, Pretty, Fresh, Vital Inviting, Brighter, Homey.</td>
<td>Enclosed (2), Mismatching, No focal- point, Not –appealing.</td>
</tr>
</tbody>
</table>

**Word count**

- **A**: 11, 0, 30, 5
- **B**: 9, 8, 15, 5
- **C**: 8, 8, 17, 7
- **D**: 9, 5, 22, 6

Note. “Freq” represents frequency.

Means of evaluation on visual appearance appear in parentheses below A, B, C, and D. The number in parenthesis indicates the times of the words that were mentioned. If the word was mention once, it has no number.
that included window view, outdoor greenery, natural light and natural color were mentioned a total of 30 times, accounting for 73% of the total positive comments (41 words). For interior space B, biophilic design attributes included wood, stone material and colors that were mentioned a total of 15 times, accounting for 62.5% of the total positive comments (24 words). For interior space C, biophilic design attributes included landscape painting, abstract tree graphics and colors that were mentioned a total of 17 times accounting for 68 % of the total positive comments (25 words). For interior space D, the indoor greenery and natural colors were mentioned 22 times, accounting for 71% of the total positive comments.

![Figure 19](image.png)

*Figure 19. Word count of positive features, comparing “General Comments” with “Biophilic Design Attributes” when viewing image A, B, C and D*

Figure 20, below, showing the word count of negative comments such as “mismatching,” “enclosed” or “plain,” suggests that the negative rating is associated with general attitudes about the interior design itself. (These considerations are addressed in redesigning the dining room. See Chapter V.)
Figure 20. *Word count of negative features on attractiveness viewing all images*

**Graphic representations of visual experiment results**

The following graphs visualize the distribution of both positive and negative comments on Images A-D in the respective subjective attractiveness rating scores. These visualizations are intended to subjectively show relationships between the rating scores on attractiveness and participants’ comments.

Figures 21-24 show how the keywords relate to participants’ subjective attractiveness scores for each visual stimulus. The “General Comments” are presented in black fonts, “Biophilic Design Attributes” in green fonts, and negative comments in grey fonts.
Figure 21. Comments and subjective attractiveness ratings on Image A
Figure 22. Comments and subjective attractiveness ratings on Image B
Figure 23. Comments and subjective attractiveness ratings on Image C
Figure 24. Comments and subjective attractiveness ratings on Image D
Audiovisual Experiment Results

This section first presents the ANOVA results on subjective loudness and annoyance, and then the correlation results between subjective attractiveness of each given interior space and subjective noise perception. As noted above, I analyzed the data from 22 participants instead of 24 because two sound samples were not played at the designed level.

**Subjective loudness and annoyance score comparison**

ANOVA with post-hoc Tukey HSD test was conducted to identify if there were statistically significant differences when participants viewed different images in terms of subjective loudness ratings scores and annoyance ratings scores with the sound stimulus played at two different levels.

The ANOVA result presented in Table 6 reveal that sound ratings on annoyance and subjective loudness did not significantly differ from each other when participants were exposed to different images. In other words, there was a null result.

**Table 6**
Subjective sound Rating Scores for Image Groups

<table>
<thead>
<tr>
<th></th>
<th>Images</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>η²</td>
</tr>
<tr>
<td>Subjective annoyance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound 1</td>
<td>2.39</td>
<td>2.22</td>
<td>2.57</td>
<td>2.20</td>
<td>.131</td>
</tr>
<tr>
<td></td>
<td>(2.28)</td>
<td>(2.09)</td>
<td>(2.23)</td>
<td>(2.23)</td>
<td>.01</td>
</tr>
<tr>
<td>Sound 2</td>
<td>3.75</td>
<td>4.46</td>
<td>4.48</td>
<td>4.11</td>
<td>.330</td>
</tr>
<tr>
<td></td>
<td>(3.05)</td>
<td>(2.62)</td>
<td>(2.79)</td>
<td>(2.72)</td>
<td>.02</td>
</tr>
<tr>
<td>Subjective loudness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound 1</td>
<td>3.11</td>
<td>3.11</td>
<td>3.76</td>
<td>3.32</td>
<td>.445</td>
</tr>
<tr>
<td></td>
<td>(2.50)</td>
<td>(1.77)</td>
<td>(2.08)</td>
<td>(2.14)</td>
<td>.02</td>
</tr>
<tr>
<td>Sound 2</td>
<td>5.00</td>
<td>5.80</td>
<td>5.76</td>
<td>5.32</td>
<td>.673</td>
</tr>
<tr>
<td></td>
<td>(2.27)</td>
<td>(2.16)</td>
<td>(2.09)</td>
<td>(2.25)</td>
<td>.02</td>
</tr>
</tbody>
</table>

Note. Standard deviations appear in parentheses below means.
Subjective attractiveness and subjective loudness/annoyance correlation

Correlation analysis was conducted to identify the relationship between subjective attractiveness rating scores and the subjective loudness rating scores and annoyance rating scores. The correlations were conducted for individual images as well as overall scores.

Table 7 shows the results of correlation for individual images A, B, C and D.

<table>
<thead>
<tr>
<th>Sound Stimulus 1</th>
<th>Sound Stimulus 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subjective Annoyance</td>
</tr>
<tr>
<td>Subjective Attractiveness</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>

Viewing visual stimulus A

As Table 7 shows, when viewing A there is an overall negative correlation between subjective attractiveness and subjective loudness and annoyance. A higher level of evaluation on attractiveness is associated with lower rating on subjective loudness and annoyance.

Table 7 also shows a small, negative correlation between subjective attractiveness and subjective loudness when the sound stimulus was softer ($r = -.22, n = 22, p = 0.304$) or louder ($r = - .17, n = 22, p = 0.304$). No statistical significance was found and the Coefficient of Determination was very small (6% and 3%).
**Viewing visual stimulus B**

As showing in Table 7, when viewing B, there is an overall positive correlation between subjective attractiveness and subjective loudness with both sound stimuli. A higher level of evaluation on attractiveness correlates with higher annoyance and loudness.

Table 7 also shows that when listening to the softer sound stimulus S1, there were small, positive correlations between subjective attractiveness and subjective loudness ($r = .145, n = 22, p = 0.058$) and the Coefficient of Determination was 9%. A moderate correlation between subjective attractiveness and annoyance ($r = .412, n = 22, p = .150$) and the Coefficient of Determination was also 9%. In terms of louder sound S2, there were also small, positive correlations between subjective attractiveness and subjective loudness ($r = .254, n = 22, p = .302$) and annoyance ($r = .254, n = 22, p = .236$). Both had low Coefficient of Determination (6%).

**Viewing visual stimuli C**

When viewing C, as shown in Table 7, there were small negative correlations between subjective attractiveness and subjective loudness ($r = -.160, n = 22, p = .150$) and medium correlations with annoyance ($r = -.406, n = 22, p = .150$) with louder sound stimulus S2. Higher levels of evaluation on attractiveness correlates with lower annoyance and loudness.

In contrast, there were small positive correlations between subjective attractiveness and subjective loudness ($r = .284, n = 22, p = .150$) and medium correlations with annoyance ($r = .301, n = 22, p = .150$) with softer sound stimulus S1. Higher levels of evaluation on attractiveness associated with higher annoyance and loudness.
When viewing D, as shown in Table 7, there were only small positive correlations between subjective attractiveness and annoyance \((r = .209, n = 22, p = .150)\) with softer sound S1. A higher level of evaluation on attractiveness correlates with lower annoyance. Table 8 combines the ratings of Images A, B, C and D as well as the ratings of the sound stimuli.

**Table 8.**

Pearson’s Product Moment Correlations for Overall Sound Rating with Overall Visual Evaluations

<table>
<thead>
<tr>
<th>Subjective Attractiveness</th>
<th>Sound 1</th>
<th>Sound 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>.054</td>
<td>.052</td>
</tr>
<tr>
<td>Subjective Annoyance</td>
<td>-.056</td>
<td>-.078</td>
</tr>
<tr>
<td>Subjective loudness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. \(N = 88\) for all analyses.

These results show that the overall correlations are positive between subjective attractiveness and subjective loudness/annoyance with Sound Stimulus S1. With Sound Stimulus S2, there are negative correlations between subjective attractiveness and subjective loudness/annoyance. However, the correlation effect is very small (< .1).

Table 9 shows the correlation between subjective loudness and annoyance.

**Table 9.**

Pearson’s Product Moment Correlations between Subjective Loudness and annoyance

<table>
<thead>
<tr>
<th>Subjective loudness</th>
<th>Subjective Annoyance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound 1</td>
<td>-.747**</td>
</tr>
<tr>
<td>Sound 2</td>
<td>-.292**</td>
</tr>
</tbody>
</table>

Note. **= \(p \leq .001\). \(N = 88\) for all analyses.
There is strong correlation between subjective loudness and annoyance with softer sound stimulus $S_1$ ($r = .747, n = 88, p = .000$) and louder sound stimulus $S_2$ ($r = .790, n = 88, p = .000$). Both of them have a large coefficient of determination of 56%.

Table 10 shows the correlation between sound ratings and participants who reported any level of hearing loss.

Table 10.

*Pearson’s Product Moment Correlations for Sound Ratings (S1) with hearing loss*

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th></th>
<th>B</th>
<th></th>
<th>C</th>
<th></th>
<th>D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing loss</td>
<td>.048</td>
<td>-.064</td>
<td>.033</td>
<td>.050</td>
<td>.020</td>
<td>.043</td>
<td>-.263</td>
<td>-.360</td>
</tr>
</tbody>
</table>

Note. $N = 22$ for all analyses.

Loud = subjective loudness, Annoy = annoyance

Table 11.

*Pearson’s Product Moment Correlations for Sound Ratings (S2) with hearing loss*

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th></th>
<th>B</th>
<th></th>
<th>C</th>
<th></th>
<th>D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing loss</td>
<td>.086</td>
<td>.068</td>
<td>.007</td>
<td>.028</td>
<td>.058</td>
<td>.040</td>
<td>.168</td>
<td>.114</td>
</tr>
</tbody>
</table>

Note. $N = 22$ for all analyses.

Loud = subjective loudness, Annoy = annoyance

The correlation results suggest no significant correlations between hearing loss and subjective sound rating.
Audiovisual experiment subjective results

As shown in figure 25, the mean of ratings on annoyance between the images suggests that when participants rated the attractiveness higher (attractiveness: A > D > C > B), they rated annoyance levels lower (annoyance: A<B with louder noise, A < C, D < B, D < C ). I interpret this to mean that participants felt less annoyed by the noise when they viewed more attractive interior spaces such as A and D. The noise is perceived less annoying when the interior space is perceived as attractive.

As shown in Figure 26, the mean of rating scores of subjective loudness between the images suggests that when participants rated the attractiveness higher, the subjective loudness levels were rated lower, which suggests that the noise is perceived as less loud. For example, this trend can be observed on the annoyance rating scores: A < C, A < B (with louder sound); D < C, D < B (with louder sound). Apparently, the
loudness is perceived as lower when the attractiveness is higher. In addition, when the sound stimuli are louder, the influence of the visual stimuli is more apparent, but not to a statically significant extent.

Summary

With respect to the subjective attractiveness ratings, the results show:

• ANOVA shows that Image A is statistically significantly more attractive than Images B and C. With respect to Images A and D, there is no statistical significance.

• Biophilic design features including window view to greenery, indoor plants, natural material and realistic landscape painting elicited positive subjective evaluations.

• Higher scores of subjective attractiveness correlated with certain biophilic design features.

• Negative comments on interior spaces appear to be associated with participants’ general impression of the interior design itself.

With respect to the sound rating, statistics yielded a null result. The influence of visual settings on sound judgments was not statistically significant in any of the four audiovisual indoor environments. Nevertheless there are some possible trends:

• In terms of different interiors, the tendency involves a tentative correlation between higher attractiveness and both lower annoyance and perceived loudness.

• When the sound level is louder, the tentative correlations above appear stronger.
CHAPTER V
DISCUSSION AND DESIGN SOLUTIONS

This thesis explored the relationships between evaluations on visual appearance with biophilic design features and evaluations on given sound conditions. The specific environment selected for this study was a dining environment with older adult users. The data were collected through visual and audiovisual experiments and analyzed using content analysis, ANOVA and correlation. These results helped to identify the relationship between visual attractiveness and biophilic design attributes and the relationship between visual attractiveness and subjective loudness/annoyance.

Discussion of Results Relating to First Research Question

Do biophilic design attributes influence the evaluations on the visual appearance of interior spaces? The content analysis results suggested that biophilic design features in interior spaces do lead to positive evaluations of the visual appearance. Biophilic design features catch people’s attention and generate positive feelings towards the built environment. Negative comments on interior spaces appear to be associated with participants’ general impression of the interior design itself.

Indoor plants can provide psychological benefits such as stress-reduction and increased pain tolerance (Bringslimark, Hartig, & Patil, 2009). According to Larson (1999), the presence of indoor plants would also increase the comfort and attractiveness of office environments, and the absence of plants can have a negative impact on perceived
attractiveness. My study similarly suggests that in dining environments indoor plants help to create attractive spaces.

My study also suggests that biophilic design attributes including realistic painting and natural material also generate positive comments on interior spaces. This observation is in line with previous work that suggests that the use of a natural material, such as wood, influences user preference (Nyrud, Bringslimark, & Bysheim, 2013). Both natural and simulated nature environments facilitated stress reduction (Kjellgren & Buhrkall, 2010).

Based on my research, I conclude that this result implies that biophilic elements have a positive visual impact on interior design. Secondly, interior designs that are characterized by certain general features which correlate with basic design principles also affect positive evaluations. Moreover, my results suggest that not following general design principles tends to invoke negative reactions.

Discussion of Results Relating to Second Research Question

What are the relationships between evaluations of attractiveness of interior spaces and subjective loudness and annoyance in the older population? In my study, neither correlations nor ANOVA results revealed statistically significant relationships between attractiveness and sound ratings. That is, the influence of visual setting on sound judgments did not occur statistically significant in the given audiovisual indoor environment.

There are possible explanations for the null results. Noise annoyance can relate to many factors, such as the noise sensitivity of the individual participant, the amount of noise, the nature of the noise, and the volume of the noise. In my study, the volume of the sound
samples (62dB and 72 dB) and their relatively short duration (30 seconds) may have been below the annoyance threshold of the older participants. In addition, and importantly, the participants may have been less sensitive to the noise due to their hearing loss. Finally, because this study used the same sound sample with each of the four visual stimuli, the participants may have been inclined to rate the sound the same or almost the same for each one.

Limitations and Future Research

This study is limited in a number of ways. It used a very small sample size. It used a limited age demographic. The testing was conducted in two non-identical testing rooms. The study did not thoroughly investigate the effect of various levels of hearing loss among the participants. The study relied on images of interior spaces rather than using actual interior spaces. Moreover, each interior space was intentionally constructed with only one major biophilic design attribute. The study used one sound stimulus, played at two different volumes.

Limitations of my study could be addressed in the future by:

- Using a larger sample size.
- Focusing on different age demographics, such as young adults (say, age 20 to 40) or “middle-age” adults (say, 41 to 65).
- Focusing on adults with no hearing loss, or investigating the effect of various levels of hearing loss.
- Using a single testing room and ideally one that is soundproof.
• Refining the visual stimuli and sound stimuli for better control.

• Using more varied sound stimuli. For example, the sound stimuli could be played at more than two volumes and/or could include different kinds of noise.

• Modifying the visual stimuli to include multiple variations in the biophilic design features rather than varying only one major biophilic design attribute in each stimulus.

My study suggests several additional avenues for further research. First, field observation and testing could be conducted in a real indoor environment instead of using an artificial audiovisual environment approach. For example, biophilic design attributes such as indoor plants could be placed in a real indoor environment and participants could be asked to evaluate the sound with or without their presence.

A second avenue of further research could involve comparing the effects of different biophilic design attributes on noise annoyance modification. For example, a study could be designed to compare two attributes including image of nature and indoor plants. An image of nature might be placed on a partition as a sound barrier wall, and indoor plants might be placed to form a partial sound barrier wall as well. Perceived loudness and noise annoyance could then be compared in two or more applications.

Conclusion with Design Solutions

Research has demonstrated that biophilic design can reduce stress, enhance creativity and clarity of thought, improve well-being and expedite healing. Theorists, research scientists, and design practitioners have been working for decades to define aspects of nature
that most impact our satisfaction with the built environment (Browning, Ryan & Clancy, 2014). This study suggested that where an interior space is perceived as more attractive, noise annoyance and loudness are perceived as lower.

As Browning, Ryan and Clancy (2014) point out, biophilic design patterns (attributes) are flexible and replicable strategies for enhancing the user experience that can be implemented under a range of circumstances. Biophilic design interventions are based on the needs of a specific population in a particular space. Connecting my study with the previous research on the psychological benefits of biophilic design and noise annoyance reduction, I propose comprehensive guidelines for designing a biophilic space for older adults in a dining environment with a design focus on perceived attractiveness as well as perceived loudness and annoyance levels. These guidelines include three concepts:

Concept 1: Incorporation of nature elements in built environments. As several researchers pointed out, nature scenes promote positive emotion, physiology, cognition and health. Nature elements reduce stress while enhancing creativity and clarity of thought, thereby improving well-being and even expediting healing. In addition, the visual presence of greenery and water has been shown to reduce noise annoyance.

Concept 2: Person-centered design. This concept is developed based on the person-centered care concept in the LTC industry. It involves transforming the care of older adults from task-oriented to person-centered. The concept reflects resident individuality, empowers residents in decision-making, and endeavors to achieve a more holistic approach to wellness (Caspar et al., 2009). The transformation involves remodeling the facility environment from “institutional” or “hospital-like” to “homelike”.
### Incorporating natural elements

<table>
<thead>
<tr>
<th>Key Concept</th>
<th>Design criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Views through the window</td>
<td>• Gardens, wetland parks, garden parks, landscape with water</td>
</tr>
<tr>
<td></td>
<td>• What should not be in the view</td>
</tr>
<tr>
<td>Outdoor nearby greenery</td>
<td>• Gardens, healing gardens, horticulture, street greenery, landscape with water</td>
</tr>
<tr>
<td>Indoor plants</td>
<td>• Small green lightly scented plants for optimal health and well-being</td>
</tr>
<tr>
<td>Image of nature</td>
<td>• Natural scene mural</td>
</tr>
<tr>
<td></td>
<td>• Painting with water scene</td>
</tr>
<tr>
<td>Natural material</td>
<td>• Intermediate amount of wood</td>
</tr>
<tr>
<td>Natural light</td>
<td>• Proper shading to direct sunlight</td>
</tr>
<tr>
<td></td>
<td>• Avoid glare</td>
</tr>
</tbody>
</table>

### Person-centered design

<table>
<thead>
<tr>
<th>Key concept</th>
<th>Design criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design reflects person centered care domains</td>
<td>• Provide flexible configurations for different dining choices</td>
</tr>
<tr>
<td></td>
<td>• Multiple uses of space to provide socializations</td>
</tr>
<tr>
<td></td>
<td>• Provide waiting area</td>
</tr>
<tr>
<td>Home environment</td>
<td>• A corner for Home setting within big dinning space</td>
</tr>
<tr>
<td></td>
<td>• Using amenities to create home feel, such as table clothes</td>
</tr>
<tr>
<td>Design facilitates hearing</td>
<td>• Control noise level at a minimum</td>
</tr>
<tr>
<td></td>
<td>• Arrange spaces away from noisy zones</td>
</tr>
<tr>
<td></td>
<td>• Enclosed soundproof walls</td>
</tr>
<tr>
<td></td>
<td>• Sound absorption material can be applied to walls, floors and ceilings, draperies, acoustic panels</td>
</tr>
<tr>
<td></td>
<td>• Avoiding long, rectangular rooms</td>
</tr>
<tr>
<td></td>
<td>• Using suspended or wall-mounted fixtures</td>
</tr>
<tr>
<td>Design facilitates vision</td>
<td>• Front lighting</td>
</tr>
<tr>
<td></td>
<td>• Soft and diffusion light, adequate and consistent lighting level</td>
</tr>
<tr>
<td></td>
<td>• Shield lighting sources to prevent contrast glare</td>
</tr>
<tr>
<td></td>
<td>• Use indirect pendant light and cover light</td>
</tr>
<tr>
<td></td>
<td>• Eliminate veiling reflection by specifying low-glare surfaces</td>
</tr>
<tr>
<td></td>
<td>• Avoid fluorescent lighting, which interfere with hearing aids</td>
</tr>
<tr>
<td></td>
<td>• Using high reflective material to increase lighting levels</td>
</tr>
</tbody>
</table>

### Following basic design principles

<table>
<thead>
<tr>
<th>Key concept</th>
<th>Design criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organized Complexity</td>
<td>• Axis, symmetry, hierarchy, rhythm, datum, repetition and transformation</td>
</tr>
<tr>
<td>Integration of parts to the wholes</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 27. Comprehensive guidelines for designing a person-centered biophilic space for older adults*
Concept 3: Follow universal principles suggested by nature including harmony and variety.

The three concepts implied the design guidelines for any of the LTC facilities that undergo the transformation to person-centered care. After conducting my study, I applied these design guidelines to the “Back Dining Room” in the CCRC facility. Figure 28 shows the original dining space. The settings of this dining space are defined and illustrated in Figure 29. The existed noise problems are illustrated in Figure 30. The strategies for psychological noise reduction are illustrated Figure 31.

![Image of redesigned dining room](image)

*Figure 28. “Before” Image of redesigned dining room*
**Existing setting: “Back Dining Room”**

- This is the Continuing Care Retirement Community where I conducted the research. The current dining room is open to the corridor where the heavy traffic is. It has visual connection with the family dining space at the other side of corridor.
- The dining space is used for multiple activities including dining, activities and meetings. The tables and chairs are temporary, set up according to activities.
- This dining place has window views to outside. The windows bring in the garden views as well as the view of the buildings behind it.
- Current space is relatively plain. Acoustic ceiling tile, vinyl floor, painted and wood-looking walls, and wood beams.

*Figure 29. Illustrations of the settings of redesigned dining space*
Causes of noise problems:

On-site observations revealed the following problems:

- Noise generated from the corridor/nursing station including people talking, footsteps, push carts and cleaning activities.
- Noise generated from the adjacent kitchen/resident’s room through shared walls.
- Noise generated from the nearby family dining/staff meeting space.
- The interior design scheme lacking character that positively influences people’s perception of noise.
- The lack of sound-proofing materials in the interior design scheme.

Figure 30. Illustrations of noise problems existing in redesigned dining space
Strategy one: adding barriers

- This design strategy intends to minimize the noise problems by setting up a buffer zone between noise sources and people. The buffer zone serves as a physical sound and visual barrier. Space is arranged to orient people away from the noise source and towards a focal point.
- The aesthetic of the sound barrier affects the psychological noise loudness and annoyance. This design solution intends to neutralize the visual unattractiveness of the noise sources.

Figure 31. Illustrations of strategies for redesigning dining space
Strategy two: enhancing visual attractiveness

- This design strategy intends to reduce noise annoyance by increasing the attractiveness of interior space.
- One way to accomplish this is to incorporate biophilic design features as positive distractions, as well as elements that foster positive feelings. Design interventions include window view to greenery, realistic nature painting, natural lighting and layers of artificial lighting, indoors plants.

*Figure 31 continued*

Using the guidelines and the strategies discussed above, I developed a design solution for the “Back Dining Room” in the CCRC facility. The following exhibits will feature four diagrams depicting how I have applied the guidelines and strategies discussed in a design solution.

*Figure 32. The entry of the “Back Dining Room”*
As illustrated in Figure 32, the design of the entry evokes a formal portal that features a snack display area and, for visual interest, several planters and warm lighting. The snack display shelf to the right of the portal would be wheelchair accessible and provide a temporary space for waiting.

Figure 33, below, illustrates the right-hand corner of the room as seen upon entering.

![Figure 33. The “Family Corner” at the “Back Dining Room”](image)

As illustrated in Figure 33, the “Family Corner” at the “Back Dining Room” features home settings within a large dining space. These furnishings provide additional spaces for waiting or conversation. The fireplace and art displays also create home-like feelings as well as positive visual distractions.
Figure 34 includes two images that illustrate the overall design of the “Back Dining Room” from two perspectives. Figure 35 illustrated the floor plan and reflect ceiling plan.

Figure 34. Overall Design of the “Back Dining Room”
In considering the guideline of “incorporating nature elements,” the overall redesign features multiple biophilic design attributes that exist in a harmonious setting. These
features include the use of natural plants, views to the exterior through surrounding windows, introduction of controlled natural light from windows and skylights, natural patterns within the selected materials, paintings featuring natural settings and warm natural colors. These design attributes are applied to create visual attractiveness in order to reduce psychological noise annoyance.

Existing windows reveal natural outdoor scenes. Planters with small lightly scented plants are applied to create physical barriers between noises and spaces as well as additional seating options. Wall graphics and paintings invite season-less nature into the space. Natural wood on the ceiling and walls creates a warm and natural softness using acoustically treated wallpaper. Overhead, the design includes skylights with frosted glass, inviting diffused natural light and natural scenes into the space.

In applying the guideline of “person-centered design,” the redesign keeps one large space to facilitate a variety of flexible uses. The redesign approach incorporates a “family corner” featuring a home setting to create a familiar, “home-like” feeling. To facilitate hearing, the redesign uses sound absorptive materials such as carpeting and wallpaper. Other strategies include creating barriers between noise sources and space, and creating visual interests to modify the feelings of annoyance induced by noise. To facilitate vision, the redesign includes increased lighting and a variety of lighting levels. These choices for lighting offer the resident and staff soft and diffusion lighting as well as natural lighting through skylight and windows.

In applying the guideline of “following basic design principles,” the redesign approach focuses on creating “organized complexity” and strives for unity. The application
of multiple biophilic design attributes creates visual diversity. Architectural elements such as the development of the ceiling plane offers an opportunity to create dramatic patterns and shadows. To achieve design unity, the proportion of each attribute is considered for visual balance. For example, wood material is used on two major surfaces including ceiling and one wall to achieve an optimum proportion. Unity is also achieved by repeated application of materials.

At the current dining space, the primary issues were a lack of visual interest, outdated interior, and noise because of the open floor plan. In redesigning the space, the goal of creating a person-centered biophilic space was based on my research of biophilic design theory and the needs of older adults. The redesign applies “The Comprehensive Guidelines for Designing a Person-centered Biophilic Space for older adults” (see Chapter IV). The redesign focuses on older adults’ needs and creates an environment with visual complexity and holism. The redesign embraces visual connections with biophilic attributes to enhance the dining experience by increasing attractiveness and decreasing loudness and annoyance. The redesign incorporates design interventions that embrace person-centered care concepts. In conclusion, the Back Dining Room has been transformed into a space displaying a multitude of strategies to increase well-being of the users.
REFERENCES


APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2107
515-294-4566
Fax 515-294-4267

Date: 2/1/2016

To: Jingfen Guo
610 SE Rio Cir
Ankeny, IA 50021

From: Office for Responsible Research

Title: Visual Quality and Noise Perception

IRB ID: 15-761

Approval Date: 1/29/2016

Date for Continuing Review: 1/28/2017

Submission Type: New

Review Type: Expedited

CC: Dr. Jihyun Song
158 College of Design

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
APPENDIX B

VISUAL QUALITY EVALUATION

Subject number:
Treatment number:
Treatment visual stimuli order:
Sound Order:

Visual stimuli 1

1. Imaging this space is your dining room, please rate how beautiful to you. From 0-10 scale, zero is ugly (not beautiful) and ten is (very) beautiful.

<table>
<thead>
<tr>
<th>Ugly</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

2. What features of the room do you notice the most? Please tell me 2-4 of them.
   This will be recorded.

Visual stimuli 2

3. Imaging this space is your dining room, please rate how beautiful to you. From 0-10 scale, zero is ugly (not beautiful) and ten is (very) beautiful.

<table>
<thead>
<tr>
<th>Ugly</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

4. What features of the room do you notice the most? Please tell me 2-4 of them. This will be recorded.
Visual stimuli 3

5. Imaging this space is your dining room, please rate how beautiful to you. From 0-10 scale, zero is ugly (not beautiful) and ten is (very) beautiful.

| Ugly | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Beautiful |

What features of the room do you notice the most? Please tell me 2-4 of them. This will be recorded.

Visual stimuli 4

6. Imaging this space is your dining room, please rate how beautiful to you. From 0-10 scale, zero is ugly (not beautiful) and ten is (very) beautiful.

| Ugly | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Beautiful |

What features of the room do you notice the most? Please tell me 2-4 of them. This will be recorded.

7. Please rank four images in the order of less beautiful to the most beautiful.
Tell me why.

Ranking
APPENDIX C

RATING FOR (SUBJECTIVE) LOUDNESS AND ANNOYANCE (MODIFIED)

Subject number:
Treatment number:
Treatment visual stimuli order:
Sound order:

Imaging you are sitting in this dining space, please rate the sound after you look at the image.

Visual stimuli

**Loudness**

<table>
<thead>
<tr>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
</table>

**Annoyance**

<table>
<thead>
<tr>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
</table>

Visual stimuli
### Visual Stimuli

**Loudness**

<table>
<thead>
<tr>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
</table>

**Annoyance**

<table>
<thead>
<tr>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
</table>
Visual stimuli

**Loudness**

<table>
<thead>
<tr>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
</table>

**Annoyance**

<table>
<thead>
<tr>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
</table>

Visual stimuli

**Loudness**

<table>
<thead>
<tr>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
</table>

**Annoyance**

<table>
<thead>
<tr>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
</table>
Visual stimuli

Loudness

<table>
<thead>
<tr>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
</table>

Annoyance

<table>
<thead>
<tr>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
</table>
Visual stimuli

<table>
<thead>
<tr>
<th>Loudness</th>
<th>Not Noisy</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Noisy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annoyance</th>
<th>Not Annoying</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Extremely Annoying</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Hi Name,

As a graduate student in Interior Design ISU, I am researching problems associated with noise at long-term care facilities. More specifically, I am investigating the effects of the physical design of dining room spaces on the subjective impression of noise in those spaces.

My research involves on-site survey and experiment to residents and I would like to include your facility in my research. The goal of my research is to provide recommendations regarding the design of interior spaces that would facilitate comfortable dining in settings such as your facility offers.

I attached a PDF file “Introduction of Study-Jingfen” that briefly introduced the study. If you would like more information on my research and/or on your possible participation in that research, please contact me at 515 441 3624 or jguo@iastate.edu. It would be most helpful to hear from you by the end of this month if at all possible.

Thank you so much for considering my request.

Best,
Jingfen
APPENDIX E
INTRODUCTORY SCRIPT

Hello,

I am conducting a test as a part of a thesis study at Iowa State University for requirements to complete a Master of Fine Arts. This study is about interior design with nature elements and how it influences noise perception.

Your participation is completely voluntary, and you may refuse to answer any question that seems too personal, or you may choose not to complete the survey or test at all. All of the information you provide will be kept strictly confidential and reported in summary form only. No individual will be identified, nor will your name be attached to any data. At the project’s end, researchers will destroy any personal identifying information. As this is an unfunded class project, we cannot offer compensation for your participation in this study.

Please read about inform consent letter to get more details. If you are 65 or older and would like to participate in this study please e-mail name (administrator) at email address (The name and email address will be substituted according to different nursing homes) or inform name (administrator) verbally so as to sign up a testing schedule. Please feel free to contact Jingfen Guo with any questions or concerns at jguo@iastate.edu.
APPENDIX F

INFORMED CONSENT DOCUMENT

Title of Study: Interior Design and Noise Perception

Investigators: Principle Investigator: Jingfen Guo
Advisor: Jihyun Song, Professor
jsong@iastate.edu
515-294-3397

This is a research study. It has information to help you decide whether or not you wish to participate. Please feel free to ask questions at any time.

Introduction

The purpose of this study is to investigate how visual quality of interior space influence noise perception. Interior space will feature design with natural elements. The aim of this study is to develop design recommendations for nursing home designers or administrators.

You are being invited to participate in this study because you are over 65 years old. You will be asked to provide hearing loss level (mild, moderate, severe, profound) information in your questionnaire because there are sounds involved in the test. The elderly who are blind will be excluded because the blind cannot see the visual stimuli, which is a major component of my study.

Description of Procedures

If you agree to participate in this study, your participation will last for approximately 25-30 minutes. This test will be conducted either at a room located at your facility or a room at a location that you will agree on. It may incur some cost for parking and/or may need to walk a distance in order to get to the testing location. The room will be darkened using blind or curtain in order to project the images best.

The test begins with a user profile questionnaire for demographic information, following by a questionnaire that asks you to evaluate and rank four dining interior spaces represented by projected pictures and orally give responses. You will be audio recorded. Once you are familiar with the spaces in the pictures, the test will add background sounds. So, you will be asked to look at each image and image you are in that dining space, then judge the sounds.

Risks or Discomforts

The sounds you will hear in the test are recorded at a busy restaurant containing
people talking and walking, dishes and silverware touching each other, furniture moving and kitchen sounds. The sounds are intended to simulate the dinning room situation, and they may be considered as unpleasant or uncomfortable noises to you. However, there are not harmful sound sources. The sound volumes will be control under 85dB, which is not harmful. For example, 85 dB sounds like heavy traffic or power lawn mower.

**Benefits**

If you decide to participate in this study will be no direct benefit to you. However, the knowledge or information gathered in this research will help future research in designing long term-care communities such as nursing homes or assisted living.

**Costs and Compensation**

You will not have any costs from participating in this study. You will not be compensated for participating in this study.

**Participant Rights**

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. For the questionnaire at the beginning, you can skip any questions that you do not wish to answer.

**Confidentiality**

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken:
The data collected will not be identifiable by name. Storage for the results will be on a password protected personal computer, inaccessible to the public. The questionnaires will be shredded after information is entered into the computer.

**Questions**

You are encouraged to ask questions at any time during this study. For further information about the study, contact Jingfen Guo at 515-441-3624 or jguo@iastate.edu. Or contact professor Jihyun Song at 515-294-3397 or jsong@iastate.edu
If you have any questions *about the rights of research subjects or research-related injury*, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

**Consent and Authorization Provisions**

Participant’s Name (printed) ______________________________________

_________________________________________  Date

Participant’s Signature
Hello,

Jingfen is a graduate student pursuing her interior design degree at Iowa State University. She has been interested in healthcare design and turns her focus on nursing homes. She is conducting a test as a part of a thesis study for requirements to complete a Master of Fine Arts. This study is about interior design with nature elements and how it influences noise perception.

Your participation is completely voluntary, and you may refuse to answer any question that seems too personal, or you may choose not to complete the survey or test at all. All of the information you provide will be kept strictly confidential and reported in summary form only. No individual will be identified, nor will your name be attached to any data. At the project’s end, researchers will destroy any personal identifying information. As this is an unfunded class project, we cannot offer compensation for your participation in this study.

Please read about the introductory letter and inform consent letter to get more details. If you are 65 or older and would like to participate in this study please e-mail me at this email address (The name and email address will be substituted according to different nursing homes) or inform me verbally so as to sign up a testing schedule. Please feel free to contact Jingfen Guo with any questions or concerns at jguo@iastate.edu.
Volunteers Needed for Testing Influences of Interior Design on noise perception.

Are you 65 years old or older and willing to spend 25 to 30 minutes participating in testing of influences of Interior design on noise perception.

If you are interested in participating in this study, please contact:

Jingfen Guo at jguo@iastate.edu
APPENDIX I
A QUESTIONNAIRE

1. What is your gender? □ Female □ Male

2. What is your age? □ 65-70 □ 71-74 □ 75-80 □ 80-85
   □ 85-90 □ over 90 □ other (       )

3. How long have you been in your facility?
   □ Less than 5 years □ 5-10 years □ Live independently
   □ 10-20 years □ More than 20 years

4. What is the level of hearing loss?
   □ No hearing loss □ Mild □ Moderate
   □ Moderately severe □ Severe □ Profound
   □ I do not know □ I do not want to answer this question

6. Are you wearing hearing aid? □ Yes □ No

7. When do you experience the loudest noise when you are dining in your facility?
   □ Before breakfast □ During breakfast □ After breakfast
   □ Before lunch □ During lunch □ After lunch
   □ Mid afternoon □ During supper □ After supper

8. List noises that bother you in your facility/home during the day?

9-12. Look at the four images and answer the questions.